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Business model for energy efficiency in manufacturing

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Abstract

The study proposes a business model for energy efficiency and provides a tool that describes how manufacturing companies create, deliver and capture value, and at the same time evidencing the energy inefficiencies, wastes and manufacturing performances that are critical to the business model. Accordingly, we analyze cause-effect relationships between manufacturing performances and business model performances, and patterns of business models that can be adapted to develop a new structure focused on energy efficiency. To achieve this, a case study in the rubber manufacturing industry is carried out for the development and validation of concepts.

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Keywords: Energy efficiency; sustainable manufacturing; business model; eco-factory; performance.

1. Introduction

Traditional manufacturing companies used to focus their business models on delivering high-quality tangible products at low costs. However, the competition rules in the industry have changed in the last decade since pure low cost strategies are not as effective as before. In that regard, sustainability has become a key strategy that not only returns benefits for the environment and society, but also provides significant opportunities for the companies to increase their competitive advantage, attract eco-friendly customers and reduce costs in the long term.

Improving energy efficiency is one way to start the journey toward sustainability, especially in energy-intensive manufacturing industries, as it returns higher productivity, increased competitiveness and lower costs, apart from the benefits associated with environment [1]. There is a growing global concern along with the powerful pressure on policy makers and the industry since global energy consumption, where the majority of supplied energy continues to be from carbon based sources, increased more than 25% in the last 20 years and a further 15-35 % increase is expected by 2030 [2]. Besides, the manufacturing sector accounts for one third of global primary energy consumption, corresponding to more than 38% of the direct and indirect CO2 emissions [3]. Manufacturing units and factories therefore play a critical role in achieving these targets. A factory as a socio-technical system combines factors such as labour, material, energy, information and machines for the purpose of value creation in forms of products and services. While a significant part of energy and resources are used to create value, significant parts are wasted in terms of emissions, heat, and other losses [4, 15].

Nevertheless, so far this concept has been approached mostly in technical and operational levels rather than managerial. Hence, this study intends to alter the notion of energy efficiency to a strategic level by proposing a business model for energy efficiency for manufacturing companies. With this aim in mind, we provide a tool that describes how manufacturing companies create, deliver and capture value, and at the same time evidencing the energy inefficiencies, wastes and manufacturing performances that are critical to the business model. Accordingly, we analyze cause-effect relationships between manufacturing performances and business model performances, and patterns of business models that can be adapted to develop a new structure focused on energy efficiency. To achieve this, a case study in the rubber manufacturing industry is carried out for the development and validation of concepts.

The research might benefit manufacturing companies that want to improve their business models by adopting an energy efficiency philosophy, as the model could enable a comprehensive view of the inherent business logic and

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environmental impact, allowing top managers to take green decisions.

2. State-of-the-art

Over the past few decades, the increasing concern about climate change, scarcity of resources and energy supply has increasingly changed the attitudes of society and industry towards the environment. Industrial firms have been affected by growing energy prices, strict environmental regulations, customer demand and environmental awareness. Guided by this paradigm shift toward energy management in manufacturing due to global and industrial drivers, the issue of improving energy efficiency (EE) therefore gains more and more importance. Thus, companies have been feeling the pressure to single out the determinants of environmental performance for their manufacturing processes [5]. As a consequence of this, EE has become the new topic of interest for the industry and academia as it can reduce both economic and environmental impacts related to the consumption of energy [6].

Improving EE in production facilities has become a big challenge for managers regardless of the industry sector. For a shift toward energy efficient manufacturing systems, proper tools are required to model and assess energy consumption behaviour in a manufacturing environment [16]. Guided by this particular challenge, academicians and practitioners have been making attempts to provide efficient and reliable tools, and this field has become a rapidly developing area [7]. Hence, a significant number of tools have been proposed for this purpose [17].

Implementing energy efficiency like any other strategy needs a properly developed Business Model, that supports not only the company during its path to achieve energy efficiency but also to evaluate and improve manufacturing performance, not just in terms of traditional indicators, but also taking into account energy efficiency in response to the environmental problems and the accelerated climate change which increase customers' demand for eco-friendly products and trigger more strict regulations set by governments [1].

The current state and trend of environmental degradation (from regulatory, consumer, and moral positions) indicates a need for a change in manufacturing strategy, i.e. a fundamental shift in the way production systems operate. This requires an approach towards sustainability, achieved through significant reductions in energy and material use and a move away from one-time use and product disposal. The first step in such a shift is to extend the structure of the current one-way supply chain to a closed loop, including supply chain operations designed for end-of-life product and packaging recovery, collection, and reuse in the forms of recycling and remanufacturing [8].

Energy efficiency is considered as one of the most relevant sustainability archetypes. The potential of the energy efficiency programs is significant as only 37% of the primary energy is converted into useful energy [9]. Thus, this significance of energy efficiency strategies has been tested worldwide through the production of vehicles that require less fuel, home appliances and lamps which consume less electricity.

Nowadays, companies invest more and more to implement energy efficiency practices to compete in relation to added value dealing with clients who demand eco and energy friendly products daily. Thus, explanatory guidelines and additional motivational factors are required to make companies implement energy efficiency strategies. Bowen et al. [10] state that organizations will adopt material and energy efficiency management practices if they identify that this will result in specific financial and operational benefits. Thus, this research investigates the potential link between the mentioned practices and the increasing of competitiveness and enhanced economic performance, to provide an impetus for organizations to green their supply chains. On the other hand, enterprises in practice need a guide and a model to achieve EE successfully. The model should aggregate the findings of the current literature and combine it with empirical findings to suggest a list of objectives, enablers and practices for EE in different levels of the supply chain.

In this context, the main portion of the literature missing till now is related to the inclusion of energy efficiency concept in a strategic tool such as a business model. Thus, this study addresses the following gap:

Gap: Lack of a widespread and precise business model for energy efficiency for manufacturing companies that can describe the companies' logic for generating revenue while implementing an energy efficiency approach

Doing this, the study determines the impacts of the energy efficiency performances in manufacturing companies, as well as defining the principal drivers of energy efficiency that impact the performance of this kind of companies. This analysis is carried out in order to create knowledge for the implementation of a more effective business model which supports manufacturing companies in entering the sustainable journey by considering all the enablers, variables and relationships that exist between energy efficiency and other manufacturing performances of companies.

3. Research framework

A research hypothesis is the first step of an academic research. According to Kothari et al. [11], research hypothesis is a logic statement of what will be investigated in the research and it has a supportive nature of predicting the relationship between variables. This research is based on two hypotheses. The first one is the preliminary hypothesis which predicts the additional value perceived by the customer that is generated by the design of the energy efficiency business model in companies, while the second one is the main hypothesis which predicts the positive impact of the energy efficiency business model on the manufacturing performances of a company.

The research framework is a key aspect for the researchers to choose the right research methods. The framework presented in Figure 1 is divided into three main sections: (i) enablers, (i) business model for energy efficiency for manufacturing companies, and (iii) manufacturing performances.

The enablers are the influencing theories and factors that facilitate the knowledge creation. The most important enablers for the creation of the business model for energy efficiency for manufacturing companies originate mainly from the sustainability theory. In this context, May et al. [6] proposed 4 main enablers for energy efficiency: (i) strategic approach, (ii)

supporting tools and methods, (iii) manufacturing process paradigms, and (iv) ICT. In this research, our main focus is on the strategic approach enabler since business models are tools that support companies on the strategic level.

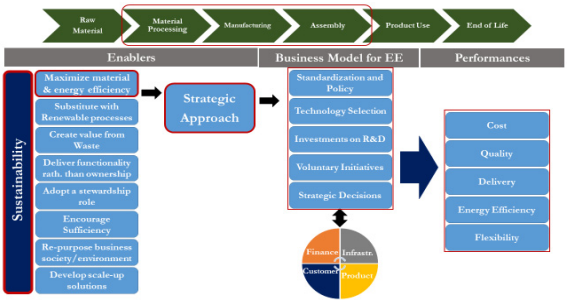

Fig. 1. Research framework

However, as sustainability is a broad concept, we consider it in eight main archetypes proposed by Bocken et al. [12]. For the creation of a sustainable business model, it is of paramount importance to consider these eight "sustainable business model archetypes", i.e. groupings of mechanisms and solutions that allow the development of business model for sustainability. In particular, this research focuses on the "maximize material and energy efficiency" archetype.

Taking into account the research gap and the research hypothesis of the previous sections, the objective of this research in general can be defined as "design a business model for energy efficiency in order to provide knowledge that can be used by manufacturing companies to incorporate an energy efficiency strategy".

In order to achieve this objective of the study, we present the research process in different stages (Figure 2), each one including a number of sequences of tasks and activities. We divide our study into three general phases, each phase targeting a specific research objective.

Figure 2 shows that the research process is made of a number of related activities, as it is indicated through I to VII. We classify the steps in three main phases: (i) context analysis and definition, (ii) development and design, and (iii) interpretation. The first two phases concern the first research objective, i.e. design a business model for energy efficiency in manufacturing companies; whereas the third phase targets the second research objective with (i) qualitative modelling of the business model, (ii) cause- effect analysis; and (iii) interpretation of the final business model through an industrial application (i.e. Manuli Rubber Industries).

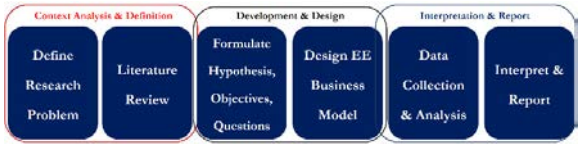

Fig. 2. Research process

4. Business model for energy efficiency

In this section, we describe the model proposed in this research, starting from a global explanation of the model and followed by a detailed description of each of the building blocks that are implemented in the business model for energy efficiency for manufacturing companies. We propose a model which comprises ten building blocks. Our starting point was the business model canvas that is considered among the best instruments to describe business models available in the literature, but when approaching the energy efficiency and manufacturing values, some gaps were identified.

In our model, as well as in the canvas, we propose building blocks that all together describe the way the company have to generate revenues. The particularity of the proposed business model for energy efficiency for manufacturing companies is that we include two new building blocks that the Canvas does not consider. First, the "Waste Generators" building block which aims at identifying the "Muda" inherent in the business model and so, the impacts that this generates to the environment. The second building block that we considered to add is the "Manufacturing Performances". This building block is essential for an energy efficiency business model as high performances could directly relate to the profitability and enhanced sustainability for companies. Hence, Figure 3 illustrates the business model for energy efficiency for manufacturing companies.

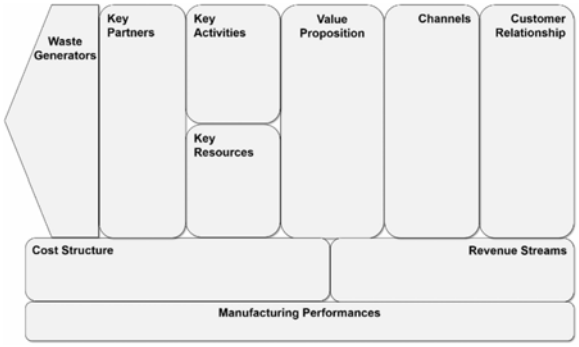

Fig. 3. Business model blocks

The business model is based on four main pillars: customer interface, manufacturing strategy, evaluation aspects, and infrastructure management. These pillars were adapted from the ones employed by Osterwalder on his publication "Business Model Ontology" [13]. Unlike Osterwalder's approach, the building blocks can be supported in more than one pillar. **The manufacturing strategy** pillar encompasses the building blocks that are core for manufacturing companies.

In a manufacturing strategy, there are always involved activities performed to manufacture the product, the value proposition that is core for every strategy and the channels to approach the customers. **The customer interface** pillar supports all the building blocks that aim at establishing relationships or connections with the customer. This pillar includes the channel and the customer relationship building blocks. **The infrastructure management** comprises the building blocks that define the infrastructure, the resources and the partnerships needed to perform the value proposition, and also the wastes that the model generates. **The evaluation aspects** pillar contains the building blocks that evidence the performances of the model (cost structure, revenue streams and manufacturing performances). This pillar reflects the requirements of manufacturing companies to control cost

margins and performances to ensure and sustain a competitive position for the organization.

Figure 4 illustrates the relationships between the pillars and the building blocks of the business model for energy efficiency for manufacturing companies.

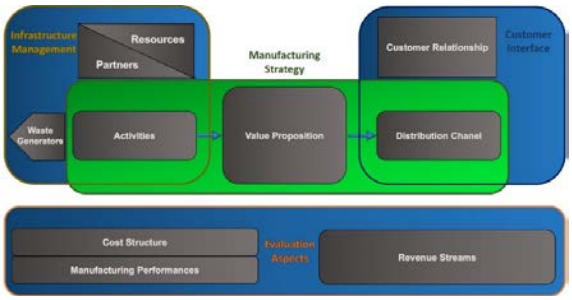

Fig. 4. Business model pillars

The final Energy Efficiency business model was constructed based on the collected data from the literature and the case application. In this respect, a set of enablers and objectives are required for defining the EE strategy. To develop this, we used a hierarchical diagram using a top down methodology (Figure 5). Initially, for each block of the business model, we set a specific theoretical model that allows the description of the respective block, and established a set of objectives that should be achieved in order to pursue an EE approach. In the next step, we list the potential enablers for each objective. This list is limited to the enablers or suggested decisions that mainly focus on the energy efficiency strategies rather than the traditional manufacturing practices. The following approach is used to establish the details for each block of the new EE business model.

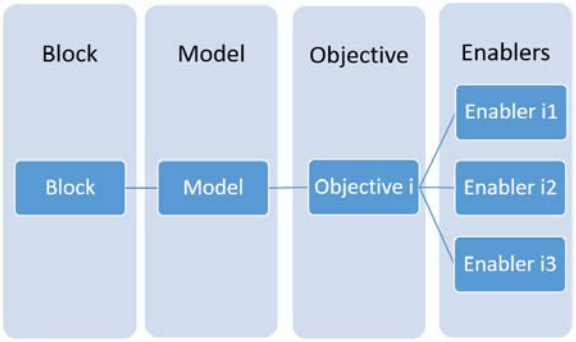

Fig. 5. Hierarchical diagram

Below, we will provide the details for the two new blocks, i.e. (i) waste generators, and (ii) manufacturing performances.

Waste Generators: Given that the impact of the energy inefficiencies and wastes generated by the company are crucial for the implementation of green manufacturing, the Waste Generators building block was devised mainly to highlight these two streams in a strategic tool such as a business model (see Figure 6). The main purpose of this block is to highlight the company's environmental impact to control energy and waste streams on a strategic level.

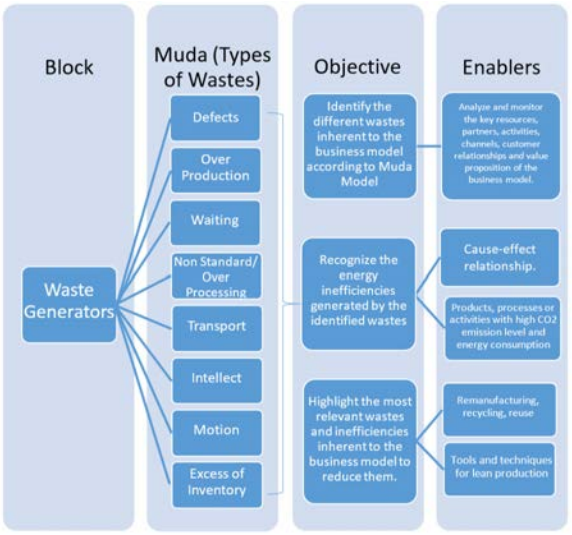

Fig. 6. Waste generators

Manufacturing Performances: An important component in the supply chain analysis of the manufacturing companies is the establishment of appropriate performance measures. A performance measure is used to determine the efficiency or effectiveness of an existing system, or to compare competing alternative systems. The concept of operational strategy is defined by the relative importance of the manufacturing performances of low cost, quality, delivery and flexibility. Nowadays, it is important to introduce another manufacturing performance, i.e. energy efficiency. Even if a traditional strategy is not adopted, energy efficiency is a mechanism that allows companies to: (i) decrease dependence on scarce primary energy sources, (ii) reduce greenhouse gas emissions,

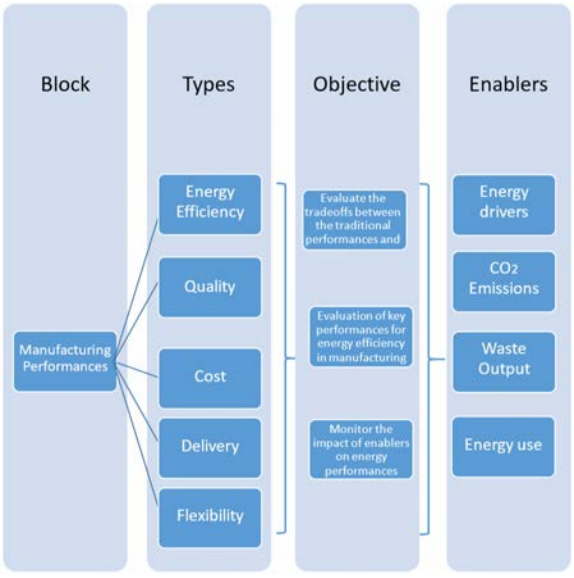

Fig. 7. Manufacturing performances

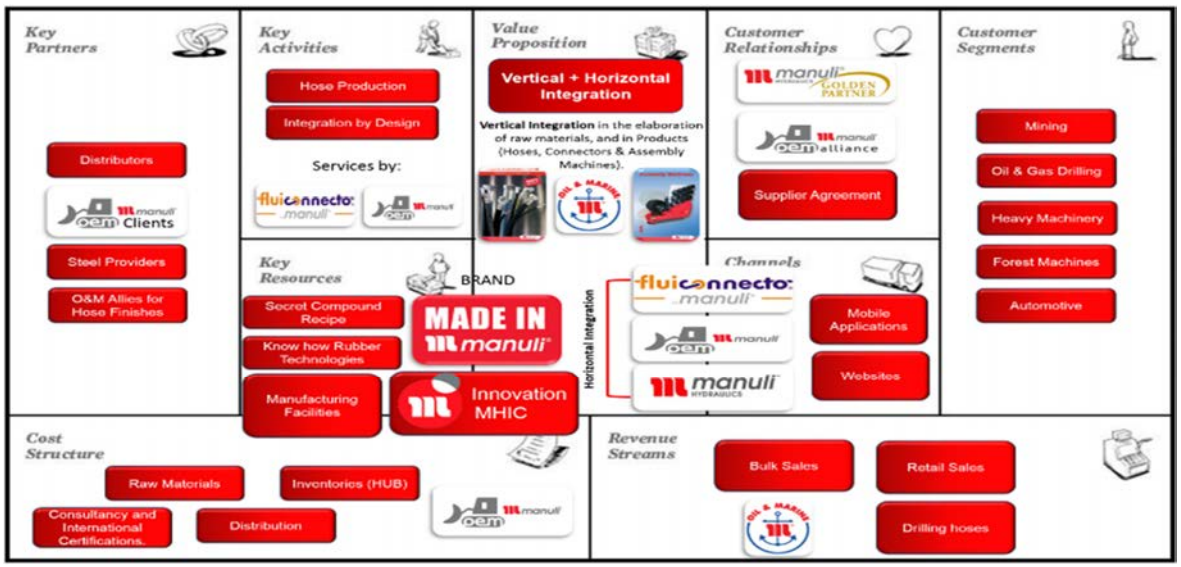

Fig. 8. Business model canvas for Manuli Rubber Industries

(iii) achieve better economic performance, and (iv) contribute to the improvement of the quality of life of the society [14].

5. Case study

To develop the EE business model, we carried out an extensive review of the literature on energy and manufacturing efficiency and conducted a case study with an Italian manufacturing company (Manuli Rubber Industries). The objective of the case study analysis was to elaborate and identify the EE and manufacturing efficiency practices and enablers to develop the EE business model. Analysis of the data from the case study generates a set of enablers which can be applied in manufacturing companies. Then, based on the set of enablers it is possible to create two new building blocks, i.e. manufacturing performances and waste generators.

Even though the success and long history of Manuli rubber Industries, in the past the top managers have not implemented a strategic tool such as a business model in the decision making processes. Consequently, the industrial application included two phases, and in the first phase, we mapped the "As-is" business model canvas. Then we redesigned this "As-is" model of Manuli Rubber Industries (MRI) in the second phase, but this time we considered also the requirements and additional building blocks for the development of a business model for energy efficiency in manufacturing. Figure 8 highlights the results of the business model canvas designed for MRI, describing as well each of the nine building blocks.

Despite the fact that both the canvas and the business model for energy efficiency for manufacturing companies represent the same reality of how the company generate revenues, in the second model, top managers have available also the main

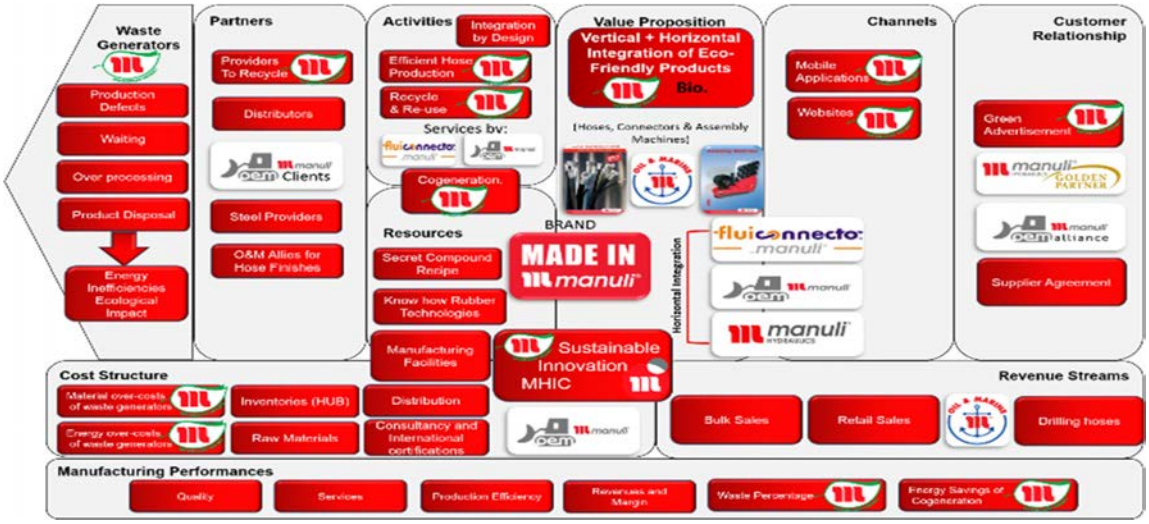

Fig. 9. Business model for energy efficiency (Manuli rubber industries case)

weaknesses and challenges that the company should attack in order to improve energy efficiency and the "Muda". This information, represented in the "Waste Generators" building block, is not presented in the Canvas, and support top managers to understand where the company needs to improve, facilitating and supporting the long term decision making process of the company. Figure 9 highlights the results of the business model for energy efficiency for manufacturing companies designed for Manuli rubber industries, describing as well each of the ten building blocks.

Another benefit of the "Waste Generators" building block, when compared to the Canvas, is to support the cost structure building block in identifying the cost for energy inefficiencies and wastes. With this information, and considering that the majority of the decisions made by a company are influenced by the cost and revenues, top managers will better understand the hidden costs of not being efficient and green.

On the other hand, the business model for energy efficiency for manufacturing companies, alike the business model canvas, highlights the main manufacturing performances that the company is committed to, so as to verify that the strategic decisions are aligned with these traditional performance measures as well.

6. Discussion and concluding remarks

This study was developed observing a linkage between energy efficiency and manufacturing performances in the literature. In order to support manufacturing companies, the research aimed at developing a business model that can be implemented not only to improve their energy efficiency performance but also to enable the manufacturing efficiency.

By analyzing the case study of Manuli Rubber Industries and applying the semi-structured interviews and the action research methodology, we were able to identify the way in which manufacturing companies address energy efficiency strategies. Besides, we analyzed together with the top managers of MRI the variables related to energy efficiency that are more relevant at the strategic level of the company, and together predicted the main benefits that such business model structure will provide to the company. Finally, we assessed the main cause-effect relationships between manufacturing and business model performances. After the culmination of the modelling phase, the top managers of MRI analyzed and validated the output and the applicability of the model. They believe that this model will enhance the sustainable approach that the company is having nowadays.

Despite the advantages that arise from this research, there are some limitations as well. The first limitation is that most of the manufacturing companies are in an immature phase of energy efficiency implementation what makes difficult to find established energy efficiency strategies. Moreover, due to the lack of access to the right contacts at a strategic level of other manufacturing companies, the final number of companies used as industrial cases is just one. The outcome would be more reliable based on use a larger sample of companies.

In order to improve the present research, upcoming studies should be oriented to empirically test the effectiveness of this model in other manufacturing sectors and geographical areas. Cross-sectorial together with cross-location comparative studies are essential to certify the validity and applicability of the model.

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