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Proposal of an audit-based model for implementation of energy management in Small and Medium Enterprises

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ABSTRACT

Energy Management has become a matter of utmost importance for organizations worldwide, many of which are implementing energy management solutions to comply with regulations, improve their usage, and enhance their reputation with their customers. Typically, in SMEs - small and medium-sized enterprises, the culture of Energy Management is incipient, leading to energy waste due to poor strategic and operational management. This research aimed to develop a model to support the implementation of an energy management program based on audits. A conceptual model was developed for conducting audits, analyzing the electricity consumption of equipment, using the multicriteria method Promethee-ROC to rank recommendations from the IAC - Industrial Assessment Centers database, proposing performance indicators, and finally, analyzing the performance of the proposed model and its applicability. The procedural model was developed using the Process Approach methodology to construct a model that will assist in the audit process, analysis, recommendations, and decision-making. A case study was conducted in a small plastic injection company, where the model was tested and refined. As a result, the company obtained a ranking of recommendations according to its reality, along with a set of indicators and tips for implementing an energy management system based on ISO 50001. The manager's perception of the process was also evaluated, yielding results all above good in terms of usability, feasibility, and usefulness for the proposed model.

Keywords

Energy Management;
Process approach;
Audit;
Multicriteria;
Promethee ROC;
Small and Medium Enterprises

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1. Introduction

Energy is a fundamental necessity for various purposes in industrial, commercial, and residential facilities worldwide. It is, therefore, a crucial factor for economic competitiveness and employment. However, global population growth and energy demand are increasing simultaneously. This issue must be addressed by the international community to prevent potential energy resource shortages in the future and to promote cleaner and more sustainable production systems [1, 2, 61].

According to [3] and [4], energy has evolved into a significant opportunity for companies to create value, establishing a competitive advantage over their peers. Among the various reasons prompting companies to adopt an energy management system are increasing profits, cost reduction, and enhancing their image in society. However, there are also significant circumstances hindering companies from investing in or transitioning to more energy-efficient production methods, mainly related to a lack of knowledge or expertise, lack of directive involvement, or budgetary constraints [5].

According to [3] and [4], energy has evolved into a significant opportunity for companies to create value and establish a competitive advantage over their competitors. Among the various reasons driving companies to adopt an energy management system are increased

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profits, cost reduction, sustainability concerns, and the enhancement of their public image. However, several factors hinder companies from investing in or transitioning to more energy-efficient production methods, primarily related to a lack of knowledge or expertise, insufficient managerial engagement, or budgetary constraints [5].

Organizations, to remain dynamic in the current market, require good management for long-term success and efficient operation; energy management is no exception [6]. [7, 8, 9, 10] note that the subject has become extremely important for organizations worldwide, many of which are implementing energy management solutions to comply with legislation, improve usage, meet energy standards, and fulfill their requirements, as well as to enhance the organization's reputation with customers.

According to the [11], energy management is the proactive, organized, and systematic coordination of energy procurement, conversion, distribution, and use to meet requirements, taking into account environmental and economic objectives. To enable organizations to establish the necessary systems and processes to improve energy performance, including energy efficiency, use, and consumption, ISO 50001 was launched in 2011, aiming to reduce greenhouse gas emissions and other environmental impacts associated with energy costs through systematic energy management [12].

For maximum energy utilization, a system capable of managing energy consumption in productive environments becomes necessary, regardless of the size of the company, so that companies can not only maintain stability in the market but also enhance their competitiveness [13, 14, 15].

The implementation of an energy management system in small and medium-sized enterprises (SMEs) faces several challenges that limit its adoption and effectiveness [16]. The lack of specific and standardized guidelines makes it difficult for these companies to establish a structured path toward energy efficiency, especially since most research and policies are focused on large corporations [17]. Furthermore, SMEs typically have fewer financial incentives to invest in energy improvements, as the economic returns may seem less significant in the short term [14]. According to [62], the limitation of organizational resources, such as capital, infrastructure, and technical expertise, also hinders the implementation of effective energy management practices. As a result, many of these companies struggle to maintain competitiveness in markets that increasingly demand efficiency and sustainability [15]. In this context, it is crucial that public policies and specific incentives be developed to facilitate the adoption of standards such as ISO 50001 and other practices that promote more efficient energy use in SMEs [2].

To support small and medium-sized enterprises, this study aims to develop a model to facilitate the implementation of an energy management program based on audits, applied within a plastic injection molding company. The plastic industry segment was selected due to its high electricity consumption, primarily associated with the material heating processes required for plastic injection, as evidenced by studies conducted by [54, 55, 56]. This indicates that industries in this sector represent a fertile ground for energy management research, given the considerable potential for energy savings and the significant impact of energy efficiency improvements. The heating process for plastic injection is particularly energy-intensive, making energy management a critical factor for the competitiveness and sustainability of these enterprises. Although the study focused on a plastic injection molding company due to its high energy consumption profile, the proposed methodological approach is sufficiently robust to be applied across a wide range of industrial sectors seeking to enhance their energy management practices.

This work is divided into a section on energy audit models found in the literature, methodology, model development, model application, and conclusion.

2. Literature Review of Energy Audit Models

As a best practice, to properly implement an energy management system, the first step is to conduct an energy audit, which is a survey examining how energy forms (electric, steam, and others) are currently used in the facility, also identifying some alternatives to reduce their costs [18]. [19] states that energy audit is the key to a systematic approach to decision-making in the field of Energy Management, as it attempts to balance total energy inputs with their usage and serves to identify all energy flows within a facility.

In the research conducted by [20], energy analyses were carried out in four industrial sectors in Spain: chemical industry, food and beverage, textile industry, and manufacturing of non-metallic mineral products. This was done by walkthrough audit to analyze process conditions, after which, energy-saving measures were proposed by the authors to improve energy efficiency. [21] conducted an energy audit in an animal nutrition industry in Morocco, where they visited the factory to analyze documentation related to energy consumption, after which, they conducted a comprehensive audit of the facilities with energy analysis equipment and infrared cameras, prepared a report identifying the issues raised in the audit, and an action plan was proposed to improve the energy efficiency of the factory.

[22] analyzed textile industries, conducting walkthrough audits and identifying problems in the plants regarding energy consumption, issuing reports for improvements, and some performance indicators for control. [23] discussed the energy audit methodology in a household appliance manufacturer, where they proposed several steps for implementation, the first being conducting meetings and training on Energy Management, followed by creating technological infrastructure with meters and software to collect information on consumption and reporting emissions, and also proposed performance indicators to monitor performance.

[24] conducted an energy audit at a car manufacturer in Serbia, where data on electricity, steam, water, and compressed air consumption were collected, and improvements were proposed to increase the energy efficiency of these resources. [25] conducted energy audits in cast iron foundries in Italy, analyzing energy bills, equipment lists, consumption, proposed improvements, and indicators to monitor the proposed improvements.

[26] conducted an energy audit using energy analyzers in a textile industry in India, where all equipment was mapped, and improvement points were identified. [27] conducted a walkthrough audit to collect power ratings, equipment operation times, and power factor, with the audit result, improvements were proposed based on the researchers' opinions and experience to improve the company's energy efficiency.

A source of data that can be useful for energy management is the IAC - Industrial Assessment Centers aimed at helping small and medium-sized American manufacturers save energy, improve productivity, and reduce waste. The program provides free technical assessments conducted by engineering student and faculty teams. The IAC is administered by the Advanced Manufacturing Office of the Office of Energy Efficiency and Renewable Energy of the Department of Energy [28].

An important document that can be used is the standard governing the implementation of energy management systems, which is ISO 50001, based on the systematic continuous improvement of PDCA (Plan, Do, Check, Act), is a management method that aims to continuously improve processes and products, and incorporates energy management into daily organizational practices, as shown in Figure 1.

In the scheme proposed by the ISO 50001 standard, audits are part of the structure for verifying the Energy Management System, which is composed of proposing an energy policy, followed by strategic planning aimed at achieving objectives, moving on to implementation

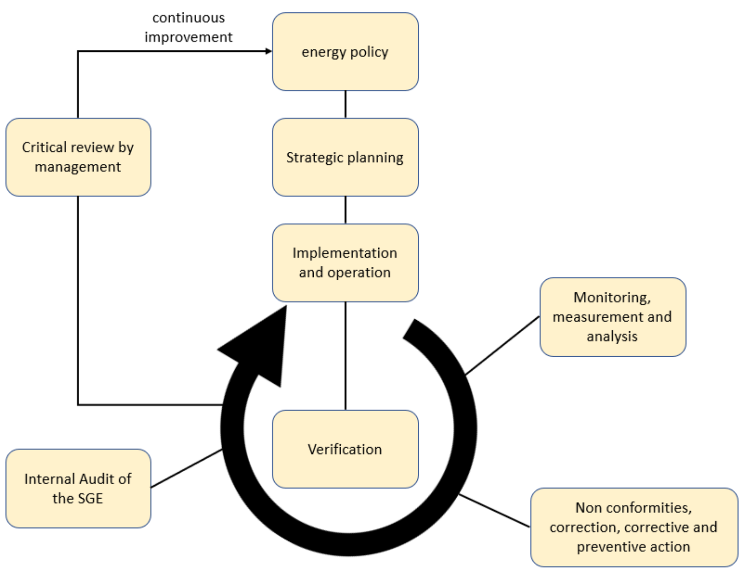

Figure 1: Energy Management System Model for ISO 50001 standard [12].

and operation, and the verification process that includes the audit, where non-conformities, corrections, corrective and preventive actions are identified. There is also a feedback process that goes from verification to the energy policy, where top management critically reviews the status of the Energy Management System.

An energy management system in industries encompasses the activities, procedures, and systematic routines of an organization, incorporating key elements such as strategy, planning, implementation, operation, control, organization, and culture. This system involves both production and support processes, aiming for the continuous reduction of energy consumption and its associated costs [13], [64], [65].

According to [21], one of the tools used for the adoption of an Energy Management System is the conduction of audits, which help identify inefficiencies in processes, often caused by poor energy management. In addition to being a recommended best practice, the first step in properly implementing an energy management system is conducting an energy audit, which serves to initiate the company's diagnosis and propose improvements [18].

In the systematic literature review carried out by [10], it was identified that the most common type of audit is walkthrough audit, being used by [27, 29, 30, 31, 32, 22, 26], which according to [33] involves touring the facilities for a visual inspection of each energy used. Typically, it includes evaluating energy consumption data to analyze quantities and usage patterns and providing comparisons with industry averages or benchmark parameters for similar facilities. It is a less costly audit but can generate a preliminary estimate of potential savings and provide a list of low-cost saving opportunities through improvements in operational and maintenance practices.

It was also noted that many studies only analyze the data from energy audits conducted by third parties in companies [34, 35, 36, 37, 38, 39, 14, 40].

In the works of [27, 29, 30, 31, 25, 41, 42, 43, 5, 26], energy audits were conducted, but it was not possible to identify the instrument or audit model used.

Through the literature review, it was possible to identify that the improvement proposals made by the authors are based on the researcher's experience; only in the [28] was a database identified with recommendations proven by the financial return that companies obtained after the audits conducted.

The studies examine energy audits across various industrial sectors, exploring methodologies and the impacts of implementing Energy Management. All share the goal of improving energy efficiency through detailed diagnostics and proposals for improvements. They have in common the use of energy audits as the primary tool for analysis and decision-making; they employ a walkthrough audit process, including visual inspection, consumption analysis, and comparisons with benchmarks. The research was conducted across a range of industrial sectors, with all studies resulting in recommendations for actions to reduce energy consumption and enhance efficiency.

The gaps identified in the literature include the lack of standardization in the methodologies used, which hinders comparison between results; few studies provide detailed descriptions of the instruments and audit models used, making replication of methods challenging; and while most studies focus on identifying energy-saving opportunities, few analyze the long-term impacts of the measures implemented.

The authors conduct empirical studies based on the collection and analysis of energy data through audits. The specific issue addressed is energy inefficiency in industrial facilities and the identification of feasible corrective measures. The goal is to propose improvements that reduce energy consumption and operational costs, contributing to more efficient energy management.

3. Methodology - Process Approach

This research used the Process Approach methodology proposed by [44]. According to [45], a process "is a sequence of events that describes how things change over time." For [46], the process approach is motivated by the development of a prescriptive approach, which operationalizes a set of concepts through a structured process.

[44] states that for a process to be effective, it should contain four elements, known as the 4 Ps: Procedures; Participation; Project Management; and Entry Point, as presented in Figure 2.

Procedure: This should be clearly defined to progress through the project stages, where information must be gathered, analyzed, and improvement opportunities proposed. For this, simple and easily understandable tools and techniques should be used, and all results should be recorded. According to [44], this is the fundamental requirement of a methodology, as it specifies the tasks to be performed.

Participation: during the project, participation is of utmost importance. It should be individual or in groups to obtain enthusiasm, understanding, and commitment. Workshop-style meetings can be held to collectively agree on objectives, identify problems, and develop improvements to foster involvement.

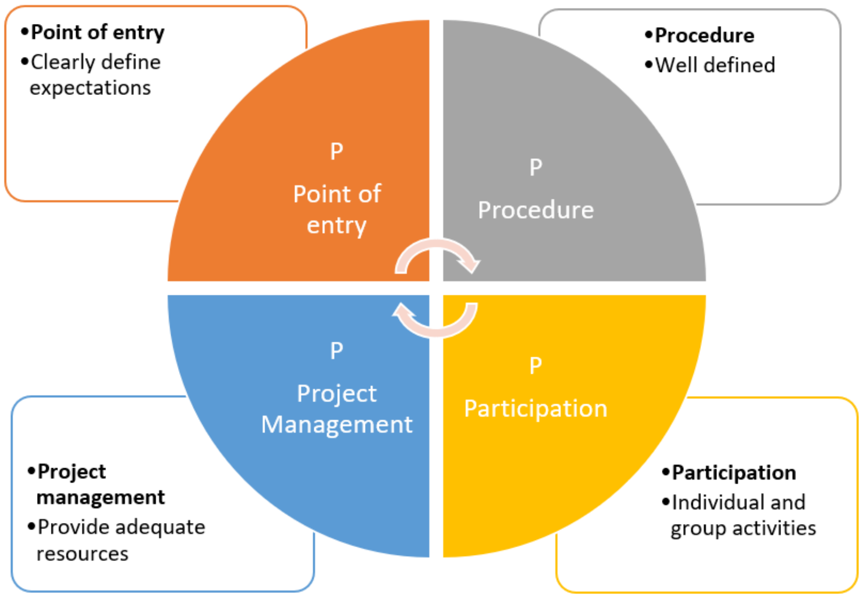

Figure 2: Platts' 4Ps [44].

Project Management: adequate resources should be available for project management, with appropriate management, support, and operational groups identified. Also, a timeline should be agreed upon among the members. A project facilitator may be appointed and will be responsible for disseminating concepts throughout the company.

Point of entry: this is a way to achieve understanding and agreement from the management group, as well as a way to establish commitment from management and operational groups. Communicate the defined expectations about what the process involves and where it aims to reach.

4. Model design and development

The model design included [44] 4 Ps, which were used to organize the steps, as shown in Figure 3.

4.1 Point of entry

The project's starting point was carried out through the initial presentation to the company manager about Energy Management concepts, best practices, technical and economic benefits, research procedures, and achievable results. To engage the company manager, an initial presentation on Energy Management has been developed for the first contact with the topic.

After the initial presentation, a questionnaire containing various elements related to Energy Management will be administered to the company's manager in order to assess the current situation of the company. The questionnaire consists of eighteen questions, based on barriers and drivers identified in the literature, as well as requirements from the ISO 50001 standard. The questionnaire template can be seen in Table 1.

The initial questionnaire is part of the entry point and was used to conduct a diagnosis of the company's Energy Management knowledge before interventions. Through the questionnaire responses, it was possible to propose some recommendations to address the identified gaps concerning barriers, drivers, and ISO 50001 items. This initial approach is also part of the research procedure.

4.2 Participation

Individual and group participation was included in this Energy Management research for its development in all stages.

4.3. Procedure

For the development of the process model, a procedure has been developed to operationalize the conceptual model. The sequence of the proposed method is described in Figure 4.

The procedure was encompass all phases of the research, from the initial survey to the proposal of recommendations. Following the initial survey, a meeting with the stakeholders in the audit process was conducted,

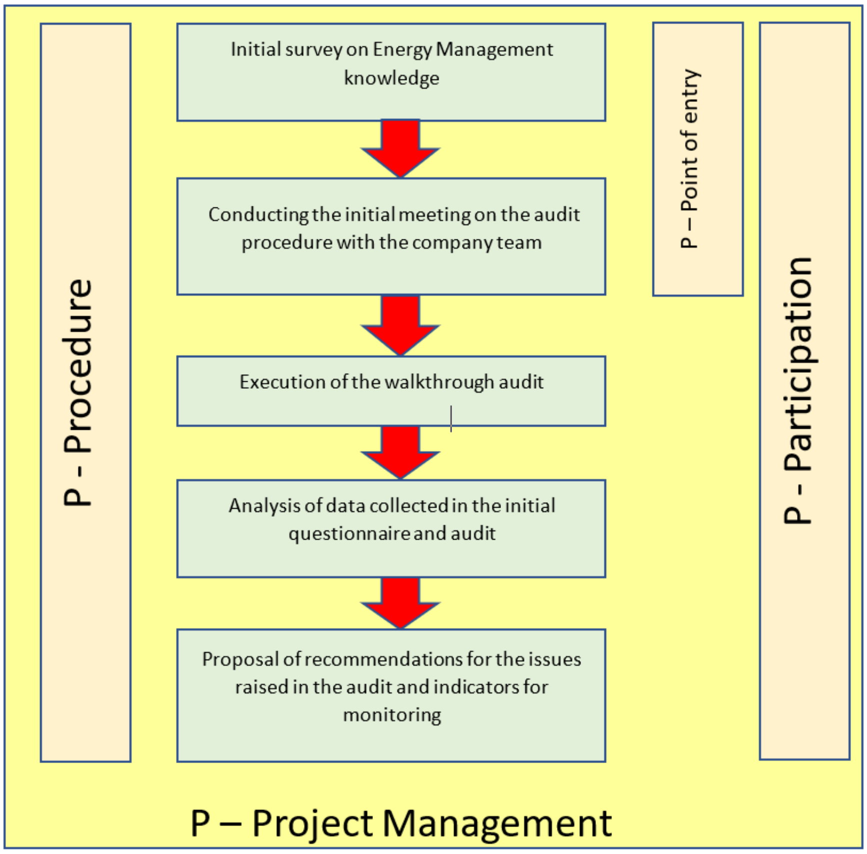

Figure 3: Sequence of research adapted into the 4Ps proposed by [44].

during which a presentation on the concept of Energy Management and the audit procedure will be given.

The stakeholders in the audit process were responsible for presenting the process flow and energy accounts to the researcher, to provide initial insight into the characteristics of the factory plant. This knowledge will be represented through flowcharts, to identify the inputs and outputs of the company's processes.

The execution of the walkthrough audit occurs through an on-site visit to the company's production process, where a mapping of all energy-consuming equipment in the process will be conducted. These will be collected in specific spreadsheets, as per Table 2.

Data related to the process to which the equipment belongs was recorded, including the name, manufacturer, power in watts, hours of equipment usage during the day, the type of energy used by the equipment (electricity, steam, etc.), and the type of equipment usage (heating, cooling, etc.).

After conducting the audit, analyses of the collected data at all stages will be performed to identify the characteristics of the equipment used in the process. These analyses will be graphically represented by type of energy and type of usage through a report developed for the audited company.

Some improvement proposals will be presented through recommendations based on the Industrial Assessment Centers (IAC), as cited by [47], in which three groups of recommendations were outlined: energy management, waste minimization and pollution prevention, and productivity enhancement. A total of 26 IAC recommendations were utilized. This high number of recommendations could lead to potential confusion during their implementation. To address this, the Promethee-ROC multicriteria decision-making support method was applied to rank the recommendations that best fit the studied context. This multicriteria method, Promethee-ROC, has been previously employed in energy management research by [63] and [60].

Promethee-ROC relies on a mathematical framework based on the interaction between outranking analyses, as applied in the Promethee II method. Additionally, it employs the surrogate weights methodology using the Rank Order Centroid (ROC) method to represent

Table 1. Initial Energy Management Research Questionnaire.

Initial Energy Management Research Questionnaire
What do you understand by Energy Management? Answer:
Does the company know the benefits of Energy Management? ( ) yes | ( ) no
Does the company have a written energy policy? ( ) yes | ( ) no
Is there someone responsible for Energy Management in the company? ( ) yes | ( ) no
Is the company interested in Energy Management? ( ) yes | ( ) no
Does the company regularly collect data on energy consumption and costs? ( ) yes | ( ) no
Does the company conduct energy audits? ( ) yes | ( ) no
Does the company have energy objectives linked to its organizational policy? ( ) yes | ( ) no
Is the company aware of any government programs incentivizing Energy Management? ( ) yes | ( ) no
Does the company know the actual consumption of its process equipment? ( ) yes | ( ) no
Does the company identify opportunities for energy savings? ( ) yes | ( ) no
Are the company's employees aware of Energy Management? ( ) yes | ( ) no
Does the company have access to available technologies for Energy Management? ( ) yes | ( ) no
Does the company have capital available to invest in Energy Management? ( ) yes | ( ) no
Does the company have qualified personnel in Energy Management? ( ) yes | ( ) no
Is the company interested in interventions for energy efficiency? ( ) yes | ( ) no
Does the company use any indicator to control energy consumption? ( ) yes | ( ) no
What are the barriers preventing the company from using Energy Management? Answer:
What would motivate the company to use Energy Management? Answer:

decision-makers preferences while considering partial information regarding the importance of criteria in the decision-making process [64]. The choice of this method is justified by its non-compensatory rationality, which prioritizes a subset of criteria that favors a given alternative.

According to [50], multicriteria decision problems are characterized by situations in which there are two or more action alternatives to be chosen, ordered, or classified, and multiple conflicting criteria involved. The steps of using the Promethee-ROC multicriteria method are presented in Figure 5.

Initially, sets of objectives were developed, along with the decision-maker (company manager), to understand which strategic objectives for Energy Management they consider important. Through these objectives, criteria were listed to seek to achieve them. These choices were

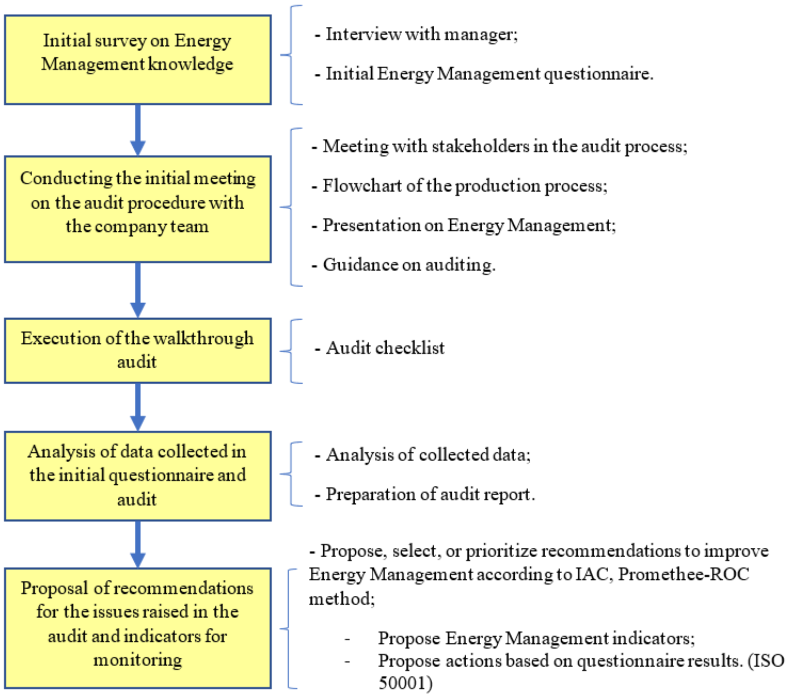

Figure 4: Sequential procedure of the research.

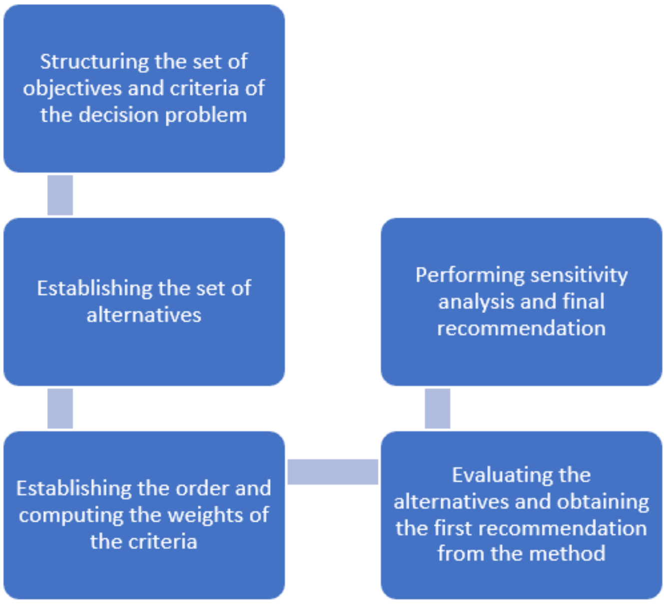

Figure 5: Structure of the Promethee-ROC method [60].

Table 2. Model of instrument for data collection during the audit.

Process	**Equipment**	**Manufacturer**	**Power (W)**	**Usage time/day (h)**	**Type of energy**	**Type of use**

based on the perception of each manager of the evaluated companies and the context in which they were inserted.

The alternatives were referred to as recommendations taken from the IAC database, for the plastic injection industry, as cited by [28].

After defining the criteria, they were ordered according to the managers' perception, by the degree of importance attributed to each one, as shown in Table 3."

The preference directions of the criteria were also be defined, whether they should be maximized or minimized. For example, a criterion could be implementation cost, in which case the preferred direction could be to minimize it.

A table with constructed attributes (which are the criteria) by the decision-maker and their consequences were used to indicate the manager's perception when evaluating the criteria about the recommendations. Initially, two values were used, 1 for low and 2 for high as consequences in the decision matrix. These were assigned by the manager at the time of evaluating criterion versus recommendation. After defining the criteria, recommendations, and constructed attributes, a table with this information was developed, as shown in Table 4.

Table 3. Ranking of criteria and preference direction.

Order	Criterion	Preference direction
1º	C1	↑ or ↓
2º	C2	↑ or ↓
3º	C....	↑ or ↓

The values of the consequences perceived by the decision-maker were filled in the criterion versus recommendation direction, one criterion at a time for all recommendations.

With all the data filled in the table, it was submitted to a Decision Support System, which is a software available on the website of CDSID - Center for Decision Systems and Information Development, Federal University of Pernambuco, Brazil.

The data was processed using the mathematical framework of the Promethee II method, presenting an initial ranking of recommendations. Sensitivity analysis of the data was performed using Monte Carlo simulation, with 100,000 simulations varying the weight of the criteria by ±10%, with a 95% confidence level, using the Crystal Ball software, as done in works by De [52, 60, 51].

After the simulations, the ranking of recommendations was evaluated to analyze if there were any changes in the positions of the initial recommendations, followed by the issuance of the report to the manager.

To assist managers in monitoring the proposed recommendations, some indicators found in the literature on energy management were proposed to monitor process performance, as shown in Table 5.

These indicators were obtained from the literature and served as support for managers in visualizing the

Table 4. Construction of consequences assigned for criteria versus recommendations.

Recommendations	Criterion x	Criterion Y	Criterion Z
Recommendation 01	Consequence	Consequence	Consequence
Recommendation......	Consequence	Consequence	Consequence

Table 5. Proposed Indicators for Energy Management.

Indicator	Equation	Objective	Cited by
Energy consumption per production	CEP = Energy consumption in the period / production in the period	To check the energy consumption per quantity produced in the period	[41, 23, 59]
Cost of electricity	CEE = Total kWh consumed in the month * kWh COST	To verify the cost of energy spent in the month	[37]
Total energy consumed	TEC = Total energy consumption (kWh)	To check the total energy consumption in the period	[42]
CO_2 emissions	ECO = Total energy consumption * conversion factor by energy type	To verify the total CO_2 emissions	[37, 30, 16, 58]

evolution of their processes after the possible implementation of the recommendations.

With the data from the electricity bills, the company was able to analyze, through the indicators, whether the actions related to Energy Management were efficient and effective, being able to direct actions where necessary.

4.4 Project Management

[44] mentions that project management requires adequate resources, which must include management, and support, and the operational group must be identified during its conduct. The resource should be composed of three types: managerial, with the company personnel responsible for ensuring the progress of the project; support, internal or external personnel providing the 'experience' of the process; and operational, the personnel directly involved in the execution of the process.

According to [53], for the implementation of an Energy Management program, the company must introduce an organizational structure in which at least one person, called the energy manager, has technical knowledge about the company's processes and is responsible for project management related to Energy Management.

For the evaluation of the process, 3 criteria proposed by [44] were used, which are:

Feasibility: Can the process be followed?

Usability: How easy is it to follow the process?

Utility: Did the process provide a useful step for implementing an Energy Management System?

These three elements show the researcher and the manager whether the process developed for this model can be followed if it is easy to understand, and if it provides useful information for the implementation of an Energy Management System. A questionnaire was prepared to evaluate the process, based on the study by [46], as shown in Table 6.

The questions used have a scale from 1 to 5, where: 1 Very little; 2 Little; 3 Medium; 4 Good; 5 Very good. It also includes a field for observations on each question, as well as a specific field for additional comments. This questionnaire was administered at the end of the audit to evaluate the executed process and gather the manager's opinion, in addition to highlighting the researcher's learning in using the method.

5. MODEL APPLICATION

This research was conducted in a plastic injection company in Curitiba, Paraná, which was named Company T. The plastic industry segment was chosen due to its high consumption of electrical energy, used in the material heating process for plastic injection, as evidenced in studies by [54, 55, 56]. Three visits were made to this company for refinement and application of the proposed model.

Table 6. Questionnaire for process evaluation [46].

Method Evaluation						
Mark the number that best expresses your response, according to the following order: 1 Very little; 2 Little; 3 Medium; 4 Good; 5 Very good.						
	Scores					**Observations**
Dimension: Feasibility	**1**	**2**	**3**	**4**	**5**	
The process was clearly defined						
There was enough information for selecting the recommendations						
Dimension: Usability	**1**	**2**	**3**	**4**	**5**	
At each stage, the process was clearly defined and easy to follow						
The process fosters engagement that facilitates achieving the objectives						
Dimension: Utility	**1**	**2**	**3**	**4**	**5**	
The outcome of the process was useful						
The process allows for active participation of those involved and group discussions						
The partial results of each stage (Meeting) justify the time spent						
The process increased my confidence in the results obtained						
The process helped me better understand issues related to Energy Management						
Additional Comments						

During the first visit to company T, five criteria considered important by the decision-maker were defined, and ordered, and the preference directions were established, as shown in Table 7.

According to the decision-maker's perspective, the criteria to be maximized include return on investment (USD), energy savings (kWh), productivity enhancement, and organizational benefits, as these criteria represent the overall gains. Conversely, the criterion to be minimized—i.e., reduced is the implementation cost (USD) of the proposed actions.

After defining the criteria, 26 IAC recommendations related to the plastic injection industry (injection and heating processes) were proposed, with the perceived impact by the decision-maker at two levels: high and low, as explained in the procedure item of the method. This situation resulted in many ties in the Promethee-ROC analysis of the recommendation ranking, making it difficult for the decision-maker to choose alternatives after ranking.

A second visit was made to company T, where new values for the perceived impact were proposed, with three levels: 3 high, 2 medium, and 1 low. Even with this expansion in the perceived impact by the decision-maker, ties persisted after applying the Promethee-ROC method. These ties made it difficult for the decision-maker to choose alternatives, generating doubts.

During the third visit, new values for the perceived impact and levels of attributes constructed by the decision-maker were proposed, with five levels: very high, high, medium, low, and very low, as shown in Table 8.

These values were used in the research so that the manager could assess the perceived impact on the criteria and recommendations. Additionally, 13 more IAC recommendations from the plastics industry were included, bringing the total to 39, compared to the previous 26. As a result, ties decreased after applying the Promethee-ROC method, making the model suitable after refinement.

5.1. Company T Presentation

Company T is a manufacturer of plastic caps for packaging solvents, food, lubricants, mineral water, wine, cleaning and hygiene products. It has 58 employees and is classified as a small business. The production process flowchart can be seen in Figure 6.

The first stage is the reception of raw materials, which are stored in the warehouse sector until they are requested for use. When there are material schedules, it is separated according to the color recipe, and then placed in injection machines to take the shape of the mold. Some products are printed or assembled, then packaged and sent to the shipping department to be dispatched to customers.

5.2. Initial questionnaire at Company T

The researcher gave a presentation to the company's manager about Energy Management, its objectives, and

Table 7. Ordering and preference direction of criteria.

Order	Criterion	Preferred Direction
1º	Return on investment (USD)	Maximize
2º	Implementation cost (USD)	Minimize
3º	Energy savings (kWh)	Maximize
4º	Productivity increase	Maximize
5º	Organizational benefits	Maximize

Table 8. Perceived impacts by the decision-maker and levels of constructed attributes for third-visit multicriteria analysis.

Perceived impact by the decision-maker	Levels of constructed attributes
1	Very low
2	Low
3	Medium
4	High
5	Very high

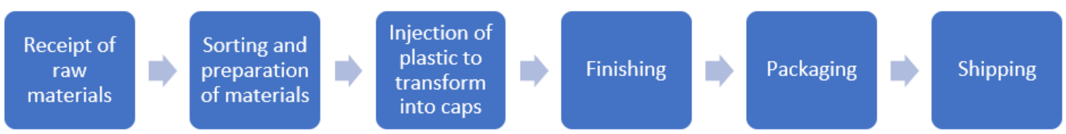

Figure 6: Sequence of the production process of company T.

history. After that, the initial questionnaire about the understanding of Energy Management was answered by the company's representative. The first part consists of questions with "yes" and "no" answers, followed by three open-ended questions about Energy Management, barriers, and drivers. The questions and answers can be observed in Table 9.

From the questionnaire responses, it is noted that the company has limited knowledge about energy management and its tools, but is willing to intervene regarding energy efficiency. The person in charge of the company also answered three open questions about Energy Management, barriers, and drivers, which can be observed in Table 10.

The person in charge of the company mentioned their understanding of Energy Management, emphasizing the mapping of energy consumption for resource administration. They also mentioned the barriers that prevent the use of Energy Management: implementation costs; lack of clarity about financial returns and gains; and lack of incentive programs from governments. These barriers are common with those identified in studies by [18, 21, 36, 44, 35, 37].

What would motivate the company to use Energy Management are financial gain; organizational gain; and process mapping regarding energy efficiency, which were also mentioned in studies by [34, 31, 41, 38, 42, 22, 18, 14, 57, 40, 21].

5.3. Walkthrough audit at company T

Before conducting the audit, data on electricity consumption and production were collected for knowledge and development of Energy Management indicators. The data is for June 2021 and is available in Table 11.

The company paid $0.095 per kWh of electricity used in its process, had a monthly production of 10,000 units, and a monthly electricity consumption of 118,982 kWh. With these obtained data, it was possible to frame them into four indicators for the company to use in Energy

Table 9. Manager's responses to the initial questionnaire.

Question	Yes	No
Does the company know the benefits of Energy Management?	✓	
Does the company have a written energy policy?		✓
Is there someone responsible for Energy Management in the company?		✓
Is the company interested in Energy Management?	✓	
Does the company regularly collect data on energy consumption and costs?	✓	
Does the company conduct energy audits?		✓
Does the company have energy objectives linked to its organizational policy?		✓
Is the company aware of any government programs incentivizing Energy Management?		✓
Does the company know the actual consumption of its process equipment?	✓	
Does the company identify opportunities for energy savings?		✓
Are the company's employees aware of Energy Management?		✓
Does the company have access to available technologies for Energy Management?	✓	
Does the company have capital available to invest in Energy Management?		✓
Does the company have qualified personnel in Energy Management?		✓
Is the company interested in interventions for energy efficiency?	✓	
Does the company use any indicator to control energy consumption?		✓

Table 10. Responses to open questions from the initial questionnaire about Energy Management at company T.

What do you understand by Energy Management?	Mapping of energy consumption to manage this resource.
What are the barriers preventing the company from adopting Energy Management?	Implementation cost; Financial return; Lack of clarity on the gains; Lack of incentive programs.
What would motivate the company to implement Energy Management?	Financial gain; Organizational gain; Process mapping on energy efficiency.

Management. Table 12 presents the values found for each one.

With these indicators and results, the company will be able to begin monthly measurements to monitor its performance regarding energy consumption per production, electricity cost, total energy consumed, and CO2 emissions.

Subsequently, a walkthrough audit was conducted at the company, where data on all equipment involved in the process, their consumption, quantity, and type of use were collected. A portion of the equipment data can be seen in Table 13.

The collected data on process equipment includes the process they belong to, name, manufacturer, quantity, power in kW/h, type of energy, and type of use. Electrical energy is the only one used by this company.

The equipment was grouped by type of use to understand which are the largest consumers of electrical energy. In Figure 7, you can observe the percentage of each group.

The Heating/injection equipment is the largest consumer of electrical energy at 52.25%, followed by cooling at 16.13%, compressed air generation at 15.33%, and air conditioning at 12.65%. This information guided the organization of data in the use of IAC recommendations and the application of the multicriteria method, which will be presented next for company T.

Table 11. Data on electricity consumption and cost and production at company T.

Cost per kWh	**USD 0.095**
Monthly production	10,000 units
Monthly electricity consumption	118,982 kWh

5.4 Multicriteria Analysis at Company T

The company manager was questioned by the researcher about what he considers important in Energy Management, and the criteria considered important for the analysis were identified. Five criteria were defined in the Energy Management category: Return on investment; Implementation cost, Energy savings, Increased productivity, and Organizational benefits.

These criteria were ranked by the manager according to their degree of importance, and the chosen order was: return on investment; implementation cost; energy savings; increased productivity; and organizational benefits. Only the implementation cost criterion has a preference direction for minimization; the other four are desired to be maximized.

With the impacts perceived by the decision-maker established, each criterion was assessed using a metric referred to as the natural scale value, which was developed through a consensus between the company's manager and the researcher, following the methodology proposed by [50]. The corresponding values are presented in Table 14.

Each recommendation used from the IAC database has a code, which will be used for identification; these are related to plastic injection industries for injection/heating processes. In Table 15, it is possible to observe a portion of the data regarding the perceived impact by

Table 12. Proposed indicators for Energy Management at company T.

Indicator	**Equation**	**Result**
Energy consumption per Production (kWh/units)	CEP = Energy consumption in the period/ production in the period	CEP = 11.8982 kWh/unit
Cost of electricity (USD)	CEE = Total kWh consumed in the month * kWh cost	CEE = 118,982 kWh * 0.095 USD/kWh CEE = USD 11,303.29
Total energy consumed	TEC = Total energy consumption (kWh)	TEC = 118,982 kWh
CO_2 emissions	ECO = Total energy consumption * conversion factor by energy type	ECO = 118,982 kWh * 0.0617 ECO = 7,341.19 kg CO_2 ECO = 7.341 t CO_2

Table 13. Listing of equipment and processes.

Process	**Equipment**	**Manufacturer**	**Power (kW)**	**Usage time/day (h)**	**Type of energy**	**Type of use**
Office	Computers	Miscellaneous	0.15	15	Electrical	Data processing
Feed injection	2 HP pumps	-	1.75	15	Electrical	Feed injection
Seal application	Seal applicator	-	0.66	1	Electrical	Cap finishing

the decision-maker for each recommendation according to the criterion.

The data from the matrix presented in Table 14 was submitted to the SAD – Decision Support System of CDSID Promethee-ROC. The criteria were ranked according to the decision maker's preference. After the criteria were sorted by importance, the software returned the weights based on the decision maker's choices. These weights can be observed in Table 16.

The DSS - Decision Support System of CDSID processed the provided data and generated the ranking of recommendations through the calculation of net flow, as shown in the part of the data presented in Table 17.

After applying the Promethee-ROC multicriteria method, the first recommendation is provided for the problem in question, ranking the alternatives.

5.5. Sensitivity analysis at Company T

Based on these results, the decision maker can obtain the final recommendations with greater robustness. The sensitivity analysis helped the decision maker observe how sensitive the alternatives are to changes in the values assumed in the matrix and calculated for the weights. In Table 18, it is possible to observe a portion of the ranking and the chance of the recommendation remaining after the sensitivity analysis.

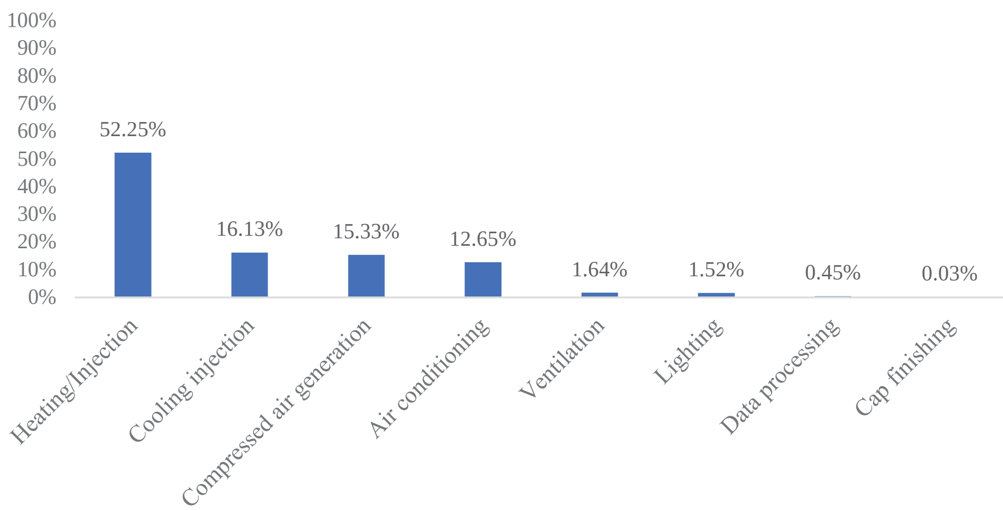

Figure 7: Grouping of equipment with higher electricity consumption by type of use at company T.

Table 14. Perceived impacts by the decision maker and levels of constructed attributes.

Impact perceived by the decision maker	Constructed attributes	Natural scale value – Return on investment	Natural scale value – Implementation cost	Natural scale value – Energy savings	Natural scale value – Increased Productivity	Natural scale value – Organizational Benefits
1	Very low	19 months or older	Up to USD 1,000	Less than 5%	Less than 5%	It does not cause impact
2	Low	13 to 18 months	USD 1,001 to USD 5,000	Between 5 a 8%	Between 5 to 10%	Low impact
3	Medium	7 to 12 months	USD 5,001 to USD 10,000	Between 8 a 10%	Between 10 to 15%	Medium impact
4	High	4 to 6 months	USD 10,001 to USD 50,000	Between 10 a 15%	Between 15 to 20%	High impact
5	Very high	1 to 3 months	Above USD 50,001	Above 15%	Above 20%	Significant impact on the organization

Table 15. Perceived impacts by the decision maker and levels of constructed attributes.

Recommendations	**implementation cost (R$)**	**energy savings (kWh)**	**return on investment (USD)**	**Organizational benefits**	**Increased productivity**
2.2622 Replace existing chiller with high-efficiency model	5	4	4	2	4
2.3135 Implement routine maintenance program during non-operational periods	5	5	5	3	4
2.4133 Use most efficient type of electric motors	5	4	3	3	3
2.4112 Install soft-start to eliminate start-up motor peaks	3	3	4	5	5
2.4156 Establish a preventive maintenance program on motors	3	3	4	5	5
2.4157 Establish a predictive maintenance program on motors	2	3	3	3	3
2.4227 Use compressor air filters	2	4	3	3	4
2.4235 Remove or close unnecessary compressed air lines	2	3	4	3	4
2.4236 Eliminate leaks in inert gas and compressed air lines/valves	3	4	4	3	4
2.4239 Eliminate or reduce the use of compressed air	3	3	4	5	5

Table 16. ROC weights for the criteria at company T.

Criterion Name	**Return on Investment (USD)**	**Implementation Cost (USD)**	**Energy Savings (kWh)**	**Increase in Productivity**	**Organizational Benefits**
ROC Weight	0.4567	0.2567	0.1567	0.009	0.04

Table 17. Ranking of recommendations.

Ranking	**Alternatives**	**Positive Flow**	**Negative Flow**	**Net Flow**
1	2.6215 Turn off air conditioning during winter heating season	0.7437	0.038	0.7057
2	2.8122 Use utility controlled energy management	0.6139	0.117	0.4969
3	2.6124 Establish equipment maintenance program	0.5874	0.1341	0.4533
4	2.7211 Clean and maintain condensers and cooling towers	0.5865	0.1402	0.4464
5	2.6218 Turn off equipment when not in use	0.5017	0.1814	0.3203
6	3.4154 Eliminate leaks in water lines and valves	0.5377	0.2174	0.3203
7	2.3135 Schedule routine maintenance during non-operational periods	0.5708	0.2714	0.2994

After conducting the sensitivity analysis, it was observed that recommendation 2.6215 - Turning off the air conditioning during the winter season remained in first place with 100%; followed by 2.8122 - Using utility-controlled energy management, with 95%; and 2.6124 - Establishing a maintenance program for equipment, with 72%. This shows that the choices made by the decision-maker are coherent after applying the multicriteria method and sensitivity analysis.

To exemplify a situation that did not reach 100%, recommendation 2.6124 - Establishing a maintenance program for equipment, with 72% and occupying the third position, will be used. This means that the recommendation varied between the 2nd, 3rd, and 4th positions. It remained in the third position in 72% of the 100,000 simulations, 23% in the fourth position, and 5% in the second position, as shown in Figure 8.

This example served to visualize possible changes that may occur between the ranking positions due to variations in the criteria weights performed in the sensitivity analysis simulation.

5.6 Evaluation of the process at Company T

After completing the method at company T, a survey was conducted with the manager to assess their opinion regarding the feasibility, usability, and usefulness of the developed process. The results can be observed in Table 19.

All dimensions scored above 4, indicating a "good" rating in terms of feasibility, usability, and utility from the manager's perspective. It was suggested that future research incorporate real-time measurements of energy consumption from equipment, as this study relied on theoretical data for electrical energy consumption. A list of suggestions based on the ISO 50001 standard for the items evaluated in the initial questionnaire was also developed, allowing the company to identify areas for improvement and understand what actions are necessary to meet the requirements proposed by the model. This list is available in Appendix.

Similar studies by [61] applied the Promethee II method for industrial energy efficiency prioritization, while [67] employed the TOPSIS method to evaluate energy efficiency investments in industrial settings. These approaches assist SME managers in making more informed and robust decisions by considering multiple financial and non-financial factors.

Five key decision-making criteria in energy management were established: return on investment, implementation cost, energy savings, productivity improvement, and organizational benefits. Heating and injection processes were identified as the largest consumers of electricity, followed by injector cooling, compressed air generation, and air conditioning. These findings are consistent with those of [68], who identified injection molding machines, compressed air systems, refrigeration systems, and auxiliary motors and pumps as the major electricity consumers in plastic injection industries.

Using the Promethee-ROC method, a ranking of 39 corrective action recommendations was generated based

Table 18. Sensitivity analysis.

Ranking	Alternatives	Net Flow	Sensitivity Analysis
1	2.6215 Turn off air conditioning during winter heating season	0.7057	100%
2	2.8122 Utilize utility-controlled energy management	0.4969	95%
3	2.6124 Establish equipment maintenance program	0.4533	72%
4	2.7211 Clean and maintain condensers and cooling towers	0.4464	78%
5	2.6218 Turn off equipment when not in use	0.3203	92%
6	3.4154 Eliminating leaks in water lines and valves	0.3203	100%
7	2.3135 Schedule routine maintenance during non-operational periods	0.2994	45%

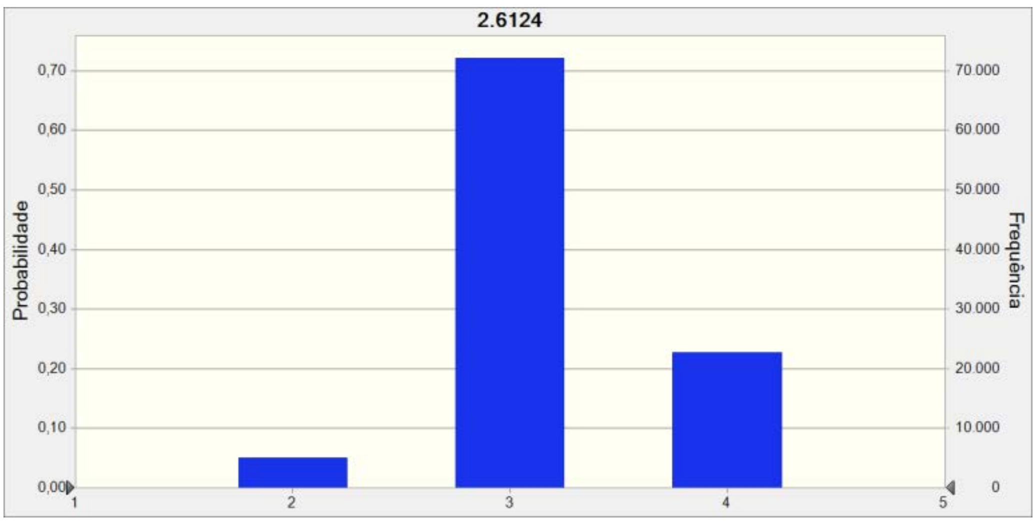

Figure 8: Variations in the positions of recommendation 2.6124 after sensitivity analysis.

Table 19. Evaluation of the method at company T.

Method Evaluation						
Mark the number that best expresses your response, according to the following order: 1 Very little; 2 Little; 3 Medium; 4 Good; 5 Very good.						
	Scores					**Observations**
Dimension: Feasibility	**1**	**2**	**3**	**4**	**5**	
The process was clearly defined				x		
There was enough information for selecting the recommendations				x		
Dimension: Usability	**1**	**2**	**3**	**4**	**5**	
At each stage, the process was clearly defined and easy to follow				x		
The process fosters engagement that facilitates achieving the objectives				x		
Dimension: Utility	**1**	**2**	**3**	**4**	**5**	
The outcome of the process was useful					x	
The process allows for active participation of those involved and group discussions				x		
The partial results of each stage (Meeting) justify the time spent				x		
The process increased my confidence in the results obtained				x		
The process helped me better understand issues related to Energy Management				x		Enhanced understanding of the importance of Energy Management in the company.
Additional Comments						
Real-time measurement of equipment energy consumption could be added to the process; in this process, theoretical consumption was used.						

5.6 Comparison to the literature

This research presents a structured and adaptable approach enabling small and medium-sized enterprises (SMEs) to identify, assess, and prioritize energy-saving opportunities, even when limited by technical expertise and resources in energy management, as initially observed in Company T. The study reinforces this concept by proposing an audit-based model for SMEs, aligned with the step-by-step auditing methodology found in the literature [22, 27], which constitutes a critical step in initiating an energy efficiency program, as highlighted by [19, 25].

A significant contribution of this research is the application and refinement of the multi-criteria Promethee-ROC method in the context of energy management within a plastic injection company. The model is designed to be replicable in other SMEs across various industrial sectors. The detailed process of adjusting impact levels perceived by decision-makers prevents tie rankings and facilitates the selection of alternatives, offering practical insights into the application of decision-support models in real-world scenarios. on IAC [28] guidelines. After sensitivity analysis, the top three recommendations were: turning off air conditioning during the winter heating season, implementing utility-controlled energy management, and establishing an equipment maintenance program. Similar suggestions are found in the work of [69], which emphasizes the importance of preventive maintenance programs, energy consumption monitoring by utility, and optimization of auxiliary systems—such as compressed air, HVAC, and equipment cooling—to reduce electricity consumption.

Additionally, four energy performance indicators were proposed for the company, based on ISO 50001 and relevant literature: energy consumption per unit of production [23, 41], electricity cost [37], total energy consumed [42], and CO_2 emissions [16, 22, 37]. The implementation of these recommendations is expected to reduce energy costs, increase productivity, and improve organizational performance, contributing to the company's sustainability and competitiveness.

The research also identifies key barriers to adopting energy management practices, such as high implementation costs, uncertainty regarding financial returns, and the lack of government incentive programs. These challenges are consistent with those frequently reported in the literature [14, 23, 34, 40]. Likewise, identified drivers—such as financial gains, organizational improvements, and process mapping for energy efficiency—are supported by the findings of [17, 25,59]. These alignments reinforce the validity of the study's findings within the broader body of existing knowledge, offering a tested and validated method that can be replicated to achieve both energy savings and organizational enhancements.

This research demonstrates the feasibility and practicality of a structured energy management approach within a small enterprise—an industrial segment often lacking the internal resources or expertise to implement complex energy efficiency programs. Various authors have noted that energy efficiency practices are more commonly adopted by large enterprises due to their greater financial and technical capacity [14, 34]. The positive feedback received from the manager of Company T regarding the feasibility, usability, and usefulness of the proposed process underscores the practical value of this approach.

Overall, this study is relevant for bridging the theoretical frameworks of energy audit models, multi-criteria decision analysis, and energy management concepts with the practical reality of an industrial SME. It offers a validated and replicable method capable of driving energy savings and organizational improvements.

6. Conclusion

The overall objective of the research was to develop a model to support the implementation of an energy management program in small and medium-sized enterprises (SMEs) based on audits, and this was achieved through the construction and execution of the model in the case study conducted in the plastic injection industry.

The literature review identified gaps regarding models for audits and implementation of an Energy Management System in small and medium-sized enterprises. Based on this, the construction of a model using information gathered from literature and standards was proposed, with the support of the Process Approach methodology. A database with recommendations for improving energy efficiency from the Industrial Assessment Centers (IAC) was also used, proposed after conducting the audit, with the assistance of the Promethee-ROC decision-making support method, which helped managers rank recommendations according to established criteria for each context.

An audit was conducted to test the proposed model, which was conducted in a small company in the plastic injection segment. Through this application, it was possible to test and evaluate the audit model. The model was evaluated through the manager's perception regarding feasibility, utility, and usability, dimensions proposed by Platts in the Process Approach, where a 'good' classification was obtained for all items.

One limitation of the research was its application in only one industrial segment, which was the plastic injection industry and a small-sized company. Another limitation was the manager's availability of time to answer questionnaires and accompany visits.

It is suggested that the developed model be used in other industry segments and sizes of companies, as this research was limited to small plastic injection industries. Additionally, using other recommendations from the IAC database to assess managers' perceptions of the recommendations using the Promethee-ROC multicriteria method would be beneficial. Furthermore, monitoring the implementation of the recommendations proposed in this research would be valuable to verify if they were efficient and effective in reducing energy consumption and increasing the energy efficiency of the company.

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APPENDIX

List of recommendations for items evaluated in the initial questionnaire

3.14 Energy policy: the organization's statement of its intentions and general guidelines related to its energy performance, formally expressed by top management. The energy policy provides a framework for actions and for establishing energy objectives and energy targets. 4.3 Energy policy The energy policy should declare the organization's commitment to achieving improved energy performance. Top management should define the energy policy and ensure that it: - Is appropriate to the nature and scale of the organization's energy use and consumption; - Includes a commitment to continuous improvement of energy performance; - Includes a commitment to comply with applicable legal requirements and other requirements to which the organization subscribes, related to its energy efficiency and energy use and consumption; - Provides a framework for establishing and reviewing energy objectives and targets; - Supports the acquisition of energy-efficient products services and projects for improving energy performance; - Is documented and communicated at all levels of the organization; - Is regularly reviewed and updated as necessary."
Is there someone responsible for Energy Management in the company? 3.10 Energy management team: person(s) responsible for the effective implementation of energy management system activities and for achieving energy performance improvements. 4.2.2 Management representative Top management should appoint management representative(s) with appropriate skills and competence(s), who, regardless of other responsibilities, have the responsibility and authority to: - Ensure that the EnMS is established, implemented, maintained, and continually improved according to ISO 50001 standards; - Identify the person(s), authorized by the appropriate managerial level, to work with the management representative in supporting energy management activities; - Report energy performance to top management; - Report EnMS performance to top management; - Ensure that energy management activities planning is aimed to support the organization's energy policy; - Define and communicate responsibilities and authorities to facilitate effective energy management; - Determine criteria and methods necessary to ensure that both EnMS operation and control are effective; - Promote awareness of energy policy and objectives at all levels of the organization."

Is the company interested in Energy Management? 4.2 Management responsibility 4.2.1 Top management Top management must demonstrate its commitment to supporting the EnMS and continually improving its effectiveness through: - Establishing, implementing, and maintaining an energy policy; - Appointing a management representative and approving the formation of an energy management team; - Providing necessary resources to establish, implement, maintain, and improve the EnMS and resulting energy performance; - Identifying the scope and boundaries to be addressed by the EnMS; - Communicating the importance of energy management to everyone in the organization; - Considering energy performance in long-term planning; - Ensuring that results are measured and communicated at determined intervals; - Conducting management reviews.
Does the company regularly collect energy consumption and cost data? 3.6 Energy baseline: quantitative reference(s) providing a basis for comparison of energy performance. The energy baseline is also used to calculate energy savings, as a reference before and after the implementation of energy performance improvement actions. 4.4.3 Energy review: The organization must develop, record, and maintain an energy review. The methodology and criteria used to develop the energy review must be documented. To develop the energy review, the organization must: - Analyze energy use and consumption based on measurement and other data, namely: - Identify current energy sources; - Assess current and past energy use and consumption; - Based on the analysis of energy use and consumption, identify areas of significant energy use, namely: - Identify facilities, equipment, systems, processes, and personnel working for the organization or on its behalf that significantly affect energy use and consumption; - Identify other relevant variables affecting significant energy uses; - Determine the current energy performance of facilities, equipment, systems, and processes related to the identified significant energy uses; - Estimate future energy use and consumption; - Identify, prioritize, and record opportunities for energy performance improvement; - The energy review must be updated at defined intervals, as well as in response to significant changes in facilities, equipment, systems, or processes.
Does the company conduct energy audits? 3.20 Internal audit: A systematic, independent, and documented process of obtaining evidence and objective evaluations to determine the extent to which requirements are fulfilled.
Does the company have energy objectives linked to its organizational policy? 3.11 Energy objective: specific outcome or achievement established to meet the organization’s energy policy related to improving energy performance.

Is the company aware of any governmental energy management incentive programs? Energy Efficiency Program The goal of the PEE is to promote the efficient use of electric energy in all sectors of the economy through projects that demonstrate the importance and economic viability of improving the energy efficiency of equipment, processes, and end uses of energy. The aim is to maximize the public benefits of saved energy and avoided demand, promoting the transformation of the energy efficiency market, stimulating the development of new technologies, and fostering rational habits and practices in the use of electric energy. PROCEL - National Program for Electric Energy Conservation It is a government program, coordinated by the Ministry of Mines and Energy - MME and executed by Eletrobras. It was established on December 30, 1985, by Interministerial Ordinance No. 1,877, to promote the efficient use of electric energy and combat its waste. PROCEL's actions contribute to increasing the efficiency of goods and services, developing habits and knowledge about efficient energy consumption, and also postponing investments in the electric sector, thus mitigating environmental impacts and contributing to a more sustainable Brazil. On May 3, 2016, with the enactment of Law No. 13,280, a new cycle began, as PROCEL began to have a source of funds. The Law provides for the definition of annual plans for the application of these resources, plans that are elaborated and approved, after a public consultation process, by representatives of the government and agents of the national energy sector, which gives transparency and credibility to the investments made. In this context, PROCEL promotes energy efficiency actions in various sectors of the economy, which help the country save electric energy and generate benefits for society as a whole.

Does the company know the actual energy consumption of its process equipment? 3.27 Significant energy use: Energy use responsible for substantial energy consumption and/or offering considerable potential for energy performance improvement.
Does the company identify opportunities for energy savings? 4.4 Energy planning: 4.4.1 Generalities: The organization must conduct and document an energy planning process. Energy planning should be consistent with the energy policy and should lead to activities that continually improve energy performance. Energy planning should involve a review of the organization's activities that may affect energy performance.
Are company employees educated about Energy Management? 4.5.3 Communication: The organization must communicate its energy performance of the EnMS appropriately to the size of the organization. The organization must establish and implement a process whereby anyone working for it or on its behalf can provide comments or suggestions for improvements to the EnMS. The organization must decide whether to communicate externally about its energy policy, the EnMS, and energy performance, and must document its decision. If the decision is to communicate externally, the organization must establish and implement a method for this external communication.
Does the company have access to available Energy Management technologies? 4.5.7 Acquisition of energy services, products, equipment, and energy: When acquiring energy services, products, and equipment that have or may have an impact on significant energy use, the organization must inform suppliers that the acquisition is partially evaluated based on energy performance.

Does the company have capital available to invest in Energy Management? Clima Fund - Efficient Machinery and Equipment Subprogram - BNDES Financing for the acquisition and production of machinery and equipment with higher energy efficiency ratings or that contribute to the reduction of greenhouse gas emissions. Clima Fund - Efficient Machinery and Equipment Subprogram - BNDES Financing for the acquisition and production of machinery and equipment with higher energy efficiency ratings or that contribute to the reduction of greenhouse gas emissions.
Does the company have qualified individuals in Energy Management? 4.5.2 Competence, training, and awareness: The organization must ensure that any individuals working for it or on its behalf and related to significant energy uses are competent based on appropriate education, training, skills, or experience. The organization must identify training needs associated with controlling its significant energy uses and operating its EnMS. The organization must provide training or take other actions to address these needs. The organization must ensure that individuals working for it or on its behalf are aware of: - The importance of compliance with the energy policy, procedures, and EnMS requirements; - Their roles, responsibilities, and authorities for meeting EnMS requirements; - The benefits of improving energy performance; - The impact, real or potential, with respect to energy use and consumption, of their activities and how their activities and behaviors contribute to meeting energy objectives and targets and the potential consequences of deviating from specified procedures.