Operation and Maintenance in Office Buildings: Defining Baseline

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Research indicates that substantial energy-saving opportunities are available through improved O&M practices in commercial office buildings. The first step in taking advantage of these opportunities is to identify O&M practices that are routinely performed in representative buildings throughout the United States. This paper reports on a federally funded project to determine O&M baseline practice in the United States.

A comprehensive mail survey was developed to identify O&M baseline. It was targeted at facility managers and operators and included questions on O&M staffing, budgets, current and future priorities, preventive maintenance, tracking and documentation, and details on O&M practice for electrical energy-using systems including HVAC, lighting and controls. To improve sampling and response rate the survey was coordinated with BOMA International and mailed to a random sample of 3,300 of their members throughout the United States. Response to the survey was good, with 432 buildings completing the survey.

The paper discusses survey results, development of an O&M baseline for commercial office buildings, and suggests how these results support the use of operation optimization as a practical approach to raising the level of current O&M practice.

INTRODUCTION

Lack of operation and maintenance strategies to maintain building energy system performance leads to increased energy use and less healthy buildings. The first step toward improved practices that take advantage of potential energy savings is to identify the O&M practices routinely performed in buildings. Understanding O&M baseline practice has two major benefits. First, baseline is the benchmark from which to measure the success of improvements in O&M practices. And second, baseline practices can be used as a guide to direct the development of improved practices.

Project Description

This paper reports on a federally funded project to determine common O&M practice in the United States. The project sought to identify the current range of commercial building O&M practices in target markets. Office buildings were selected as the project focus because they represent the largest amount of square footage and electrical energy use within the commercial sector (EIA, 1994). Additionally, the types of equipment and controls found within office buildings are relatively standard, thus providing the project with the ability to collect detailed information on the O&M practices associated with each system.

This paper first offers a working definition of Operation and Maintenance and defines the three most common approaches to O&M. The paper then reports on the results of the O&M survey, identifying the most frequently reported O&M practices. Based on the most common practices, an O&M baseline is developed, and closes with suggestions on using the baseline to improve O&M practice.

Defining Operation and Maintenance

For the purposes of this paper, the following definition of Operation and Maintenance will be used: Operation and Maintenance is the process of sustaining the performance of a building in accordance with the documented design intent, and the owner's operational needs. This process involves a set of activities that help maintain a building's profitability and sustains reliability. Operation refers to activities such as equipment scheduling and optimizing energy efficient and comfort control strategies. Maintenance activities involve caring for equipment to assure reliability and decrease the possibility of premature failure (NWPPC, 1995).

Operation and maintenance activities can be characterized as reactive, preventive or predictive. Preventative maintenance is planning in advance to systematically perform activities that generate the longest-term, most efficient operation from an entire system of integrated equipment. Reactive maintenance is the unscheduled repair of equipment when it breaks down and responding to tenant complaints. Predictive maintenance is the process of performing analytical activities such as vibration analysis that detect and remedy problems

which cause failure and is most often used in the industrial sector. This survey did not address predictive maintenance.

Survey Development

The O&M baseline mail survey was administered in cooperation with the Building Operators and Managers Association (BOMA) and was designed with assistance from an advisory group consisting of research and industry professionals. The purpose of the survey was to gather information necessary to assess baseline O&M practices in commercial office buildings. The survey was nine pages long and contained over 70 questions. The following baseline elements were investigated:

- Management and Staffing
- Training and Tools
- Budget and Costs
- HVAC and Lighting Controls and Operation
- Preventive Maintenance Programs
- O&M Problems
- Energy Accounting
- Building Documentation

3300 randomly selected BOMA members received the survey. The target response rate was ten percent (330 responses) which would allow for a robust data analysis. The realized response rate was better than expected, with 432 buildings providing responses. Buildings that responded to the survey were well distributed throughout the United States, with 38 states having at least one building respond. Buildings are evenly distributed between urban and suburban business areas and building type is predominantly multi-tenant general purpose (80%, n = 344).

BASELINE FINDINGS

The O&M Baseline survey was analyzed using SAS, a database and statistical analysis software package. For most of the questions in the survey, analysis was limited to frequencies and cross tabulation. Data table validity was measured using students t-test and chi-square. As is typical in surveys, not all respondents answered all of the questions. Throughout the report, the number of respondents corresponding to reported percentages are in parenthesis.

Building Characteristics

The survey was mailed to a random mixed sample of buildings classified as A, B or C. Class A buildings are the most prestigious buildings competing for premier office users with rents above average for the area. These buildings have high quality standard finishes, state of the art systems, exceptional accessibility and a definite market presence. Class B buildings compete for a wide range of users with rents in the average range for the area. Building finishes are fair to good for the area and systems are adequate, but the buildings do not compete with Class A at the same price. Class C buildings compete for tenants requiring functional space at rents below the average for the area (BOMA, 1995).

Primarily Class A (67%, n = 277) and Class B structures (30%, n = 124) responded to the survey. Buildings are moderate age, with 78% (n = 327) built between 1970 and 1985, and 32 percent built between 1986 and 1995. Over 80 percent are buildings with 100,000 square feet or more of conditioned space, with 7 percent (n = 29, all but two are Class A) over 1,000,000 square feet of conditioned space. The median building size is 230,000 square feet. The average building size is 347,147 square feet. The typical building in the sample has 15 above-grade stories. About half (49%, n = 207) of the buildings use electricity as the primary heating fuel, followed by gas (40%, n = 168) and purchased steam (11%, n = 48). Nearly all buildings (92%, n = 387) use electricity for cooling.

Over 80 percent of the buildings have undergone major HVAC system modernization in the recent past; 62 percent between the years 1991-1995, and 22 percent between 1986–1990. The most common component that was modernized is the EMCS (28%, n = 68), followed by the chillers (16%, n = 38) and a whole HVAC system upgrade (10%, n = 23).

Before we go further, it is important to note that data in this report most accurately describes the O&M practice of Class A buildings, which by definition, are using state of the art systems. Caution should be used in applying the results of this survey to describe commercial office buildings in general.

Management and Staffing

The majority of buildings are operated by a private management agency (74 %, n = 306). Most buildings have a variety of staff including (1) property managers whose role is to obtain and retain tenants for the building owner, (2) facility managers whose role is to oversee management of all building grounds operation and maintenance (janitorial, landscaping etc.), (3) chief engineers who are typically hired to oversee and supervise the operation and maintenance activities performed on the various building systems (electrical,

mechanical, communications, etc.), and (4) building operators who perform hands-on O&M activities for all building systems. According to the survey, it takes approximately .35 property managers to manage 100,000 square feet, or in other words, a typical property manager manages approximately 256,000 square feet. Additional staff (per 100,000 square feet) involved in the operation and maintenance are .84 of a building operator, .33 of an facility manager, .26 of a chief engineer and .16 of an energy manager (only 10% of the buildings reported having this position). The number of staff positions correlate well with the size of the building, that is the larger the building the larger the staff. Staffing levels at most buildings are described as ''just right'' (68 %, n = 281), and staffing levels have remained stable for the past 3 years.

Property managers reported that after occupant relations, building operation and maintenance issues are the highest priority. When asked to characterize the top three responsibilities of the operators and maintenance staff, respondents indicated priorities as (1) resolving occupant complaints, (2) performing unscheduled maintenance, and (3) performing preventive maintenance. Generally, in-house staff has the major responsibilities for day-to-day operation and maintenance, while intermittent activities such as equipment repair, replacement and EMCS programming are contracted out to specialized contractors. Specialized service contractors generally sell, install, repair and service a particular type of equipment such as refrigeration, water treatment, and chillers (Narel, Haasl, 1994).

We assumed that tenant relations was most important to facility managers and asked them to rank their next three concerns. These concerns are fire life safety issues, operation and maintenance followed by budget issues. Facility managers were least concerned about staffing issues.

Training and Tools

More than half of the buildings (62%, n = 260) have a training budget for the staff of $500 or less per operator. When asked what triggers the need to provide training the most cited reason was certification required by law (n = 342), followed by installation of new equipment/technology (n = 319) and staff member request (n = 248). Poor job performance was the least selected reason to provide training.

The sophistication of the in-house tools used to operate and maintain a building are often a good indicator for the level of operation and maintenance practice in a building. We asked respondents to indicate which tools are readily available for use in their building. Basic tools: the ammeter, thermometer and mulitmeter are available at nearly all buildings. However, several of the more sophisticated tools that help monitor energy use and efficiency are not available onsite. These include; data logger, power monitor, flow hoods, and combustion analyzer.

Budget and Costs

Almost all buildings have a discrete budget category for operation and maintenance (85%, n = 353). For most buildings the O&M budget represents approximately 5 percent of the overall building budget. Looking at the actual budget spent for 1994, 55 percent (n = 234) of the buildings spent $25,000 or less on directly expensed repairs (fixing something that is broken) and maintenance (ongoing care). This does not include in-house labor costs but does include contractor fees and equipment replacement costs. The median cost of repairs and maintenance is approximately $.11 per square foot, not including in-house labor costs. For the majority of respondents (90%, n = 375) any unspent portion of the O&M budget does not carry over to the next year. However, future budgets are not reduced by the unspent amount.

Interestingly, 67 percent (n = 267) of the buildings do not have capital reserves for equipment replacement. Of those that do have capital reserves, most separate the capital reserves budget from the operation and maintenance budget. The capital reserves budget is based on a fixed dollar amount, with $100,000 as the median value reported.

Controls and Operation

The survey questions focused on the control strategies for two main building systems, lighting and HVAC. Seventy-one percent (n = 305) of the respondents reported having an EMCS, with 44% of these systems in combination with a pneumatic system. More than one-half of the buildings (58%, n = 249) operate the HVAC using an automatic time-of-day control system. The second most common type of HVAC control was a programmable time clock (21%, n = 90). In nearly all buildings, the EMCS has trending capabilities (74%, n = 230). In most cases where trending is available, it is used to help troubleshoot operational problems in the building. Eighty-eight percent of those who have EMCS indicated that the system is performing to their expectations.

Lights are controlled through a variety of ways, with the most common being time clocks for both interior and exterior lighting. Exterior lighting is also controlled by photocells. Very few buildings reported using daylighting or occupancy sensors. Considering most respondents operate their building using an EMCS it is noteworthy that very few respondents (n = 46) operate their lights using electronic sweep control.

HVAC O&M Problems

Occupant complaints are the most common way that Building Management finds out about problems (41%, n = 176) rather than through routine inspection (30%, n = 125) or through the EMCS (19, n = 80). The average number of calls per week complaining about temperature is 9.5. This practice is considered a reactive rather than a proactive approach to building operation.

The three greatest operation and maintenance problems identified by buildings in the sample are undersized equipment (23%, n = 100), poorly located equipment (21%, n = 92) and poor or lack of documentation (16%, n = 68). It is difficult to say whether the equipment is really undersized or just perceived as undersized. Equipment that is not operated or maintained properly may appear to be undersized. Poorly located equipment is generally a design issue and makes it difficult to access equipment to perform maintenance tasks. This may indicate that maintenance does not get done as often as it should.

The typical building did not report having either air-or water-balance problems. However, balance deficiencies are not always easily detected as a main or contributing source for comfort problems. The trouble often appears to be remedied by increasing or decreasing set points or closing local diffusers. Also, equipment appearing to be undersized may be due to balance problems.

The two HVAC control issues cited most often were the need for an EMCS and problems with tenants tampering with thermostats.

Preventive Maintenance Program

Most respondents have a preventive maintenance program (98%, n = 422). Approximately half of these preventive maintenance programs are computerized (52%, n = 213). Preventive maintenance is reported to be performed on schedule ''always'' or ''most of the time'' (96 %, n = 411). Nearly all buildings have water treatment for the HVAC (88 %, n = 373).

Respondents indicated that preventive maintenance is typically not budgeted with a specific number of hours (86%, n = 355). However, for those who do budget by hours, (14%, n = 56), the range of budgeted hours is quite large (from a low of 500 to a high of 7000). It is reasonable to assume that the amount of hours required in the budget depends on the size of the building and complexity of its systems. About half of the respondents have a preventive maintenance budget of 500 hours or less, while the other half budgeted up to 7000 hours. Additionally, the number of hours budgeted is not necessarily the number recommended by the manufacturer; 38% (n = 27) did not know if the hours were the same, and 23%, (n = 16) used different hours. Most respondents (361 out of 432) did not answer the question suggesting they were unaware of the manufacture's recommended hours.

Each respondent was asked to complete a matrix describing the frequency of preventive maintenance for a variety of equipment. Table 1 displays the preventive maintenance schedule followed by the majority of the respondents

If the schedule of preventive maintenance described in Table 1 is in fact followed, it would represent a program comparable and in some cases exceeding the recommended PM frequencies suggested in BOMA's 1996 edition of ''How to Design and Manage Your Preventive Maintenance Program''. However, the reader should bear in mind that survey responses are largely from Class A buildings, and Table 1 most likely overstates the preventive maintenance practice for the broad population of office buildings.

As part of the preventive maintenance section, respondents were asked if efficiency testing was performed on their major equipment. Over half (55%, n = 228) either do not perform tests, or did not know if efficiency tests are performed on their equipment. However, 45% (n = 189) said they performed efficiency testing. This is surprisingly high and suspect, since efficiency testing in the field is difficult and often requires sophisticated test instruments that many respondents claim not to have available on-site. Respondents may have misunderstood the question since no definition was of what constituted an efficiency test was provided.

Energy Accounting

As expected, the most common way to track energy use is by monitoring the monthly energy bills. Most of the respondents, 69 percent (n = 297), do not use energy accounting software. Of those who do use energy accounting software (30%, n = 128), most generate energy accounting reports monthly (n = 113). These reports are most often distributed to the property manager and the chief building engineer. Very few of the respondents (n = 22) said the building operator received a report.

It is interesting to note that when asked to provide the energy use index (energy budget in Btu per square foot) for the building, very few respondents could provide a number (23%, n = 97) and several called asking what the energy use index meant. Of those who did provide the EUI, the values were widespread and unreasonable. To help better characterize the buildings in the sample and to define baseline energy use, this question will receive follow up. For each participant, a card will be sent out rephrasing the question.

Table 1. *Frequency of Preventive Maintenance*

PM Activity	Annual	Semi-Annual	Quarterly	Monthly
Clean Indoor Evaporator Coils	X			
Clean Outdoor Condenser Coils	X			
Change Filters			X	
Cooling Towers		X		
Dampers		X		
Tighten Fan Belts			X	
Grease Bearings			X	
Inspect Chillers			X	
Inspect Packaged Unit			X	
Air Compressor Controls			X	
Calibrate/Adjust System Sensor		X		
Calibrate/Adjust Space Thermostat		X		
Calibrate/Adjust Space Sensor	X			
Calibrate/Adjust Terminal VAV Box	X			
Calibrate Adjust Pneumatic Controls		X		
Economizer Controls		X		
Grease/Lube Motors		X		
Grease/Lube Pumps			X	
Grease/Lube Fans			X	
Water treatment Equipment				X
Boilers		X		
Heat Pumps			X	
Inspect Control Valves			X	
Steam Traps	X			

Documentation

A resource that is essential to proper operation and maintenance are the documents describing the building systems. We asked respondents to indicate what operation and maintenance documents are available and the completeness of the document. Table 2 shows the responses.

As can be seen in Table 2, at least one-third of the respondents have either incomplete or no documentation on most systems. Generally, the documents that apply directly to the operation of the building (sequence of operations and control strategies) are incomplete or not available.

SUMMARY: BASELINE PRACTICE

The definition of baseline operation and maintenance is the practice reported by the greatest number of respondents or the practice described by 50 percent or more of the respondents (median).

Table 3 summarizes the operation and maintenance baseline derived from the survey. This baseline is most appropriate for Class A buildings with 100,000 square feet or more of conditioned space. Caution should be used when applying this baseline to the general population of buildings.

CONCLUSIONS

For the most part, the baseline operation and maintenance practice described by the respondents is quite good and, for some elements, approaches what might be defined as best practice. For example 98% reported having a preventive maintenance program with 52% having their program computerized, and 70 % control (operate) equipment with an EMCS and 82% use EMCS trending to troubleshoot operational problems. But, this is not surprising, given the respondents represent the group most likely to be educated, financially able, and motivated to encourage good practice. However, the survey results reveal some key areas where building O&M programs need improvement. Among these are operation (as opposed to maintenance), documentation, operator training, and tools.

Looking at building operation, there is obvious support for concluding that maintenance of equipment, in general, has a higher priority than operation of equipment. For example very few of the respondents selected operations as one of the three top priority responsibilities for their building operators where as preventive maintenance was almost always among the top three.

More evidence for the lack of focus on operating issues appears when we look at the EMCS section of the survey. Although 70% of the respondents said they have an EMCS, when we examine how respondents use the EMCS, it becomes apparent that the system is, in many cases, just a sophisticated scheduling device. Table 4 lists typical scheduling and optimization capabilities for most of today's systems yet in approximately 50 percent of the responses related to optimization, the capability is not used.

Examining questions regarding building documentation reveals not only documentation areas needing improvement but continues to demonstrate the low importance of building operation. Most stated they have complete sets of building-system drawings and O&M manuals but 70% had partial or no written control strategies and 60% have partial or no

Table 2. *Status of Operation and Maintenance Documents*

Document	Complete Set	Partial Set	None Available
Equipment Operation and Maintenance Manuals	250	152	17
Mechanical Drawings	274	135	15
Electrical Drawings	265	139	19
Test and Balance Reports	169	169	80
Control Drawings and Schematics	231	155	30
Written Sequence of Operations	165	171	73
Written Control Strategy	122	145	138

Table 3. Summary of Baseline Practices

Practice Description	Baseline Practice
Management and Staffing	
• Building management	The survey showed most buildings are managed by private management agencies (74%, n = 306)
• Staffing levels	A typical property manager manages 256,000 sf. The number of building staff increases with the size of the building.
• Facility or property managers greatest concerns	The top three concerns for managers are fire, life, and safety issues, followed by O&M and budget issues.
• Staff responsibilities	The number one responsibility for O&M staff is resolving occupant complaints followed by performing unscheduled and preventive maintenance. Saving energy was not among the top three priorities.
• Use of outside service contractors	Specialized contractors are used for equipment repair, replacement and EMCS programming.
Training and Tools	
• Training budgets	More than half the buildings have training budgets (62%, n = 260). Most spend $500/year or less per building operator for training.
• Reason for operator training	Most sited a need for certification required by law (n = 342) followed by a need to understand a new installation or technology (n = 319).
• Tools	Most said they have basic troubleshooting tools such as ammeter (78%), thermometer (91%), and multimeter (91%). 25% or less have more sophisticated tools such as combustion analyzers, power monitors, or data logger available for in-house staff.
O&M Budgets and Costs	
• O&M budget	Most said they have discrete budgets for O&M (85%, n = 353) and for most this represents approximately 5% of the overall building budget. For 90% of the respondents the unspent money in the O&M budget does not carry over to the next year
• Directly expensed repairs & maintenance	55% (n = 234) spent $25,000 or less on repairs and maintenance.This does not include in-house labor costs. Median cost is $.11 per sf. excluding the in-house staff payroll.
• Repairs and maintenance cost	
• Capital reserves	67% (n = 267) of the buildings do not have capital reserves for equipment replacement but of those that do have a capital reserve budget, it is separate from the O&M budget
Controls and Operation	
• Control systems	70% (n = 305) use energy management control systems and of these 44% are used in combination with a pneumatic control system.
• HVAC equipment scheduling	Over half the buildings (58%, n = 249) schedule equipment through the energy management control system and 21% (n = 90) use programmable time clocks. Interestingly, very few (9 %, n = 90) still use mechanical time clocks.
• EMCS Functions	Those having an EMCS primarily use it for HVAC time-of-day scheduling (70%, n = 301).
• EMCS trending capability	74% (n = 230) say they have systems with trending capability and 82% (n = 197) say they use it for troubleshooting operational problems
• EMCS maintenance	Approximately half of the respondents indicated they have a maintenance service contract for their EMCS
• Lighting controls	Most said Interior lighting is primarily controlled by time clocks (56%, N = 171) and exterior lighting is also primarily controlled using time clocks (81%, n = 256) followed by photocell control (69%, n = 217).83% (n = 218) have no lighting-sweep controls for their buildings.
Preventive Maintenance	
• Preventive maintenance program for HVAC	Most respondents said they have a preventive maintenance program (98%, n = 422) and 52% said they have a computerized PM program.
• Preventive maintenance schedule	Most respondents said they perform preventive maintenance on or close to schedule (96%, n = 411).
• Efficiency tests	Most do not perform efficiency tests on major energy-using equipment.
• Water treatment	Most buildings (88%, n = 373) have water treatment for heating and air conditioning systems. The water treatment service is primarily provided by outside contractors.
O&M Problems	
• Problem detection	The most common way to detect problems is by occupant complaints (41%, n = 176) followed by routine inspection (29%, n = 125).The average number of comfort (temperature) related calls per building is 9.5.
• Three greatest O&M problems	(1) Undersized equipment (2) poorly located equipment (3) lack of documentation
Energy accounting	
• Tracking Energy	Most respondents track energy by reviewing the energy bills (67%, n = 290). Most do not use energy accounting software.
• Reporting	Of those using energy accounting software (n = 128) the property manager and chief engineer see the report while only 22 of the 128 said the building operator is given a report.85% said they generated monthly reports.
Building documentation	Most said they have complete sets of mechanical, electrical, and control drawings along with building O&M manuals.Most had either partial or no written sequences of operation (60%, n = 244) and partial or no written or control strategies (70%, n = 283).34% said they had no written control strategies.

Table 4. *EMCS Capability vs. Actual Use*

Operational Use of EMCS	Percent
Time of Day Scheduling of Lighting	31%
Time of Day Scheduling of HVAC	70%
Modulate Outside Air Dampers	48%
Load Shedding	23%
Zone Temperature Control	44%
Enable and Disable the Economizer	40%
Use Optimum Start	47%
Capacity Control of Chillers	39%
Morning Warm-Up	41%
Capacity Control for Cooling Towers	33%
Night Purge	27%
Supply Air Reset	38%
Chilled Water Reset	39%
Heating Water Reset	28%

written sequences of operations. The information relating directly to building control and operation is least available. It is also interesting to note that one of the top three O&M problems listed by respondents was lack of documentation.

Looking at operator training and tools issues, the survey showed building managers are most interested in training building operators when there is a requirement or certification needed by law or when a new technology is installed. These are good reasons and not surprising, however the budgets for training are very low. Most spend $500 or less per year per operator and 48% have no training budgets. The ‘‘new technology’’ often installed in a building is an EMCS. Thorough training on these sophisticated systems could easily exceed $500 especially if the operators time as well as the training costs are considered. Regarding tools, very few respondents have more than the basic tools such as ammeters, thermometers, and multimeters. Tools for testing efficiencies and monitoring equipment operation over time, such as combustion analyzers, power monitors and data loggers are clearly missing from the building operators tool box as indicated in Table 5.

Most of the areas needing improvement concern building-system operation. Traditionally, preventive maintenance plans and contracts focus efforts on maintaining equipment (as in lubricating, cleaning, and tightening), often missing any significant operational problems. For example, an air conditioner may have excellent maintenance but if the equipment runs far longer than needed because schedules are incorrect and the set points are lower than necessary, or the resets are not working properly, equipment life is still compromised and more energy is used than required. These issues can be costly to a building owner if they are ignored.

Operation optimization as part of, or in concert with, the preventive maintenance plan directly addresses the often overlooked operational issues. Building equipment should be viewed as an asset to be both optimally maintained and operated. Although the need to focus equally on operational issues may be old news to researchers, it still is not a primary focus for most building managers, operating personnel, or service contractors. Service contracts and in-house preventive maintenance plans spell out maintenance tasks such as changing filters, checking belts, checking electrical components, greasing motors and fan bearings, and monitoring equipment condition, but seldom, if ever, call out tasks that address operation. Checking equipment schedules and regu-

Table 5. *Tools Available On-Site*

Tool	Buildings Reporting Availability of Tool
Combustion Analyzer	68
Ammeter	337
Data Loggers	107
Digital Thermometer	393
Tachometer	198
Flow Hood	248
Power Monitor	95
Multimeter	392
Light Meter	216
Refrigeration Gauge Manifold	297

larly monitoring equipment to ensure it is running only when needed, along with monitoring various temperatures and pressures to understand if operating strategies can be improved, is generally not part of the O&M program.

NEXT STEPS

It is important to remember that most of the buildings surveyed were large class A office buildings with an median square footage of 230,000. If these buildings are demonstrating a need for O&M improvements we might expect that smaller class A, class B, and class C buildings of any size are even more in need of improvement. Understanding more about these buildings as well as institutional and public buildings regarding baseline practices is an important next step in determining the best approach to moving baseline practice toward best practice for each sector.

Continuing to emphasize the importance of operation as well as maintenance through building tune-up and commissioning studies provides information and demonstrates how these improvements benefit building owners and users both economically and environmentally. We are presently looking at common operating deficiencies from various building tune-up and commissioning projects in order to determine where improvement efforts would be most effective.

Using survey data, secondary research, and input from industry professionals, we are putting together a best practices checklist to be distributed to building operating personnel and energy managers. We hope to capture facility and energy manager's attention by providing a checklist tool that helps them improve several areas of building operations and maintenance. The checklist emphasizes energy efficient O&M strategies.

Researchers working more closely with installers, distributors and manufacturers of energy management control systems could help determine why such a valuable technology for optimizing building operation is being underutilized . Finding solutions to remedy this rampant problem takes input from all invested parties. One vehicle for disseminating information and education are industry professional groups such as those formed in the Pacific Northwest (Northwest Energy Efficiency Council) and in Massachusetts (Massachusetts Energy Efficiency Council). These non-profit membership supported councils have direct access to those in the industry who will benefit and are mandated in their charter to provide membership education.

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