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Towards an energy management maturity model

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HIGHLIGHTS

- Real-world energy management activities are not aligned with the literature.
- An Energy Management Maturity Model is proposed to overcome this alignment gap.
- The completeness and relevance of proposed model are validated.

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ABSTRACT

Energy management is becoming a priority as organizations strive to reduce energy costs, conform to regulatory requirements, and improve their corporate image. Despite the upsurge of interest in energy management standards, a gap persists between energy management literature and current implementation practices. This gap can be traced to the lack of an incremental improvement roadmap. In this paper we propose an Energy Management Maturity Model that can be used to guide organizations in their energy management implementation efforts to incrementally achieve compliance with energy management standards such as ISO 50001. The proposed maturity model is inspired on the Plan-Do-Check-Act cycle approach for continual improvement, and covers well-understood fundamental energy management activities common across energy management texts. The completeness of our proposal is then evaluated by establishing an ontology mapping against ISO 50001.

1. Introduction

Energy management has been defined as the systematic use of management and technology to improve an organization's energy performance (CarbonTrust, 2011) or, in academic research, as the control, monitoring and improvement activities for energy efficiency (Bunse et al., 2011). Regardless of definition, the topic has become of utmost importance for organizations worldwide, many of which are currently deploying energy management solutions to improve their energy use, to comply with legislation, energy standards and their requirements, and to enhance the organization's reputation among customers. By implementing energy management programs, organizations can save up to 20% on their energy bill, and can also achieve savings up to 5%–10% with minimal investment, effectively cutting operational costs (CarbonTrust, 2011).

Energy management and its associated practices vary greatly mainly because there is no well-understood energy management model, as evidenced by the disparity in the reviewed literature. As will be clear later, despite the existence of several guides to assist companies in implementing energy management activities (CarbonTrust, 2011; Sustainable Energy Ireland, 2008), case-studies show that real-world implementations of energy management programs fail to cover the breadth of energy activities defined in these guides (Gonzalez et al., 2012; Coppinger, 2010). In summary, there is a gap between theory and real-world implementation practices of energy management that needs to be closed.

This paper proposes and conducts a preliminary evaluation of an Energy Management Maturity Model, meant for energy managers in all kinds of organizations, that organizes the essential energy management activities across five maturity levels, therefore contributing to bridge the gap between theory and real-world practice. Overall, for an organization, an Energy Management Maturity Model will: (i) structure and improve the understanding

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of energy management practices, (ii) provide a roadmap towards continuous improvement, (iii) provide an understanding of the steps required towards successful energy management, (iv) enable benchmarking the current energy practices against other organizations, and (v) guide investment efforts.

According to the International Organization for Standardization (ISO), Energy Management stands out as one of the top five areas that require the development and promotion of international standards. The adoption of a standard, such as the ISO 50001, increases energy efficiency by more than 20% in industrial facilities (Piñero, 2009). To further emphasize the relevance of this topic, a study made by Lawrence Berkeley National Labs about energy efficiency projects in the United States concluded that the total project spending in energy service companies, from 1990 to 2000, increased from US$500 million to US$2 billion (Van Gorp, 2004).

Another study has identified that, out of the 3749 respondents, 85% state that energy management was very important to their organizations and 63% have actually invested in energy efficiency projects (IBE, 2012). Regarding legislation, for example, the EU has also established an energy improvement target of 20% by 2020 (Wesselink et al., 2010).

Energy efficiency can be improved through investments in energy technologies and promoting energy management practices (Backlund et al., 2012). While energy management shares some common practices across the literature, there is still a great diversity in these practices: some activities are neglected while others are more common. For example, existing solutions for measurement, analysis and control of energy do not address all the requirements of energy management at the organization or process level because they do not adequately develop workforce awareness of the energy used in their business (Vikhorev et al., 2012). Some common energy management activities include ensuring management commitment, appointing individuals or teams responsible for energy management, defining energy policies and action plans, as well as reviewing implemented measures by management, or metering of energy use.

In an analysis of the Swedish industrial energy efficiency programs (Thollander et al., 2007), energy audits allow a potential energy performance increase between 16 and 40% and an electricity savings potential between 20 and 60%, and have been identified as very important for the identification and implementation of cost-effective energy-efficiency opportunities (Shen et al., 2012).

The approaches taken to implement such activities can vary greatly in terms of practices and technological sophistication: an organization might use energy-saving practices based on the experience of the facility manager and/or users, while another may employ a computerized Energy Management System, which is by definition a management system that provides a framework for managing and continually improving organizational policies, processes and procedures (Hipkiss, 2011). However, the use of these energy management systems is not a very commonly adopted practice (Molla et al., 2012).

On one hand, the recently published ISO 50001 standard (ISO, 2011) enables organizations to establish energy management systems and processes necessary for energy performance improvement to reduce energy costs, greenhouse emissions and other environmental impacts. However, standards such as IS393 (SEAI, 2006), ANSI/MSE 2000 (ANSI, 2008), BS EN 16001 (BSi, 2009), and more recently ISO 50001 only define the requirements for organizations to establish, maintain, implement and improve energy management systems. These standards do not provide organizations with a model to assess their current situation against other organizations, except for a final certification, or allow them to plan their energy management implementation in an incremental way along an established improvement roadmap.

On the other hand, maturity models have been extensively studied and utilized in multiple engineering domains as an instrument for continuous improvement (Wendler, 2012). Following the success of the Capability Maturity Model (CMM) for Software (Paulk et al., 1993), there has been significant interest in this field across multiple areas, both from an academic and professional point of view. CMM has evolved into the Capability Maturity Model Integration (CMMI) with three separate models—CMMI-SVC, CMMI-DEV and CMMI-ACQ (CMMI Product Team, 2010b, 2010a; SEI, 2010), for providing services, product and service development, and product and service acquisition, respectively—that have been adopted by thousands of organizations worldwide.

Maturity models can be used as a tool to assess the as-is situation of a company, derive and rank improvement measures, and control implementation progress (De Bruin et al., 2005). They consist of a sequence of maturity levels that represent a desired organizational evolution path, in which the initial maturity level represents a state that can be characterized by an organization having few capabilities in the chosen domain, while the highest maturity level represents a stage of total maturity (Becker et al., 2009). Maturity, in this case, can be defined as a metric to evaluate capabilities of an organization regarding a certain discipline. Advancing through this evolution path indicates that organizations are improving their capabilities step by step (Becker et al., 2010).

According to a recent survey on maturity models, out of the 237 studied articles, only 3 efforts focused on the topic of sustainability (Wendler, 2012), showing that research regarding maturity models in the energy field is still at its inception. Up to now, no maturity model has been created specifically for energy management. However, maturity models have been created for Smart Grid implementation (SGMM Team, 2011) and for data center efficiency (Curry et al., 2012), which are related to this topic.

Furthermore, the approach taken by international standards is different from the approach taken by maturity models. In order to reach compliance with a standard such as ISO 50001, organizations need to show evidence about every single defined requirement, in the form of a final certification. Maturity models have the same ultimate goal of process improvement but they establish several levels of organizational maturity as organizations increase their improvement efforts and implement the required processes at their own pace, providing them with an implementation roadmap not included in ISO standards.

This paper starts by performing a literature review of several sources related to energy management (such as energy management systems, energy guides, and case studies), and also of sources related to maturity models. This literature review is then followed by a comparative analysis contrasting the current state of energy management in organizations, obtained from case studies, energy management guides and other energy management articles. This analysis then sustains the identification of a set of energy management activities that will be the basis for the proposed maturity model. The model is then evaluated for completeness by performing an ontology mapping to the requirements of ISO 50001 using Wand and Weber's method to identify ontological deficiencies.

2. Energy management

The literature of interest identifying the significant activities in energy management comprises good practice guides for energy management, scientific articles, and texts covering energy management systems. The most relevant literature related to maturity models, some related to the topic of energy management, is also analyzed in this section.