Early Lessons Learned from Building an ISO 50001: Conformant Energy Management System for MIT

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ABSTRACT

In July 2011, the International Organization for Standardization (ISO) released ISO 50001, *Energy Management Systems – Requirements with guidance for use*. This standard advocates continuous improvement of energy performance and provides requirements for an energy management system (EnMS) to achieve this continuous improvement. The Massachusetts Institute of Technology (MIT) has multiple initiatives on their Cambridge campus to improve building energy efficiency and minimize their carbon footprint. As such, MIT was keen to adopt ISO 50001. Due to the stochastic nature of energy performance on campuses, they decided to pilot EnMS implementation in a single building before committing to campus-wide deployment. MIT selected a laboratory building on their campus to ensure a rigorous test case. They are in the process of developing an EnMS for the building and selecting performance improvement measures. In this paper, we discuss the successes and challenges of implementing the ISO 50001 standard at MIT and present lessons learned thus far. We focus this paper on the process of developing the EnMS at MIT. Specifically, we discuss the role of the EnMS in revealing efficiency opportunities in the laboratory building. We also provide recommendations for future whole-campus ISO 50001 implementation at MIT and other campuses.

Introduction

Carbon neutrality goals and sustainability goals for college and university campuses have spurred an interest in reducing energy consumption in buildings. Traditionally, reducing energy consumption in buildings translated into making a lighting retrofit, (re-) commissioning the building heating-ventilation-air conditioning (HVAC) system, or implementing other efficiency measures (Brase 2010). However, to achieve neutrality goals, incremental improvements will not be enough. Rather, focus must shift to proactive, real-time energy management.

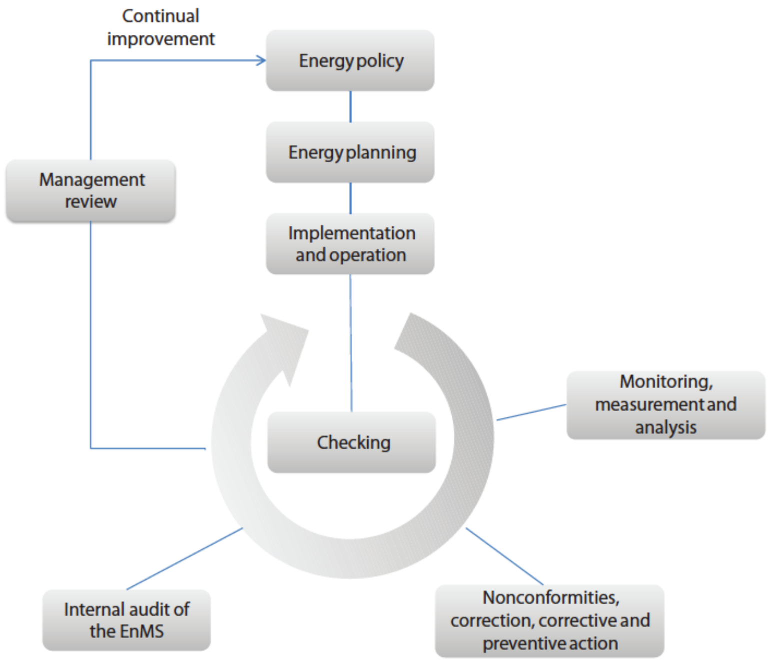
Commercial Building Energy Management Standards

Buildings account for approximately one-third of the primary energy consumption in the United States (DOE 2010). Other developed countries report similar statistics (European Commission 2010; Fridley et al. 2007). To address building energy consumption, various policies have emerged to manage energy consumption in buildings, ranging from voluntary rating systems (e.g., LEED) to mandatory labeling programs (European Union 2002). While these programs motivate energy efficiency in the commercial buildings sector, they do not necessarily provide a means for achieving energy efficiency. By contrast, energy management standards provide a roadmap for continually improving energy performance.

We present here the concept of the plan-do-check-act cycle (Deming 1986; Deming 2000; Shewhart 1939) that underpins the ISO 50001 standard, as well as its precursors, EN

16001, *Energy Management Systems* (European Committee for Standardization 2009) and IS 393 *Energy Management Systems Standard* (NSAI 2005). The plan-do-check-act cycle assures continuous improvement through defining and testing possible energy-savings measures to determine their impacts (Deming 2000). Figure 1 illustrates how plan-do-check-act applies to energy management. The energy policy provides a mission the organization can align around and may provide a goal that in turn motivates the energy planning, doing, checking, and acting. We describe the specific steps of building and implementing an EnMS in the following sections.

Figure 1. Plan-Do-Check-Act Management System



Source: ISO 2011

Energy Management at the Massachusetts Institute of Technology (MIT)

The Massachusetts Institute of Technology (MIT) Cambridge campus comprises more than 12 million square feet that includes approximately 158 buildings ranging in age from less than 2 years old to 130 years old. Energy efficiency in these buildings is a priority for MIT as part of the campus' sustainability commitment. Efficiency commitments include signing a partnership with their local gas and electricity utility, NSTAR (MIT 2012b); participating in the U.S. Department of Energy's Commercial Building Partnerships Program (U.S. Department of Energy 2011); and implementing their Building Energy Efficiency Program (MIT 2012a). MIT's partnership with NSTAR, the MIT Efficiency Forward Program, is a three-year, $13 million effort to reduce electrical consumption on the Cambridge campus by 34 million kilowatt hours, or approximately 15% of MIT's electricity consumption (MIT 2012b). MIT's involvement in the Commercial Building Partnerships Program requires MIT "retrofit two or more building systems…to achieve significant energy savings" (U.S. Department of Energy 2010). This includes work on a lighting retrofit and developing new campus standards for data center operation. Finally, the Building Energy Efficiency Program focuses exclusively on retrofits in existing buildings, with projects ranging from chilled water projects to lighting retrofits (MIT 2012a). While each of these programs is saving energy, they represent a *project-based approach* to energy management that focuses on energy savings for a given project after the project is selected. By contrast, the ISO 50001 implements a *management-system approach* that requires organizations think holistically about energy and make decisions based on organization-wide energy goals and priorities. Organizations desiring to take a management system approach to energy require an EnMS, as described in the following section.

What is an EnMS?

ISO 50001 defines an energy management system as "a set of interrelated or interacting elements to establish an energy policy and energy objectives, and processes and procedures to achieve those objectives" (2011). More specifically, ISO (2011) requires the following elements as part of the EnMS: (1) management responsibility, (2) an energy policy, (3) an energy planning process ("plan"), (4) an implementation plan ("do"), (5) an evaluation ("check"), and (6) a management review ("act"). We describe each of these in more detail below. Note ISO 50001 does not prescribe exactly *how* the EnMS will address these six elements. The non-prescriptive nature allows users to modify their existing processes to achieve continuous improvement.

Management Responsibility

ISO 50001 requires management responsibility to ensure that management of an organization supports the EnMS and thus, provides resources to ensure continuous improvement of energy performance. Specifically, the standard requires Top Management (who may be one person or a team of people) and a Management Representative be identified. The Top Management is expected to define (or at a minimum, endorse and enforce) the energy policy and provide resources and support to ensure successful implementation of the EnMS (ISO 2011). The Management Representative, named by Top Management, is responsible for developing and interacting with an energy team to support the development and implementation of the EnMS.

Energy Policy

The energy policy articulates the energy goals for an organization and provides the basis for the EnMS, as later sections focus on how to achieve the goals outlined in the energy policy. Among other requirements, ISO 50001 (2011) requires the energy policy include certain commitments. Namely, the energy policy must include commitments to:

- Continual improvement in energy performance
- Ensuring availability of information and resources to achieve objectives and targets
- Comply with applicable legal and other requirements to which the organization subscribes related to its energy use, consumption and efficiency

Energy Planning Process

The energy planning process requires the Management Representative and energy team develop a plan to achieve the goals articulated in the energy policy. Activities include:

- Setting a scope and a boundary for the EnMS
- Understanding past and present energy consumption (i.e., how much energy is used) and use (i.e., how the energy is used)
- Identifying significant energy uses
- Developing a set of energy efficiency measures that could reduce the energy consumption of these significant energy uses
- Developing an energy baseline
- Developing a set of energy performance indicators that can be used to assess the effectiveness of the energy efficiency measures
- Developing objectives and targets for the organization that support the energy policy
- Developing action plans to achieve the objectives and targets

Energy planning is critical to the EnMS as it grounds the system and ensures that the organization understands current consumption. Moreover, it is during this phase that the energy team develops plans for improving energy performance.

Implementation Plan

The implementation plan is the "Do" portion of the plan-do-check-act cycle. During this phase of EnMS implementation, organizations train building users or make them aware of the impact of their actions on the significant energy uses identified during energy planning. Moreover, organizations develop communication plans to inform members of the organization about their EnMS and energy performance. Organizations may opt to develop external communication plans as well. During this implementation phase, organizations also put (new) operational controls, design, and procurement procedures in place to ensure energy efficient design and operations of the building(s). Finally, the implementation plan requires the organization document how each of the elements of the energy plan was implemented.

EnMS Evaluation

This evaluation phase allows the organization to check that the EnMS implemented is supporting the energy policy and ensure that the energy performance indicators are measured and objectives and targets (developed during energy planning) are met. The organization can also conduct an internal audit of the EnMS during this phase to ensure the management system is compliant with organizational and other goals and targets. Finally, this is the phase where organizations may opt to make revisions to their EnMS, especially if elements of the EnMS are found to be non-conformant. The organization should document the results of the evaluation, just as they documented the implementation of the EnMS.

Management Review

The management review provides an opportunity for Top Management to make changes to the EnMS to ensure that the EnMS supports the company's energy goals and other organizational values. This review often takes the form of a briefing meeting where Top

Management is presented with the EnMS documents for review and the energy team or Management Representative presents the energy savings resulting from EnMS implementation.

Developing an EnMS at MIT

In previous sections, we introduced the elements of an EnMS. In the following sections, we shift our focus from the general case of developing an EnMS to the specific case of developing an EnMS for MIT. At the time of this publication, MIT is completing the Energy Planning activities. The energy team at MIT has also drafted some of the implementation plans for their EnMS. In the following subsections, we describe how MIT developed specific elements of their EnMS. Note these elements did not necessarily proceed in the order outlined above; rather, they proceeded in a chronology that fit within MIT's existing business practices.

Scope and Boundary

MIT's first step in building their EnMS was to select a scope and a boundary for the EnMS. They quickly determined they would be certifying a single building. Thus, for the scope (essentially the activities and decision-making encompassed within the EnMS) and the boundaries (physical limits of the EnMS), they selected the activities within the building and the physical building, excepting energy for transportation of people and goods to and from the building, as their scope and boundary, respectively. MIT considered two buildings, a chemistry lab building and a materials science laboratory building. Initially, the MIT team favored the chemistry lab building because it was due for renovation, and thus, energy savings were nearly guaranteed. However, the scale of that renovation was large, which increased the duration of the project, and thus, increased the time required to implement the EnMS (specifically the energy savings measures) and become ISO certified. By contrast, the materials science lab building, Building 13, needed relatively less renovation, and therefore could be certified sooner. Figure 2 shows a photograph of Building 13. Building 13 is approximately 183,000 square feet, and houses labs for materials science, physics, and electrical engineering, as well as teaching laboratory and office spaces.

Management Responsibility

Once the scope of the EnMS was determined, MIT was able to select the appropriate Top Management and Management Representative. Given the scope and boundary of the EnMS is a single building, Top Management could consist of Directors of the MIT Department of Facilities as the Department has control of human and financial resources required to implement the EnMS at the single-building level. Had the scope of the EnMS been larger, the Top Management may have also included members of the MIT administration. Once the Top Management was determined, it was easy to select a Management Representative based on current reporting structures within the MIT Department of Facilities. For Building 13, the Director of Commissioning and MEP Turnover was deemed the appropriate Management Representative. Finally, MIT needed to select an energy team for the EnMS. They opted to use their existing energy team, consisting of construction project managers, LEED coordinators, and Sustainability Managers, for their EnMS to minimize re-structuring. This decision has proved fruitful, as the energy team is already responsible for energy management on the campus, so EnMS development is more focused on codifying the energy team's current activities than on developing new processes for ISO 50001 certification.

Figure 2. Views of the MIT Materials Science Building, Building 13, which MIT plans to have ISO 50001 Certified

Source: http://authors.library.caltech.edu/5456/1/hrst.mit.edu/hrs/materials/public/Simha/Simha.htm

Legal and Other Requirements

ISO 50001 (2011) requires organizations identify legal and other requirements that impact energy consumption and use. As a part of the EnMS, these requirements guide the scope and selection of potential energy savings measures. At MIT, the legal requirements include all building codes that impact energy consumption. The "other" requirements include the MIT-NSTAR partnership (MIT 2012b) as well as sustainability goals for the campus (MIT Green Building Task Force 2001).

Energy Policy

Drafting an energy policy for MIT was challenging because of the organizational structure of the institute. The involvement of different administrative bodies, required to be a part of the submission and review process of campus wide policies, could extend the timing for approval well beyond the timeframe established for this pilot. Originally, MIT intended to use their Environmental Goals (MIT Green Building Task Force 2001) as their energy policy. However, ISO 50001 (2011) requires commitments in the energy policy, and the Environmental Goals (U.S. Department of Energy 2011) do not express commitments, per se, they express long-range goals that may guide campus planning. MIT wanted their policy to reflect the commitments they were making for Building 13, so they drafted an original energy policy that makes clear commitments to the tenets described above. Further, the policy includes a provision for annual review and revision to ensure that it remains current and relevant. Finally, MIT opted to write their energy policy in such a way that it could be applicable to the entire campus rather than focusing on a single building to facilitate future whole-campus ISO 50001 certification.

Energy Review

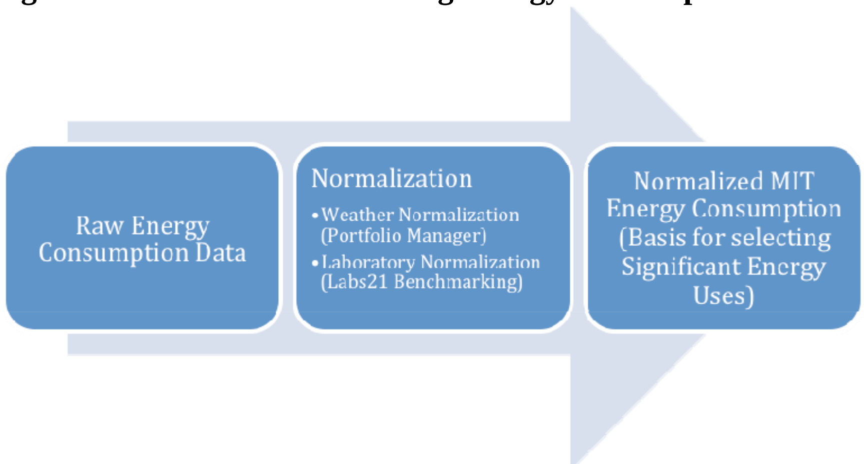
After completing the energy policy, MIT began work on their energy review. The energy review comprises three elements: (1) an analysis of energy consumption and use, (2) identification of significant energy uses, and (3) identification, prioritization, and recording of opportunities for improving energy performance. MIT chose to hire a third-party consultant to help with their energy review due to resource constraints internally. We describe MIT's progress on each of these in the following sections and highlight the roles of MIT and their consultant.

Understanding past and present energy consumption and use. The first step in the energy review is to understand past and present energy consumption and use for each energy source to understand the baseline performance. MIT tracks energy consumption by building as part of the campus accounting system, which tracks the fraction of campus consumption that each building used in a given billing cycle based on automated meter reading and square footage. That is, if the consumption in Building 13 was 5% of the campus energy consumption, then the accounting system attributes for 5% of the energy bill to Building 13. Note Building 13 consumes chilled water, steam, and electricity, each of which is tracked in the campus accounting system. While understanding past and present consumption was straightforward, understanding how energy is used within the building is more difficult. MIT opted to have their energy consultant set up trend logs to understand how energy is used.

Identifying significant energy uses. Once consumption and use are understood, MIT will work with their consultant to identify the significant energy uses in their building. MIT anticipates ventilation energy will be a significant energy use due to high laboratory ventilation requirements (relative to other building types). However, to understand how the ventilation energy in Building 13 compares to that of similar laboratories, MIT uses the DOE/EPA Labs21 tools (Mathew et al. 2004) to help identify significant energy uses for Building 13 compared to other laboratory buildings. Moreover, MIT would like to weather normalize their energy consumption and use when selecting significant energy uses to ensure that large energy consumption for certain uses is not a result of varying weather conditions. For instance, if heating energy in January is higher than in February, MIT will weather normalize to ensure that this is not simply a result of January being much colder than February. **Figure 3** illustrates MIT's process for normalizing their energy consumption. They use ENERGY STAR Portfolio Manager (EPA 2011) to weather-normalize their data to account for weather effects in consumption. They use Labs21 (Mathew et al. 2004) to account for laboratory effects in consumption. MIT does not routinely normalize when analyzing their energy performance. However, since the significant energy uses provide the base for the EnMS (which essentially manages these uses), MIT opted to normalize their performance data before selecting significant energy uses. MIT selected Portfolio Manager for weather normalization rather than another approach (e.g., (Lambert 1998) because Portfolio Manager is easy to use and requires monthly utility bill inputs that MIT had immediate access to. Based on the consultant's preliminary report, lab equipment and ventilation are the significant energy uses in Building 13.

Identification, prioritization, and recording of performance improvement opportunities. At the time of this publication, MIT was just beginning to identify performance improvement opportunities. Preliminary efficiency measures being considered are a fume hood sash management program and (as yet undefined) improvements to the ventilation system to address the significant energy uses identified in the previous section. MIT is targeting a 12-15% reduction in whole-building energy consumption (compared to a 2010 energy consumption baseline) from implementation of these measures.

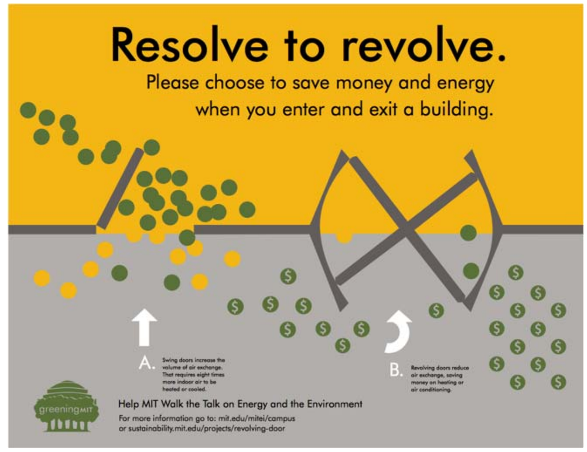
Figure 3. Process for Normalizing Energy Consumption at MIT



Developing a Communication Plan

While the previous sections described activities in the energy planning process, this section describes developing the communication plan, which is an implementation activity. The communication plan documents how the EnMS will be communicated to internal and external audiences. At MIT, this required thinking about how to communicate to the students, faculty, and staff internally as well as various audiences externally. MIT approached internal communication first, understanding why they are communicating with their audience, what they are communicating, and how they will communicate with each audience. One element of the internal communication plan is raising awareness about how the audiences' actions impact significant energy uses. For this, MIT plans to leverage their existing energy awareness campaign, the Behavior Change Projects (Craven 2009), funded through BEEP (MIT 2012a). Figure 4 shows posters from existing awareness (left) and outreach (right) campaigns.

Figure 4. Energy Awareness Posters at MIT



Sources (left; right): sustainability.mit.edu; Craven (2009)

Suggestions for Broader Implementation at MIT

MIT is developing the EnMS described in this paper for Building 13. However, the organizational elements of the EnMS will be applicable across the campus, which reduces the additional effort that will be required to achieve full-campus ISO certification. One remaining question is how to create campus-wide documents that pertain to energy consumption and use. For example, what does an energy review look like for a whole campus? Would significant energy uses be across the campus or in specific buildings? Looking forward, MIT plans to assess energy consumption across campus (using their current metering infrastructure and accounting system) and treat those buildings that consume most energy as their significant energy uses. MIT will then focus on managing energy consumption in these buildings. University College Cork (UCC) in Ireland was the first campus to achieve ISO 50001 certification (UCC 2011). The energy management team at UCC used automated energy performance tracking software to aid in their campus energy review and this technique shows promise for the MIT stock as well. Going forward, MIT will continue to update and revise their EnMS to make it as effective as possible for managing energy on their campus. Though they have not yet determined how they will evaluate the effectiveness of their EnMS, early discussions indicate the primary metric in this evaluation will be energy savings (at the whole-building level) in those buildings identified as significant energy uses. As energy performance continues to improve, the EnMS may be evaluated for its contribution to better understanding energy performance on campus (from, e.g., installing more submetering) rather than from energy savings attributable to the EnMS. However, in the near term, the campus expects EnMS implementation will lead to measurable energy savings that will illustrate its effectiveness.

Suggestions for ISO 50001 Implementation on Other Campuses

At the time of this publication, MIT has been developing their EnMS for fourteen months and has spent approximately six person-months on this development effort. This development process has been enlightening for them about their energy consumption, use, and organizational structure. Though we could present many lessons, we focus here on those that could apply to other campuses or commercial buildings seeking ISO 50001 certification.

Documentation is Important!

It seems obvious that documenting the steps of building the EnMS is important. However, what may be less obvious from reading the standard is that each (sub) section of the standard requires **two** documents. The first documents the procedure, and serves as an instruction manual for future EnMS implementation. The second documents the execution of the procedure for the scope and boundary. For example, the Legal and Other Requirements documentation includes both a procedure for finding relevant requirements and a list of those requirements that impact the Building 13 project.

Engaging the Right Stakeholders is Critical to EnMS Success

ISO 50001 requires a commitment to continuous improvement of energy performance, but it also requires support of energy-efficient product procurement, training building users, and communication with internal and external audiences, to name a few. Not all of these tasks fall within the core competencies of the energy team, so engaging other stakeholders in the organization is very helpful for developing and implementing the EnMS. The authors recommend integrating stakeholders who are already involved in (and have expertise in) energy management, outreach and communications, and training into the EnMS development team. Not only does this approach provide a breadth and depth of expertise, it also leverages existing efforts within an organization, which in turn reduces the effort required for ISO 50001 certification, as an organization does not have to develop each EnMS element from scratch. Moreover, engaging the correct stakeholders increases the likelihood that they will use the EnMS, which will make the EnMS more likely to be certified, but more importantly, it makes the EnMS more effective for the organization.

Plan-Do-Check-Act is More Complicated than it Sounds

In concept, plan-do-check-act is intuitive; it mirrors the scientific process and it "just makes sense." However, in implementation, this can be challenging, especially in the commercial buildings sector, where plan-do-check-act is not necessarily part of everyday operations. ISO 50001 may require more effort in the planning phase than commercial building operators may be accustomed to thinking of when they hear "plan."

Conclusions

MIT elected to be an early adopter of ISO 50001 and amplified their existing commitments to environmental stewardship by committing to continuous improvement of energy performance. As part of this commitment, they are developing an energy management system to understand how and where energy is consumed and used on campus and create a process to make continuous improvement in building energy performance. Their experience highlights the need for stakeholder engagement and clear goal setting when creating energy management systems for commercial buildings. Further, the MIT experience underlines the effectiveness of applying the plan-do-check-act cycle to energy performance, despite the potential difficulties of adjusting to this context for evaluating energy performance.

As ISO 50001 penetrates the commercial buildings market, we expect more building owners to adopt this standard and seek certification, as it provides a methodology for achieving continuous improvement in energy performance, which many owners already state as a goal. Large-portfolio owners, in particular, will benefit from adopting an energy management system for the entirety of their portfolio to target significant energy uses throughout their building stock and develop a system for identifying and prioritizing energy savings measures. Moreover, this system will promote continuity in the organization's approach to energy management that in turn supports continuous improvement in energy performance.

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