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# The Evolution Of Organizational Energy Management: Developed Methodologies And The ISO 50001 Standard

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***Abstract:***
*This article presents the evolution of practices and procedures developed and applied in energy management in organizational environments. The global evolution of energy management and the evolution of guidelines applied in organizational energy management are discussed, which were consolidated in norms and standards, whose peak was reached with the international standard ISO 50001. This article reviews the published works that bring with them some contribution related to the methods developed and applied in conducting the process of implementing an energy management system, where the implementation of the ISO 50001 standard stood out, mainly in industrial environments. In all the works reviewed, it is clear that the success in implementing energy management through the ISO 50001 standard was achieved due to the continuous support of the organization's top management and the involvement and commitment of all members of the organization.*
***Key Word:*** *Energy Management System; ISO 50001; organization; evolution; methods.*

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## I. Introduction

The emergence energy conservation concept is relatively recent in modern energy history, gaining prominence after the oil crisis in the 1970s, following the rise in energy prices worldwide, and consequent energy shortages, especially in countries heavily dependent on oil, followed by serious economic instability [1]. Since then, the use of energy resources has become a matter of international discussion, and there has been a growing demand for energy alternatives for domestic supply and a consequent reduction in dependence on foreign oil. Since then, the use of energy resources has become a matter of international discussion, and there has been a growing demand for energy alternatives for domestic supply and a consequent reduction in dependence on foreign oil. Added to these factors is the need for environmental protection, by reducing air pollution, water pollution and greenhouse gas emissions, and more recently the need to expand and create jobs associated with new energy alternatives [2]. It was in this context that countries diversified their energy matrices by exploiting renewable energies and adopting energy conservation measures in end uses, thus leveraging energy planning and management actions.

Energy management, as a separate discipline, really began to evolve after the first oil crisis, when real energy prices rose dramatically [3]. Energy management was first introduced through energy conservation actions characterized by reducing or even restricting energy consumption and later evolved into the concept of energy efficiency, which means "reducing the amount of energy needed to provide the same services" [4]. More than forty years on, it is now possible to classify the evolution of modern energy management through the various phases it has gone through. There are six distinct phases in the evolution of energy management. The periods relating to each phase are presented with approximate dates, where there was a natural evolution of techniques and approaches [3], however, there was no sudden transition between one phase and another, the process took place gradually. The evolution of energy management can be divided into the 6 phases shown below:
Phase 1: 1973 - 1981: energy conservation phase.
Phase 2: 1981 - 1993: energy management phase.
Phase 3: 1993 - 2000: energy procurement phase
Phase 4: 2000 - 2010: carbon reduction phase
Phase 5: 2010 - 2020: energy efficiency phase
Phase 6: 2020 - Current: contemporary phase and future expectations.

Although geopolitics may change the current energy scenario, there is a natural trend towards improving energy efficiency and the use of clean technologies, associated with the implementation of management procedures for processes involving energy.

## II. The Emergence And Consolidation Of Energy Management Standardization

In response to the oil crisis, legal mechanisms were created to encourage energy conservation with the aim of reducing consumption and the associated greenhouse gas emissions. The United States, for example, formulated the first national energy efficiency regulations in the 1970s [2]. The European Union also began to formulate its legal instruments at the same time, setting targets for reducing energy demand and pollutant emissions in its member states [1]. These political instruments and government programs that have emerged in various countries have historically been important drivers of the first energy management actions by demand side. Over the years, these actions have evolved within corporate environments into what is now known as organizational energy management.

Therefore, with the emerging demand for the management of energy resources in internal organizational environments, the need arose to systematize this process, through standards with clear guidelines to guide the process of implementing and maintaining energy management. This has happened through the development of various norms and technical standards for energy management.

A norm or standard is nothing more than a document based on the consolidated results of science, technology and experience, designed to provide the best benefits to the community [5]. Therefore, energy management standards follow this concept in proposing Energy Management Systems (EMS). A distinct and organized EMS includes modelling, forecasting, benchmarking, analysis of energy use and costs, measurement and verification of all stages of this process [6]. It is important to note that the term "energy management systems" (EnMS) are purely managerial systems and should be distinguished from building energy management systems (BEMS), that are based on a set of applicable technologies whose purpose is to manage, monitor and control energy use. Thus, BEMS systems are an integral part of the solutions applied by EnMS systems. Energy management standards have been developed since the 1990s, such as the Australian standard AS 3596-1992 Guidelines for definition and analysis of energy and cost savings [7]. This standard is aimed at commercial and industrial organizations and provides guidance on obtaining and analyzing energy data, cost forecasting and financial evaluation of energy efficiency actions, as well as highlighting the need to record data and adjust the actions taken.

From the year 2000 onwards, the energy management standards drawn up present a systematized structure for their implementation, through a process of continuous improvement that begins with the commitment of the organization's top management and closes with a review of the tasks carried out and the results obtained by the organization, as well as proposals for improvement. The main modern standards designed to guide the implementation of an Energy Management System are as follows [8]:

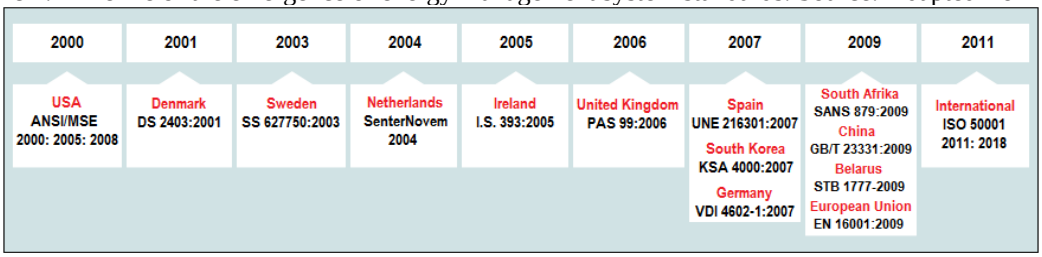
- ANSI/MSE:2000-2005-2008 - A Management System for Energy (EUA).
- DS 2403:2001 - Energy Management System (Denmark).
- SS 627750:2003 - Energy Management System (Sweden).
- SenterNovem:2004 - Energy Management Specification (Netherlands).
- IS 393:2005 - Energy Management System (Ireland).
- PAS 99:2006 - Integrated Management System (United Kingdom).
- UNE 216301:2007 – Sistema de Gestión Energéticia (Spain).
- VDI 4602-1:2007 - Energy management - Fundamentals (Germany).
- KSA 400:2007 - Energy Management (South Korea).
- SANS 879:2009 - Energy Management – Specifications (South Africa).
- GB/T 23331:2009 - Energy Management System Requirements (China).
- STB 1777-2009 - Energy efficiency systems (Belarus).
- EN 16001:2009 - European Energy Management Standard (European Union).
- ISO 50001:2011-2018 - Energy Management Systems (International).

The first known technical standard drawn up with a proposal to systematize energy management was the ANSI/MSE 2000 standard - A Management System for Energy, developed by the American National Standards Institute - ANSI in partnership with the Georgia Tech Energy and Environmental Management Center in the United States. This standard provides the necessary elements to help organizations achieve management with sustainable improvements in energy efficiency [9]. This normative standard was updated in 2005 and 2008, proposing a systematized approach to corporate energy management in the United States. In Europe, Denmark is considered a pioneer in this field, because through a joint initiative by the Confederation of Danish Industries, the Danish Energy Agency and various scientific establishments, it became feasible to draw up the first national energy management standard, presented in 2001 [10].

Other countries also felt the need to draw up a national standard for energy management, so in 2003 came Sweden's standard for systematizing energy management. In the following years, countries such as the Netherlands, Ireland, the United Kingdom, Spain, Germany, South Korea, South Africa, China and Belarus also drew up their own standards (Figure 1), with the aim of meeting their national demands for standardization of

corporate energy management. Figure 1 shows various energy management standards for use in different countries. Although there have been attempts to develop a joint system for energy management [11], the development of a common standard for multinational application only became possible with the creation of a working group of the European Committee for Standardization (CEN), which drew up the single European standard for energy management, EN 16001:2009 - European Energy Management Standard. This standard has favored the certification of European companies to a single European standard. Other countries outside Europe have also drawn up their own national standards for energy management (South Korea, 2007; South Africa, 2009; China, 2009), all with a similar approach to the European standard EN 16001:2009 and the American standard ANSI/MSE:200:2008 [10].

**Figure 1**: Timeline of the emergence of energy management system standards. Source: Adapted from [10].




Source: Adapted from [10], 2012.

Through joint efforts between the International Organization for Standardization (ISO), the European Committee for Standardization (CEN), together with the collaboration of others national standardization organizations such as the American National Standards Institute (ANSI) and the Brazilian Association of Technical Standards (ABNT), it became possible to draw up a global energy management standard that was launched in June 2011. This is the international standard ISO 50001:2011 - Energy Management Systems, whose basic structure was drawn up from elements of the American standard, ANSI/MSE: 2008, the European standard, EN 16001:2009 and elements of other recognized national standards [10]. Since then, multinational companies with facilities in several countries have been able to apply the same ISO 50001 energy management system to all their plants in any country.

## III. The International Energy Management Standard – ISO 50001

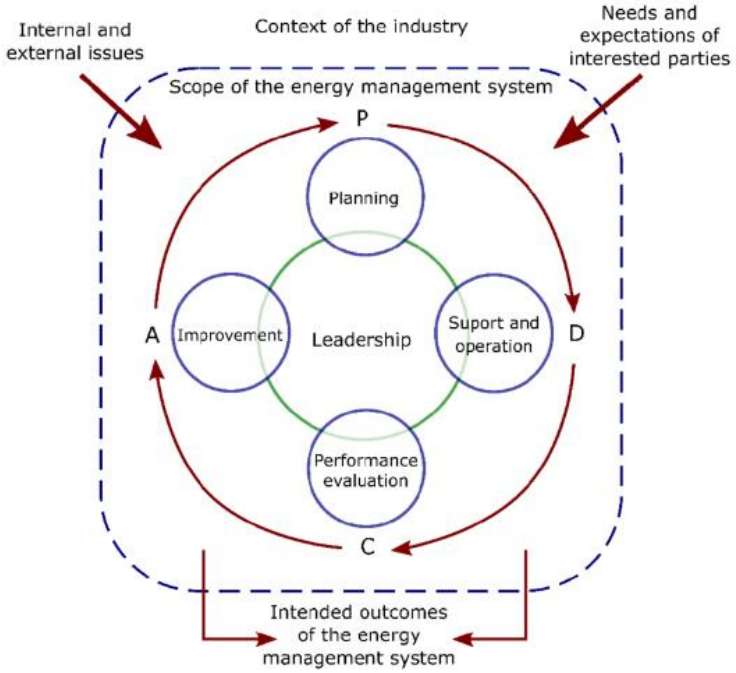
The ISO 50001 standard, published by the International Standard Organization 2011 and revised in 2018, is an international standard that provides practical guidance and specifies the minimum requirements for implementing an energy management system [12]. The ISO 50001 standard is divided into 10 sections:

1. *Scope*: presentation of the standard and its field of application, that is, organizations of any size, segment or location;
2. *Normative references*: shows the references;
3. *Terms and definitions*: defines the main terms used in the standard;
4. *Context of the organization*: deals with the characterization of the organization, identification of parties involved and definition of the EnMS scope and its boundaries;
5. *Leadership*: presents the need for senior management's commitment to the energy management system, the definition of an energy policy and the roles and responsibilities of the members of the energy management team;
6. *Planning*: deals with identifying risks and opportunities to achieve pre-established objectives and goals. Tasks such as energy review, determination of performance indicators and the organization's energy baseline must be carried out, in addition to planning for collecting energy data and preparing action plans to meet the defined objectives and goals;
7. *Support*: describes the support that the energy management system must have in the organization through the resources necessary to maintain and improve management. Defining competencies and providing training to the employees involved, in addition to communicating results and raising awareness among all those involved;
8. *Operation*: deals with the planning and control of processes and operations related to the use of energy, project development and acquisition of energy-efficient goods and services.
9. *Performance assessment*: presents the need to assess the organization's energy performance, through monitoring, measurements and analysis.
10. *Improvement*: provides recommendations on corrections and continuous improvement of the energy management system.

The process of implementing and maintaining the standard in an organization must follow the management tool known as the PDCA Cycle (Plan, Do, Check, Act), within which the tasks described in the

sections of the standard are allocated. The PDCA cycle operates to promote continuous process improvements, focusing on the cause of the problem and not the consequences. Figure 2 shows in a simplified way the operating process of a PDCA cycle.

**Figure 2** - PDCA cycle applied to an energy management system. Source: [12].




Source: [12], 2018.

The four stages of the PDCA cycle within which the tasks to be carried out to implement the energy management system are described below [12]:

***Plan:*** understand the context of the organization, establish an energy policy, set up an energy management team, conduct an energy review, develop actions to face risks and take advantage of opportunities, identify the energy significant uses, define energy performance indicators, identify energy baselines, stipulate energy objectives and targets, define an action plan necessary to obtain results that will lead to improved energy performance in accordance with the policy energy.

***Do:*** implement action, operation, maintenance, communication plans and ensure skills and consider energy performance in projects and acquisitions.

***Check***: monitor, measure, analyze, evaluate, audit, and carry out critical analyzes of the energy performance, by senior management.

***Act***: adopt actions to address non-conformities, continually improve energy performance.

To assist in the interpretation and implementation, complementary standards to ISO 50001 were developed:

- ISO 50002:2014 – Energy audits – Requirements with guidance for use.
- ISO 50003:2021 – Energy management systems – Requirements for bodies providing audit and certification of energy management systems.
- ISO 50004:2020 – Energy management systems – Guidance for the implementation, maintenance and improvement of an ISO 50001 energy management system.
- ISO 50005:2021 – Energy management systems – Guidelines for a phased implementation.
- ISO 50006:2023 – Energy management systems – Evaluation energy performance using energy performance indicators and energy baselines.
- ISO/TS 50008:2018 – Energy management and energy savings — Building energy data management for energy performance — Guidance for a systemic data exchange approach.
- ISO 50009:2021 – Energy management systems – Guidelines for implementation a common energy management system in multiple organizations.
- ISO/PAS 50010:2023 – Energy management and energy savings — Guidance for net zero energy in operations using an ISO 50001 energy management system.
- ISO/TS 50011:2023 – Energy management systems – Assessing energy management using ISO 50001:2018.

- ISO 50015:2014 – Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance.

Although there is an international energy management standard, the interpretation of that standard can vary depending on the field of application in which an energy management system is to be implemented. The next section presents a review of the energy management methodologies found in this research, analyzing the methods developed for implementing energy management based on ISO 50001.

## IV. Review Of Energy Management Methodologies

Energy management has undergone a process of evolution over the years, starting with simple measures to reduce consumption and consolidating into contemporary approaches, consisting of effective actions that combine administrative management and technological innovation with the efficient use of energy resources. In this evolutionary process, the concept of energy management has been consolidated through different formulations based on different perspectives. Table 1 shows the definitions of energy management found in academic publications.

**Table 1**. Definitions of energy management found in scientific articles.

| Definition | Source |
|---|---|
| Energy management involves monitoring, measuring, recording, analyzing, critically examining, controlling and redirecting the flows of energy and material through systems, so that less energy is spent on achieving worthwhile goals. | [13] |
| Energy management is the judicious and effective use of energy to maximize profits and enhance competitive positions through organizational measures and optimization of energy efficiency in the process. | [14] |
| Energy management can be defined as the application of business and organizational management methods to assist in the optimal use of energy resources. | [15] |
| Energy management is a strategy devised with procedures for reducing energy requirements per unit of production, keeping constant or reducing total production costs at the output of these systems. | [16] |
| In our research, we define "energy management in production" as the activities of controlling, monitoring and improving energy efficiency. | [17] |
| Energy management is a combination of energy efficiency activities, techniques and related process management, which result in lower energy costs and carbon dioxide emissions. | [18] |
| Energy management is the planning and execution of energy-related objectives, such as conservation, reduction of the environmental footprint and cost savings. | [19] |

Source: Vide Table.

In more recent elaborations, the concept is no longer limited simply to controlling and improving energy use and consequent cost savings but is integrated into the contemporary concept of energy management, the socio-environmental aspects [19].

**Review method adopted**

To identify the energy management methodologies already developed and published in academic articles published in international journals, a systematic review of previous publications was carried out. The aim of this review was to identify the methods developed for implementing organizational energy management. To this end, the review sought to answer the following question: What methodologies have already been developed to guide the implementation of energy management in an organizational environment?

To answer this question, exploratory research was carried out using the systematic review method as proposed by [20] and [21], and applied later by [22] to industrial energy management. The systematic review method adopted consisted of the following stages:

1 - *Planning the review*: identifying the need for the review and drawing up a review protocol;

2 - *Conducting the review*: identifying the research, selecting and evaluating the studies, extracting and synthesizing data;

3 - *Communicating and disseminating the review*: the review can be disseminated in a thesis or through an article published in a journal or congress;

The systematic review protocol drawn up for this work, based on the references cited, is summarized in Table 2.

**Table 2**. Systematic Review Protocol.

| Stages | Description of the stages of the systematic review |
|---|---|
| Purpose of the review | Identify existing organizational energy management methodologies. |
| Question to be answered | What methodologies have already been developed to guide the implementation of organizational energy management? |
| Selection of sources | Scopus, ScienceDirect, Web of Science e Scielo. |
| Key words | "Energy management" and "methodology" and "organization". |

| | |
|---|---|
| Search strategy | Articles published in journals available in online databases in the sources selected in step 3, covering the period from 1977 (oil crisis) to 2022. Search for the defined keywords in the title, keywords and abstract fields of the search tools. |
| Selection criteria | Articles with a methodological proposal for energy management in organizations. |
| Data extraction | Basic information on each selected paper is recorded (bibliography, date of publication, author and others), extracting the main contributions of each publication related to the subject of the review. |
| Summary of results | A synthetic analysis of the contributions and conclusions found in the selected articles is presented. |

Source: Adapted from [20], 2003.

**Discussion of results**

The academic articles found in this review were published in online databases from the late 1970s to 2022, with the first publication on organizational energy management methods found in 1977, identifying the first systematic procedures for corporate energy management [13]. The review was carried out on selected databases (Scopus, ScienceDirect, Web of Science and Scielo), and querying the keywords returned the following results:
- Scopus: 94 scientific articles were found, of which only 7 met the selection criteria.
- ScienceDirect: returned 20 articles, 4 of which met the selection criteria.
- Web of Science: returned 16 articles according to the keywords, of which only 1 met the selection criteria.
- Scielo: 2 articles were found, both of which met the selection criteria.

Of the 132 articles located in this review of online databases, excluding duplicate articles found in more than one database, we obtained 12 articles that made significant methodological contributions to the implementation of organizational energy management. The methods found have different levels of detail and theoretical and normative backgrounds. Table 3 shows the papers published and found in this review.

**Table 3.** Published works with methodologies for energy management.

| Article | Field | Author | Journal | Database |
|---|---|---|---|---|
| Energy Management | Any organization | [13] | Applied Energy | Scopus |
| Soft-Systems Model of Energy Management and Checklists for Energy Managers. | Any organization | [23] | Applied Energy | Scopus |
| Methodology for Energy Efficiency on Process Level | Any organization | [24] | Procedia CIRP | ScienceDirect |
| Innovative model of integrated energy management in companies. | Any organization | [25] | Quality Innovation Prosperity | Web of Science |
| Implementing Energy Management System to Increase Energy Efficiency in Manufacturing Companies | Industrial | [26] | Procedia CIRP | ScienceDirect |
| Energy management in industry e a systematic review of previous findings and an integrative conceptual framework. | Industrial | [22] | Journal of Cleaner Production | Scopus |
| Specification of energy assessment methodologies to satisfy ISO 50001 energy management standard. | Any organization | [19] | Sustainable Energy Technologies and Assessments | Scopus |
| Energy Management System for non-energy intensive multi-site industrial organizations: A methodology. | Multi-site organization | [27] | Energy | Scopus |
| Energy Management in Industry: An Enterprise Engineering Approach | Industrial | [28] | Brazilian archives of Biology and Technology | Scielo |
| A model for integrating energy management in lean production. | Industrial | [29] | Procedia CIRP | ScienceDirect |
| Energy management in energy-intensive industries: Developing a conceptual map | Any organization | [30] | Brazilian archives of Biology and Technology | Scopus |
| Effective implementation of ISO 50001: A case study on energy management for heating load reduction for a social building stock in Northern Italy | Set of buildings | [31] | Energy and Buildings | Scopus |

Source: Vide Table.

The first methodological scheme for implementing energy management found in this research relates available energy supplies and alternatives, taxes, policies, environmental and engineering aspects to internal objectives defined by the company which must be met [13]. The method known as the Flexible Energy Management Model [23], on the other hand, has a structure with previously defined stages, but in the first methods there was no precise definition of roles and coordinated actions; the methods were still empirical and focused on reducing energy consumption. The structuring of energy management methods reached a certain level of maturity through the support provided by the normative standardizations that emerged from the year 2000, consolidating with the ISO 50001 standard in 2011. Recent methodological approaches are characterized by the presence of key

elements from the ISO 50001 standard. Despite variations in the interpretation of the normative guidelines and the necessary adjustments to the field of application of energy management, since 2011 the methodologies developed and validated after application in a certain type of organization have been based on the same normative substrate as ISO 50001. An example of this is the method presented in this paper [24], where the starting point for implementing energy management was senior management support for the creation of an energy management team made up of representatives from various sectors and led by an energy manager, followed by an energy audit process with measurements, the development of indicators, evaluation of (industrial) processes and specific efficiency measures for each process.

A work with a broader vision, but with little methodological detail, can be found in this paper [25], with a proposal for a conceptual model for integrating management systems, the focus of which is to improve energy performance indicators by integrating internal energy conservation programs in each department of an organization. The result was a database available to all departments for evaluation and selection of actions, in the process resulting in a synergy of indicators for maximum overall energy savings, after application in an automotive industry.

In another method found [22], the author presents a methodology divided into three components: implementation element, which includes operational decisions related to the acquisition, allocation, use and disposal of resources, especially with regard to financial investments, and the payback period for these investments, as well as the need for ongoing energy audits to monitor the progress of energy management; the control element, which guarantees the constant collection of data, the monitoring of energy use and costs and the definition of performance indicators, measuring the effects of actions taken, making internal and external comparisons and proposing corrective actions; and finally the organizational element, which comprises two aspects, the governance structure within the company and the policies/procedures that the organization will adopt when conducting energy management. In the method proposed by[28], the importance of integrating internal functional areas and agents external to the industry is highlighted. The internal areas of the organization that must necessarily be involved in the process are: Senior Management (selected board of directors); Energy Management Team (EnMT) / Energy Manager; Engineering; Maintenance; Production; Administration. This method highlights the importance of integrating external parties (electricity utilities, electricity retailers and energy service companies), due to their direct or indirect influence on an industry's energy planning stage.

The proposal entitled Totally Integrated Energy Management [29] recommends the creation of an internal administrative structure (department) as a factor that will contribute to the success of energy management but recognizes that this may not be feasible in most companies. The method of [19] highlights one of the critical stages in the implementation of an energy management system, the energy review of the organization, detailing how this stage should be conducted. Previous work has already shown that this phase is one of the main ones in the energy management process, encompassing measurements, monitoring and data analysis [32], [33].

When an organization is distributed across several sites (multisite), the challenge of implementing organizational energy management is much greater. To tackle this problem [27], developed a methodology called the Global Energy Management System, highlighting that the energy team should be global, including representatives from all units of the organization, there should be a communication forum for the members of this team and the energy policy should be unified. The observed results of implementing this energy management methodology in a multisite organization have been an increase in awareness of avoided carbon emissions, a strengthening of business continuity and an increase in corporate sustainability and social responsibility for the organization that implemented it.

A unique method for application in a set of social housing units was developed by [31] following the standardized roadmap in ISO 50001. With the implementation of the method, immediate improvements related to retrofits were possible, such as replacement of windows, thermal insulation of attics, replacement of the heat generation system. After the practical measures, the phase of verifying the implementation of the energy management system and critical analysis by building management followed, closing the PDCA cycle provided for in the standard.

## V. Conclusions

The methodological approaches developed to implement corporate energy management have gone through a transition process, with methods initially developed based on the management and structural knowledge of the organization and the expertise of their proponents. With the emergence of national and international technical standards and norms for systematizing energy management, in particular the ISO 50001 standard, methodologies have been based on normative guidelines, systematizing the process by adding management concepts and tools, such as the PDCA cycle, which has standardized the general approach to implementing energy management. It is important to highlight that the consolidated standard for energy management, ISO 50001, does not provide a specific method for each type of organization, it is necessary to adapt the normative guidelines of ISO 50001 to the particularities of each organization. Although most methods are intended for use in the industrial

sector, ISO 50001 can be used in organizations of any segment. However, regardless of the organization's segment, the success of implementing energy management will be directly linked, initially, to the commitment of the organization's senior management through the provision of financial resources and the designation of a team responsible for conducting the process. And for the process to continue, it will also be necessary to have the support, involvement and ongoing commitment of all members of the organization.

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