

# High-performance facilities engineering: Preparing the team for the sustainable workplace

*Received (in revised form): 13th July, 2004*

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## Abstract

Rising energy costs, mould remediation and 'greening up' the workplace are among the many new challenges facing today's organisation. Where does management turn for solutions? In most organisations, it is the facilities management (FM) department and, for many, this the best place to look, because a skilled engineering group can be the organisation's greatest asset for addressing energy consumption, peak load management, indoor air quality and greening of the building. How can organisations get on the path to accessing their FM engineering group more effectively? It begins with workforce skill assessment, followed by an organisational commitment to effective, lasting training. This paper is for middle and upper-level managers seeking to prepare their FM departments for the sustainable workplace. Topics include a review of operation and maintenance (O&M) best practices for energy efficiency, an assessment of the O&M workforce within the facilities department, and a summary of the competency areas for improved O&M practices. Readers will become familiar with the critical elements of an O&M programme aimed at reducing utility costs as well as the workforce competencies necessary to implement such a programme. The results promise good return on the organisation's investment as well as enhanced stature for the FM department.

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**Keywords:**

energy efficiency, operation and maintenance programme, facilities engineering, high-performance buildings

**INTRODUCTION**

Buildings are where Americans spend about 90 per cent of their time. They use one-third of US total energy and two-thirds of US electricity. Their construction consumes a quarter of all harvested wood; 3bn tons of raw materials are used annually to construct buildings worldwide. Buildings consume 17 per cent of water and 50 per cent of chlorofluorocarbons (CFCs). They also produce, indirectly, 33 per cent of carbon dioxide (a global warming gas) and 40 per cent of landfill waste.<sup>1</sup>

Facilities management (FM) departments have historically taken a quiet role in the company infrastructure. Today, with rising energy costs, indoor air quality concerns and the greening of the workplace, companies are realising how much facility management affects the bottom line and the overall well-being of employees. This affords the FM department an opportunity to have a larger role in helping the organisation achieve its goals. The FM department's engineering group is key to making this role effective. Consider this example — a skilled and motivated engineering staff can reduce energy and water utility costs by 15 per cent or more,<sup>2</sup> with little or no capital investment — simply through changes in the practice of operating and maintaining increasingly complex building systems and equipment. Yet fewer than 10 per cent of organisations harness this human resource effectively.

How can organisations get on the path to accessing their FM engineering group more effectively? It begins with workforce skill assessment followed by an organisational commitment to effective, lasting training. This paper is for middle and upper-level managers seeking to prepare their FM departments for the sustainable workplace. Topics include a review of operation and maintenance (O&M) best practices for energy efficiency, an assessment of the O&M workforce within the facilities department, and a summary of the competency areas for improved O&M practices.

How does an organisation build, operate and maintain sustainably? Definitions for sustainable development come from many sources, including the development, design and engineering community and, more recently, the FM profession. The Hannover Principles, developed in 1992 by architects William McDonough and Michael Braungart, were among the first to address the fundamental ideas of sustainability and the built environment by asking organisations to remember three essential principles in their decision-making processes: to recognise interdependence between the built and natural worlds, to eliminate the concept of waste, and to understand the limitations of design by treating nature as a model, not as an inconvenience to be evaded or controlled.

**A skilled and motivated engineering staff can reduce energy costs by 15 per cent or more**

Since the development of these principles, much work has been done to move the field of sustainability from the conceptual to the concrete. The result has been the development of a number of performance-based design and engineering tools to enable planners, architects and engineers to put principles of sustainability into practice. These tools include the EnergyStar benchmarking tool, ISO 14001 Environmental Management Program, US Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) Green Building Rating System, with the LEED and ISO programmes offering the most performance-based guidance in the areas of building development and design for high-performance sustainable buildings. (USGBC) LEED has been adopted by a number of Federal, state and municipal governments in the USA by requiring LEED certification for new construction projects. Several states also offer green building tax credits tied to LEED certification. ISO has been widely used by companies throughout the USA and Europe to establish a process for setting environmental goals and monitoring progress towards their achievement.

In 1999, the US Government issued Executive Order (EO) 13123, *Greening the Government through Efficient Energy Management*, which established sustainable design principles for application to Federal projects in order to reduce pollution and other environmental costs associated with construction, operation and eventual decommissioning. Other guidelines have been developed, such as the *Whole Building Design Guide* prepared by US Department of Energy (DOE) Federal Energy Management Program; the *Advanced Building Guidelines* prepared by the New Buildings Institute; and the US Environmental Protection Agency's EnergyStar Buildings rating system.

Common to all these documents is the role and responsibility of the FM department in reducing energy consumption and costs, improving working environments and reducing the environmental impact of their operations. These guides are good first steps towards putting principles into practice, and many FM departments are on their way to adapting their O&M programmes to ensure the successful performance of green buildings.

### **O&M PROGRAMMES FOR THE GREEN BUILDING**

The performance of the green building is a result of the integration of the work of the architect, mechanical system designer, contractor(s) and commissioning authority. The owner's performance goal is to produce a structure which is energy and resource efficient and offers both financial and productivity rewards for the building's tenants/occupants. The ongoing realisation of this goal is the responsibility of the FM department and requires a facility operation and maintenance (O&M) programme that differs from standard practice.

**A number of guidelines offer ideas for facility management departments to improve their O&M programmes**

Traditionally, the term O&M has been viewed as a single unified process. For many in the field, the activity was expressed as a maintenance and repair (M&R) function. Maintenance has been defined as 'the work necessary to maintain the original anticipated useful life of a fixed asset'.<sup>3</sup> Repair relates to 'work to restore damaged or worn-out property to a normal operating condition'.<sup>4</sup> These are excellent definitions to describe the necessary maintenance work for a facility. They do not, however, address the 'O' in O&M.

Separating the O from the M helps one think about how the two types of activities are different. For example, performing most maintenance activities involves mostly physical skills, whereas performing most operational activities involves mostly mental skills. Maintenance activities ensure that equipment and systems have the *capacity* to run effectively. For example, dirty condenser coils reduce the capacity of the air conditioning system by not allowing sufficient heat transfer to occur. Operational activities ensure that equipment and systems perform optimally. If air conditioning compressors are poorly staged or operating when free cooling could be used, they are wasting energy and sometimes affecting comfort by overcooling spaces. O&M activities are different but equally important.

Operation is, of course, more than just the expression of the cost of operating a facility. Good operation within a building serves as a fundamental component of a best-practices programme. Without attention to operation, 'even when the staff meticulously maintains equipment, operation that relies on inadequate control strategies or improper scheduling can result in a significant energy waste, higher energy bills, reduction in the useful life of equipment, and poor indoor environmental quality'.<sup>5</sup> Clearly, a green building's intent to use resources efficiently and provide an indoor environment that spurs higher levels of worker productivity can be subverted without a conscientious approach to the maintenance and operations of the building.

A best-practices operation of the facility provides persistence of the owner's goal for the building over its lifetime. The owner's goal for a green building is for energy and resource efficiency and an indoor environment that is conducive to high worker productivity. Facilities management departments must redefine their approach to O&M to include operational activities that sustain the benefits of green design.

### **On the way to O&M best practices**

The FM professional can turn to a number of resources to discern a 'best-practices' approach for managing the green building. Of course, any building benefits from adopting a sound O&M approach to FM. As a baseline, the Federal Energy Management Program lists ten steps for maintaining operational efficiency in an existing building.

**Putting the 'O' into O&M is a fundamental component of a best-practices programme**

### *Ten steps for maintaining operational efficiency in an existing building<sup>6</sup>*

- Step 1:* Strive to increase management awareness and appreciation of the operations and maintenance programme/department.
- Step 2:* Commit to begin tracking O&M activities.
- Step 3:* Through tracking, begin to identify troubled equipment and systems.
- Step 4:* Commit to addressing at least one of these troubled systems.
- Step 5:* Commit to striving for operational efficiency of this system.
- Step 6:* Commit to purchasing or contracting for some form(s) of diagnostic, metering or monitoring equipment.
- Step 7:* Commit to trending the collected tracking and diagnostic data.
- Step 8:* Select, request funding for and complete first 'Operational Efficiency' project.
- Step 9:* Strive to highlight this success — capitalise on visibility opportunities.
- Step 10:* Commit to choosing the next piece of equipment.

### **Best practices for the green building**

Beyond this baseline of good practices O&M, a number of recent reports outline for FM departments a heightened commitment to operational practices appropriate to the green building. Research sponsored by the California Energy Commission in the persistence of benefits from retrocommissioning<sup>7</sup> concluded that the persistence of the value of commissioning activities within a facility was enhanced by

- providing operators with training and support
- providing a complete systems manual at the end of the commissioning process
- tracking building performance
- starting commissioning in the design phase to prevent nagging design problems.

The US Environmental Protection Agency (EPA) and US DOE sponsored the development of a report series on O&M best practices which summarised a number of specific O&M goals for the facilities manager.

### *O&M goals for the facilities manager<sup>8</sup>*

- Goal 1:* Incorporate goals for energy-efficient building operation into the strategic business plan.
- Goal 2:* Require an energy management plan with energy-efficient operation as a primary component.
- Goal 3:* Use an energy accounting system to locate savings opportunities and to track and measure the success of energy-efficient strategies.
- Goal 4:* Hire or appoint an energy manager.

- Goal 5:* Train building operators in energy-efficient O&M activities.
- Goal 6:* Require service contracts that support energy-efficient building operation.
- Goal 7:* Acknowledge energy-efficient operation as a cross functional activity.
- Goal 8:* Maintain continuity and reduce troubleshooting costs.
- Goal 9:* Equip O&M staff with state of the art diagnostic tools.
- Goal 10:* Perform a comprehensive O&M site assessment.
- Goal 11:* Perform O&M tune-up actions.
- Goal 12:* Make full use of automatic controls to optimise efficient operation.
- Goal 13:* Operate equipment only when needed.
- Goal 14:* Track actual performance against expected performance for major equipment.
- Goal 15:* Redefine preventive maintenance to include activities critical to energy-efficient building operation.

**LEED™ for Existing Buildings provides guidance for the facility management department**

Even more specific to operating and maintaining green buildings, the US Green Building Council's new LEED™ for Existing Buildings (LEED-EB) provides guidance for the FM department. Still in working draft, the Green Building Rating System for Improving Building Performance through Upgrades and Operations allows owners to receive credits for 'ensur[ing] that the building systems are continuously commissioned and maintained appropriately so that they go on delivering target building performance goals over the long term'.<sup>9</sup> To meet this intent, owners must

- establish/maintain continuous commissioning programme that monitors indoor environmental parameters (CO<sub>2</sub>, temperature, humidity) on a daily basis to ensure building systems are operating properly to meet standards for indoor environmental quality and optimal levels of energy efficiency, as specified by manufacturers, service contractors
- establish/maintain contracts or in-house resources in place for post warranty equipment maintenance
- implement/maintain a comprehensive best practice and continuous preventive maintenance programme.

Green buildings clearly require a well-developed, best-practices approach to FM. To achieve the high-performance potential of the building, the design, construction and commissioning process must connect to the FM department, whose financial and human resources realise that potential over the life of the building.

**ASSESSMENT OF THE O&M WORKFORCE**

Workforce assessment is part of a larger field of human resource development and is defined by established standards and guidelines for assessing personnel needs. Yet workforce assessment is also recognised as an important responsibility for the facility manager.

**Workforce  
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important  
responsibility of the  
facility manager**

For the purpose of this paper, this study focuses on the assessment of the O&M workforce to ascertain the department's capacity to operate and maintain green buildings in accordance with the owner's goals. Two assessment steps will be discussed, including competencies necessary for operating and maintaining green buildings and resources for greening the O&M workforce.

**Competencies for operating and maintaining green buildings**

The term competency is defined as 'an area of knowledge or skill that is critical for producing key products or services to others. They are internal capabilities that people bring to their jobs, capabilities which may be expressed in a broad, infinite array of on-the-job behaviours'.<sup>10</sup> The field of HR defines competencies in four broad categories — technical, business, interpersonal and intellectual — for all job positions from CEO to building custodian. The discussion of green buildings focuses on the technical competency area only and works to define a set of functional knowledge and skills necessary for operations and maintenance personnel including in-house staff and contractors.

The attributes of the best-practices operations discussed in the section above form the basis for identifying the technical competencies of O&M. It draws on research in persistence of benefits from building commissioning,<sup>11</sup> research on the benefits of trained building operators<sup>12</sup> and guidelines proposed in the LEED-EB standards.

From these data, the following competencies were compiled for operations and maintenance personnel.

*Competency: Familiarity with the building systems manual and baseline performance of the building*

The building systems manual is completed at the time the building is commissioned. It is a product of the commissioning project and includes the design intent, system descriptions, sequences of operation and a commissioning report. Building commissioning, including retrocommissioning, is a detailed analysis of a building's mechanical system, lighting and controls to ensure that the building operates at its design intent. Operators should be familiar with the building systems knowledge and documentation. Examples include knowing the location of HVAC and lighting system documentation, and keeping a maintenance log for HVAC equipment and lighting equipment.

*Strategies for developing this competency*

- Involve operators in the design phase of green building to prevent design problems that make the building difficult to operate and maintain over time. Facilities operators have experience working with systems, equipment and manufacturers that can be valuable to the design team. Systems and equipment that are easy to access and maintain by the operations staff have

**Involving facility engineers in the design process can result in better, more sustainable designs**

a greater likelihood of receiving proper care over their life. Building operators at the City of Seattle participated in the design process for a new City Hall, recently completed and applying for LEED Silver certification. Their participation enabled the design team to address green roof irrigation and maintenance issues early on in the process, which avoided costly mistakes. Involvement in the design phase also offers operators time to familiarise themselves with the building and lead time to prepare an O&M plan for new equipment and systems.

- Involve operators in new initiatives such as retrocommissioning, energy conservation and pollution prevention. New work assignments for operators such as assisting as a team member on commissioning projects and energy efficiency initiatives such as lighting system upgrades and building management systems can provide excellent learning opportunities for operating and maintaining the green building. O&M staff at Pacific Northwest National Laboratories (PNNL) in Richland, WA, partnered with building scientists to demonstrate and test innovative FM technologies.<sup>13</sup> Pairing operators with veteran operators or project consultants is another strategy for skill building and cross-training in the department. During the California energy crisis, PNNL staff paired with researchers to perform an assessment of load and energy reductions techniques (ALERT) which identify energy efficiencies at Federal facilities.

*Competency: Track building performance*

Operators should be able work from the documented baseline operation identified in the commissioning report to develop a method for tracking performance. Tracking should include consumption of energy, water and waste, followed by an analysis of monthly and annual trends. The analysis should provide operators with feedback on the performance of their buildings and identify opportunities for O&M improvements. LEED-EB calls for use of the US EPA's EnergyStar Portfolio Manager for tracking energy consumption. Other tracking tools, such as ISO 14001 Environmental Management cover water and resource consumption in addition to energy.

*Strategies for developing this competency*

- Explore department restructuring. Hiring or appointing an energy manager to track utility consumption can assist the facility manager with the tracking function. Alternatively, many Federal and military facilities such as Ft Lewis Army Base in Washington State and Camp Pendleton in California use Resource Efficiency Managers or Resource Conservation Managers (REM/RCM) to track consumption and identify opportunities for improving resource-efficient operations in the building. The REMs track utility bills and energy and water



consumption in the facility, with the goal of identifying efficiency improvements (including billing errors) substantial enough to pay for the REM's salary annually.

*Competency: Monitor and maintain equipment efficiency*

Operators should be able to perform diagnostic tests to ensure equipment is operating at designed efficiencies and to incorporate diagnostics into the PM plan. Examples include cleaning heating/cooling coils regularly, confirming economiser operation, detecting sensor failure and replacing as needed, repair gaskets on doors for air handler, check condition of dampers and seals regularly, and conduct preventive maintenance on the cooling tower.

*Competency: Optimise building and equipment operations*

No matter how well the building equipment is maintained, if it is operated poorly or operated when it could be shut down, the result is energy waste. Operators should be able periodically to check schedules to ensure that equipment is operating only as needed to fulfil its intended function and to diagnose operating problems by measuring and tracking the various parameters that indicate proper operation. For example, they should be able to review and determine that deadbands or lockout temperatures are properly set to keep cooling and heating from occurring simultaneously, and that sensors critical to efficient operation are calibrated more than once a year. They should record occupant complaints and comments and record new and changed control settings. They should provide supervisors with ideas for energy savings and comfort improvement opportunities.

*Competency: Specify energy and environmental goals with suppliers and contractors associated with the use of their products and services*

Equipment suppliers and contractors are an important part of the O&M team. Begin by sharing with them the company's green building performance goals. Explore with contractors how they might upgrade standard service contracts to move beyond basic maintenance and focus on optimising equipment operations and improving cleaning and maintenance practices. A consortium of electric utilities in the north-western USA is working with area contractors to offer customers a premium HVAC service for packaged rooftop units commonly found on commercial buildings. The service offers a beyond-basics maintenance contract, which promises energy savings of 10 per cent or more through economiser adjustments, thermostat resets to match building occupancy, sensor replacements, damper repair and more.

When working with contractors, it is important to establish clear lines of communication, review and document work, and conduct spot checks. The publication *O&M Service Contracts: Guidelines for Obtaining Best-practice Contracts for Commercial Buildings*<sup>14</sup> is an

**Service contractors  
are an important part  
of the facility  
management team**

excellent resource for the facilities manager (see Resources section below). Contract terms may want to reflect a set of green building performance expectations of the contractor.

*Competency: Familiarity with local utility energy and water efficiency programmes*

Facilities managers in most regions of the country will find excellent technical assistance and training resources through their local electric, gas and water utility companies. Utility conservation staff are well versed in new technologies and equipment such as high-efficiency lighting, heating and cooling systems. Many utilities also offer financial incentives — often 50 per cent or more of the cost to retrofit outdated equipment with new energy-efficient alternatives. For example, the University of Miami in Coral Gables, Florida, upgraded its chillers to high-efficiency units and installed variable speed pumping units; their electric utility paid for 61 per cent of the cost through grants and incentives. The efficiency improvements (and a rate adjustment) are saving the university an estimated \$800,000 annually. Finally, utilities may also be a resource for training on O&M of energy and water efficient equipment. In California alone, four utilities — Pacific Gas & Electric, Sacramento Municipal Utility District, Southern California Edison and Southern California Gas — each offer energy and technology training centres where customers can attend workshops and tour demonstration facilities with energy-efficient lighting, heating and cooling technologies.

**A commitment to professional development ensures staff have the skills to sustain building performance**

While improving the skills of the O&M workforce begins with an assessment of existing talent and expertise, the final outcome should be a professional development plan for each operator which provides the skills to perform best-practice O&M. Training and motivating building operators can reduce utility costs at facilities by at least 5–15 per cent.<sup>15</sup> Savings reported in a 1995 review of over 30 studies of O&M improvements ranged from 5 to 30 per cent. Building Operator Certification™ (BOC™), a growing national energy efficiency training and certification programme, is one means of providing this training. In a comparison of BOC-trained and non-trained operators, BOC-trained operators were 30 per cent more likely to engage energy efficiency practices and preventive maintenance.<sup>16</sup> Building operator certification is available in 17 states, with sponsorship from local electric and gas utilities.

Other training resources include seminars and conferences offered by the US Green Buildings Council, the US Department of Energy FEMP, US EPA EnergyStar, and through local energy and water utility training programmes. Topics of benefit to operators of green buildings should address the building diagnostics, fundamentals and advanced control systems, optimising operation of energy-intensive systems such as lighting and HVAC, and preventive maintenance.

Funds for training should be budgeted amply on an annual basis

## Training and other resources abound

to allow each operator to attend training during the year. If training budgets are limited, the resourceful facilities manager can explore training scholarships through their local utility, energy service provider (eg Energy Service Company (ESCO)), service contractor and through professional membership associations such as the IFMA.

### SUMMARY

The green building offers the potential for energy and resource efficiency, lower operating costs for owners and managers, and an indoor environment that enhances worker productivity and comfort. Research confirms that a skilled and motivated engineering staff can reduce utility costs by 15 per cent or more through adoption of practices that address both proper maintenance of equipment and effective building operation schedules. The FM department's approach to the operations and maintenance of the green building determines how and whether that potential is fully realised. A set of best-practices O&M activities is critical to maintaining the design intent of the green building. The facilities manager must approach this task with a thoughtful and strategic assessment of the workforce of the FM department and a commitment to an O&M approach which achieves the goals of the green building.

### Resources

The path to greening the O&M workforce begins with small steps and a host of resources for support. This paper has referenced a number of resources from best-practices lists to utility efficiency programmes to training and tools. Table 1 provides a summary of key resources for facilities managers ready to get to work.

**Table 1:** Resources for greening the facilities engineering group

Professional development and training for building engineers	Building Operator Certification™: <a href="http://www.theBOC.info">www.theBOC.info</a> BOMA's System Maintenance Administrator: <a href="http://www.bomi-edu.org">www.bomi-edu.org</a> Federal Energy Management Program O&M Management Workshops: <a href="http://www.eren.doe.gov/femp">www.eren.doe.gov/femp</a> Association of Energy Engineers: <a href="http://www.aeecenter.org">www.aeecenter.org</a> Energy Management Certificate Program: <a href="http://www.nweei.org">www.nweei.org</a> University of Wisconsin Extension Program: <a href="http://epdwww.engr.wisc.edu/">http://epdwww.engr.wisc.edu/</a> Texas A&M: <a href="http://www.tamu.edu">www.tamu.edu</a>
Utility efficiency programmes	Resource Efficiency Manager (REM): <a href="http://www.energy.wsu.edu/ten">www.energy.wsu.edu/ten</a> Northeast Energy Efficiency Partnerships: <a href="http://www.neep.org">www.neep.org</a> Northwest Energy Efficiency Alliance: <a href="http://www.nwalliance.org">www.nwalliance.org</a> Midwest Energy Efficiency Alliance: <a href="http://www.mwalliance.org">www.mwalliance.org</a> Local electric, gas, and water utility conservation offices
Guidelines and tools	LEED for Existing Buildings: <a href="http://www.usgbc.org">www.usgbc.org</a> US EPA EnergyStar Benchmarking Tool: <a href="http://www.energystar.gov">www.energystar.gov</a> PECI Best Practices Series: Fifteen O&M Best Practices, O&M Assessment, Service Contracts, Energy Management Systems: <a href="http://www.peci.org">www.peci.org</a> Advanced Building Guidelines: <a href="http://www.newbuildings.org">www.newbuildings.org</a>
Associations	Building Commissioning Association: <a href="http://www.bcxa.org">www.bcxa.org</a> Northwest Energy Efficiency Council: <a href="http://www.neec.net">www.neec.net</a>

## ACKNOWLEDGMENT

Portions of this paper were published in *World Workplace with Facilities America Conference Proceedings*, Vol. 2, printed in 2003 for the International Facility Management Association.

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