O&M Best Practices for Energy-Efficient Buildings

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ABSTRACT

Overarching Operation and Maintenance ("O&M") practices can lead to the efficient operation of office buildings and retail facilities without requiring owners to invest in energy-efficient capital improvements. These O&M practices ("best practices") were identified as part of the *Operation and Maintenance in Buildings* study, which demonstrated that low-cost energy savings opportunities exist in commercial office buildings and retail establishments. This two-year study (1994-1996) was funded by the U.S. Environmental Protection Agency in cooperation with the U.S. Department of Energy. This paper is based on the *The O&M Best Practices For Energy-Efficient Building Operation* report which is the foundation for a series of practical documents (Haasl 1997; Stum et al. 1997) designed to help building owners and facility operators implement these practices in their buildings.

Consistent with the study's focus on energy, best practices are defined as those O&M activities and approaches that contribute to, or are directly responsible for, producing energy savings while maintaining or enhancing indoor environmental quality and equipment reliability. The identified best practices fall into one of the following major categories:

- Management—energy-efficient building operation and the "big picture";
- Teamwork—energy-efficient building operation is everybody's business;
- Resources—information saves time and money; and
- Energy-Efficient O&M—Tune it up, turn it off, check it out.

This paper describes these best practices and includes a discussion of key activities that can be used by facility managers, energy managers, property managers, and building operators to integrate energy-efficient operation into their organization's O&M program.

Introduction

Building operation and maintenance programs specifically designed to enhance operating efficiency of HVAC and lighting systems can save 5 to 20% of the utility bill without significant capital investment. The Operation and Maintenance in Buildings study, funded by the Atmospheric Pollution Prevention Division of the U.S. Environmental Protection Agency in cooperation with the U.S. Department of Energy, demonstrated that low-cost energy savings opportunities exist in commercial office buildings and retail establishments. The three-phase investigation, which took place in 1994 - 1996, consisted of a literature search, an O&M baseline-practices survey of 432 class A and B office buildings (Gordon & Haasl 1996), and an O&M tune-up of three office buildings and two retail facilities. The buildings ranged in size from 80,000 to 278,000 square feet (Haasl et al. 1996).

A primary goal of the study is to report on the O&M best practices that were identified during the investigation. This paper is based on the *The O&M Best Practices For Energy-Efficient Building Operation* (Portland Energy Conservation, Inc., Fall 1998) report that is the foundation for a series of practical documents designed to help building owners and facility operators implement sound O&M

practices in their buildings. The objective of the report is to provide commercial building owners, managers, and operators with a checklist of key activities that can be used to integrate energy- efficient operation into their organization's O&M program and to assist them in obtaining support from senior management.

In line with the study's 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. This paper highlights overarching O&M practices that lead to the *efficient operation* of office buildings and retail facilities rather than emphasizing energy-efficient capital improvements, (such as energy-efficient lighting and HVAC retrofits), or equipment-specific maintenance procedures, (such as recommendations to periodically clean indoor and outdoor heat pump coils, tighten fan belts and change filters).

Over 80 percent of the problems found during the building tune-up phase of this study were operational in nature which emphasizes the need to focus on improved building operation. Because there is very little information on building operation (the "O") compared to the volumes written on building maintenance (the "M"), this report emphasizes activities that support energy-efficient building operation. Maintenance is not ignored but is limited to discussing those maintenance activities that support efficient operation of equipment and systems.

The following paper presents fifteen significant best practices along with action tips for implementing each practice. Each of the practices falls into one of the following four major categories: management, teamwork, resources or energy-efficient O&M.

Management—Energy-Efficient Building Operation and the "Big Picture"

Best Practice 1: 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 assets employed. This focus increases opportunities for energy managers, facility managers and property managers to demonstrate the relevancy of energy-efficient building operation. 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. The following are action tips for accomplishing this practice:

- 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 having 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 and methods needed to achieve it.

Best Practice 2: 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. Effective energy management planning generally consists of three basic elements, purchasing energy at the lowest cost, operating energy consuming equipment efficiently, and replacing old equipment or retrofitting building systems with new, more efficient technologies. 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. The following are action tips for accomplishing this practice:

- Include a component in the energy management plan that clearly defines energy-efficient operation for 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.

Best Practice 3: 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 program. For an energy management program 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 not possible to understand or communicate in any measurable way the progress of the overall energy management plan as well as the various energy-saving components. The following are action tips for accomplishing this practice:

- Choose an appropriate energy accounting system or method depending on the size and number of buildings involved. The accounting system may be a simple spreadsheet or a sophisticated computer software program.
- Fully understand various utility bills (electric, gas, water, etc.) 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. Remember senior management is more interested in dollars saved than energy (kilowatts, therms or BTUs) saved. Reports may include information in the form of charts (such as pie charts) and graphs that informs and educates the audience about energy use, demand, costs, savings, and energy management progress.
- Remember to normalize for weather 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: Hire or Appoint an Energy Manager.

Unless someone is directly responsible for energy management, it probably won't get done. Assigning or hiring someone to do energy management sends a message to the O&M staff that the energy management process is important. The energy manager supports and motivates the O&M staff's efforts in energy-efficient operation.

As part of the facility staff, an energy manager has the primary responsibility for managing energy and promoting energy-efficient building operation. When a person is assigned the energy management responsibilities, they need to have the technical background, desire, and training to develop and carry out all aspects of the energy management plan including an understanding of indoor air quality (IAQ) issues. The following are action tips for accomplishing this practice:

- 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. This could be the facility manager, property manager or building operator.
- Provide adequate, up-to-date energy management training for the staff member assigned the energy management position. Training might include conferences, seminars, and university or college classes on the subject.
- Clearly define the energy management job function along with reporting, and authority guidelines. The person responsible for energy management should know who they report to and how much authority they have to carry out their goals.

Best Practice 5: Train Building Operators in Energy-Efficient O&M Activities

In order to continually improve and sustain operating efficiency as a proactive O&M function, training resources must be allocated. Today's building systems and controls are more sophisticated and complex than in the past. New technologies such as computerized energy management control systems (EMCS) with their abilities to perform complicated energy-efficient control strategies are often underutilized because the staff operating the technology is not well trained. It is the EMCS software control logic that provides the most benefit for the building O&M staff. Understanding the control logic enables them to customize the control of equipment to account for a variety of internal and external conditions. However , without the proper training, the EMCS often become a burden for the O&M staff. Some systems become scape goats for comfort and control problems and end up circumvented.

Along with training on the EMCS' control logic, training in maintenance activities that optimize energy-efficient operation must also be incorporated. 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, it is important to clean and check the calibration of these sensors more often than other sensors. The following are action tips for accomplishing this best practice:

- Develop an individual training plan and budget for each staff member using in-house resources as well as outside classes, conferences, and seminars that focuses on energy-efficient building

operation.

- If the building uses an EMCS, obtain a complete training package specific to that system for the staff person(s) responsible for operating and maintaining the system. The training could payback in a matter of weeks from energy savings and reduced comfort complaints.

Best Practice 6: 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. Requirements for both the "O" (operation) activities and the "M" (maintenance) activities should be defined in the service contract.

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, or EMCSs). To detect and troubleshoot both maintenance and operational problems, record keeping requirements should be included in the service contract. Tracking the preventive maintenance (PM) work helps building staff locate reoccurring problems, understand when equipment performance is degrading, and assures 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. The following are action tips for accomplishing this practice:

- 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 forms be filled out by the service technician who performs the work. 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. For example, if a fan motor amperage reading is required, the nameplate amperage should be placed on the form along with the actual measured amperage. The changes in amperage can then be tracked overtime. Noticeable changes may indicate a problem with the motor condition, maintenance, or operation and troubleshooting can take place before a failure occurs.
- 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.

Best Practice 7: 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 what, 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, etc.). 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, if the users are not included and informed about proper operation they often find ways to circumvent the technology thus canceling the effects of energy-efficient operation. The following are action tips for accomplishing this practice:

- 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. Make sure they know how to operate new equipment and are given fact sheets that put to rest myths and misconceptions about operating equipment such as lights, computers, and other office equipment. Some people still believe that it is cheaper, in the long run to keep fluorescent lamps burning all of the time.
- Periodically remind equipment users such as custodians, tenants, and employees to turn off equipment when its not in use, especially when they leave the area for an extended period of time. Reminders can be done in meetings, through an energy update newsletter, stickers, etc.
- 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: Maintain Continuity and Reduce Troubleshooting Costs. Document Changes and Strategies affecting Energy-Efficient Building Operation

Many large commercial buildings start out having adequate mechanical and electrical drawings and O&M manuals, but they seldom obtain operating documentation consisting of written sequences of operation or control strategies. Documenting the sequence of operation and energy-efficient control strategies for the energy using systems is basic to understanding building control. The control documentation is critical for maintaining energy efficient operation and doing effective troubleshooting of operational problems. Also, once accurate documentation is obtained, keeping it updated is important in maintaining 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 information is lost. This often leads to costly time and energy wasting mistakes. The following are action tips for accomplishing this practice:

- Obtain a clear written set of sequences of operation and building control strategies. The following are two ways to accomplish this:
    * Have 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. This could well pay for the project in a very short time.
    * Assign an appropriate in-house staff person to develop the current operating documentation.
- Ensure all building documentation is updated, as changes occur, by assigning this responsibility to one O&M staff person.

- Record the operating schedule for all equipment that is not required to be continuously enabled. This may include lighting, HVAC equipment, cooking equipment, office equipment, etc. Periodically review and update the schedules to reflect the current needs of building occupants.
- When new control systems (such as an EMCS) or equipment are specified, 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 videos and photographs to augment the written documentation.
- When taking over a new facility, request from the engineers 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: Equip O&M Staff with State-of-the-Art Diagnostic Tools

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

For buildings lacking an EMCS or for those having an EMCS with limited data points, use of portable electronic data loggers are a solution for increasing the building's staff ability to optimize equipment operation. Portable electronic data loggers are battery powered, small, light, and easily installed and removed without disrupting building occupants (Arney 1996). Depending on complexity, they range in price from $50 to $1000. 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.

For analysis purposes, many loggers come with sophisticated software packages. Once the data are gathered, the information is down loaded into the computer software for analysis. Most software is capable, at minimum, of presenting the data in line graphs (time series) making troubleshooting, analysis, and presentation extremely "friendly". In some cases, numerous lines of data can be placed on one graph for analyzing multiple variables. The following are action tips for accomplishing this practice:

- Understand what the present EMCS trend logging abilities are and whether the building staff is trained to use them. Research the needs of the staff and facility for the number of data loggers and types of compatible measuring instruments that would be most useful. Logger instruments are able to take a variety of measurements such as temperature, humidity, pressure, electrical current, light levels, etc.
- Research the market as to the types of data loggers 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 data logger system to invest in.
- 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 member and managers responsible for obtaining and analyzing the data.
- Once purchased, keep the data loggers in use. They will easily pay for themselves in a short time by increasing staff's troubleshooting abilities and understanding of where and when energy waste is occurring.

Best Practice 10: Perform a Comprehensive O&M Tune-Up Assessment

An O&M tune-up requires 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 for a facility. 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 data logging 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 if the building is being operated optimally and develops a list of recommended O&M improvements. It provides the starting point or baseline from which to measure the effectiveness of improvements and O&M activities. A good assessment may also recommend where more extensive system commissioning is appropriate and which capital improvements to consider for further investigation.

The O&M assessment differs from an energy audit in that it's primary focus is on low cost changes in O&M practices that improve building operation rather than on identifying retrofit opportunities (more 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 the existing building systems, reducing the need for expensive technological solutions. Both have the goals of reducing operating costs and energy waste and improving the building environment. The following are action tips for accomplishing this practice:

- 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.
- 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.
- Require a final assessment report that includes a master list of improvements prioritizing the most cost effective improvements. Most low cost improvements should pay back in less than eighteen months. The number one energy waster is leaving equipment and lights on when they could be off. The payback for improved scheduling is almost immediate.

Energy-Efficient Operation And Maintenance—Tune it up, Turn it off, and Check it out

Best Practice 11: Perform O&M Tune-Up Actions

Five to twenty percent of the annual utility bill 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, improvements for control strategies or schedules, where the greatest savings often occur, may be implemented in a matter of a few hours. Implementing the initial O&M tune-up improvements allow the building to perform optimally before more extensive energy audits or studies are performed and energy efficient technologies are installed. The following are action tips for accomplishing this practice:

- Prioritize the O&M improvements by cost-effectiveness.
- Implement the improvements over a selected period of time such as six months to three years depending on annual budget pay backs, and non-energy benefits such as comfort and equipment reliability.
- Measure and document the affects of the improvements to create a benchmark for tracking O&M activities and ensuring the improvements continue to work as expected.

Best Practice 12: Make Full Use of Automatic Controls to Optimize Efficient Operation. Most Systems are Under Utilized.

Although many facilities have sophisticated, computerized, energy management control systems (EMCS) in place, most do not take full advantage of the systems capabilities. Many EMCS' are used only to schedule equipment on and off. These system 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, lighting sweeps, night purge, etc. that can save energy dollars beyond ordinary time-of-day control.

Newer HVAC equipment may have sophisticated integral controls that can be programmed to accomplish energy efficient strategies such as chilled-water reset and soft starting of motors or compressors. Unless their capabilities are fully understood by the operator, 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 EMCS, 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. The following are action tips for accomplishing this practice:

- 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. Many building managers and operators do not know what their controls are able to do as compared to what it is actually programmed to do.
- For newly installed systems, require the supplier/installer to turn over a full set of documentation on the system including *written* control strategies and sequences of operation so 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 all the energy efficiency capabilities are being applied and the EMCS 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 to oversee the control systems to ensure they are regularly updated, backed up, and the documentation remains current.

Best Practice 13: Operate Equipment Only When Needed

Although individual pieces of equipment may be performing efficiently, unless the controls and occupant needs are periodically monitored, 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 monitoring procedures are in place. Equipment may be operating very efficiently but when it's "on" and nobody's home, the only thing happening is energy waste. The following are action tips for accomplishing this practice:

- As part of preventive O&M planning, develop procedures to periodically review and monitor the EMCS's time-of-day schedules, optimum start/stop strategies, temperature setups and setback (these may be increased or decreased depending on outside conditions), lockouts 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, copiers, etc. Also, small, inexpensive "stick-on" data loggers are available on the market that can assist in understanding when equipment is running more often than needed.
- Periodically interview tenants to determine what their comfort and lighting needs are to determine if any operating opportunities exist. Consider low-cost solutions such as occupancy sensor in areas of low or intermittent use such as storerooms and employee lounges.

Best Practice 14: Track Major Equipment (Actual) Performance against Expected Performance

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 the expected performance data. Expected performance data or the "figure of merit" (FOM), such as kW per ton, may be a combination of the manufacturer's test data and the actual data obtained from field testing the equipment. The goal is to obtain benchmark performance criteria to make comparisons against. When equipment is not meeting the expected performance criteria, it may indicate an need for improved or more frequent maintenance procedures (cleaning, lubricating, etc.) or different operating parameters (setpoints, lockout strategies, capacity control strategies, etc.). The following are action tips for accomplishing this practice:

- Obtain the necessary manufacturer's performance test data and FOM for all major plant equipment, such as chillers, cooling towers, boilers, air handlers, pumps, etc. Or, establish benchmarks for the equipment using in-situ measurements.
- When developing baseline FOMs, the equipment and systems should be tested under full and part load condition and only after they have gone through rigorous annual PM procedures to ensure

they are in best condition possible. Hire a test engineer to assist in developing the baseline (expected) 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.
- Decide how frequently tracking equipment performance should occur. Some equipment data should be looked at daily. Tracking methods may include any one or a combination of manual logging of data from permanently installed gages use of hand-held instruments and portable dataloggers, permanently installed monitoring/metering equipment, or the EMCS. No mater what method is used, the instrumentation for gathering the data, thermometers, flow meters, sensors, etc. should meet rigorous calibration standards.

Best Practice 15: 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 the 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, a piece of equipment or a system may be meticulously maintained but if it's poorly operated using inadequate control strategies or improper scheduling, vast amounts of energy waste can occur. 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. The following are action tips for accomplishing this practice:

- As part of preventive O&M planning, perform periodic reviews of HVAC and lighting schedules, temperature setpoints, and occupant/tenant use requirements to ensure equipment is running 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.
- Formally incorporate the "O" (operating) activities into the PM plan. 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.

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