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Assessing the driving factors for energy management program adoption

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ABSTRACT

The concept of energy management (EnM) became a topical issue in industrial settings as a result of the energy crises that affected the global community in the 1970s. However, EnM was not implemented within industry with all its potential to improve energy security, raise the maturity level of EnM and increase sustainability. According to the results of previous empirical investigations, the expected interest in energy programs is not found and there is no clear understanding about program adoption criteria within an industry. Keeping in mind the adoption of energy investment through conformation with financial analysis and choosing the investments through contextual factors in the organization (e.g. organizational energy culture, power relationships, EnM system, expertise availability, managers' mindset) together with characteristics of EnM program as two macro perspectives in energy efficiency literature, this paper aims to understand the main driving factors which lead organizations to either adopt or not adopt a particular program (always with respect to energy management). Moreover, it aims to express the impact of those driving forces of implementing a successful EnM program which could contribute to better understanding of suitable EnM configuration. The investigation has been conducted as a multiple case study involving 15 manufacturing companies of varying size and in different sectors located in Sweden. After analyzing the minimum required steps to establish EnM, assessing the adoption of practices according to their energy strategy, and through assessing EnM maturity level, we found a low level of risk (which arises from lack of certainty and awareness) and the program's alignment with the core business as prominent driving factors for all sizes which foster positive investment decision making through top management. On the contrary, complexity of industry (for large manufacturing companies) and access to capital (for small and medium-sized companies) are the main barriers to adopting those programs.

1. Introduction

Believing energy to be finite and nature as a place to live not only for the present generation, but for future generations increasingly leads us to use energy smarter and more efficiently. Meanwhile, industry, especially energy-intensive industries, as a major energy user receives relatively more attention. While according to an International Energy Agency report in 2007 [1], industry in all sectors had made successful improvements, Hirst and Brown's claim in 1990 [2] about the existence of the gap between the actual level of Energy Efficiency (EE) and its potential still remains strong [3]. According to IEA, if current trends continue, two-thirds of the economic potential to improve EE will remain untapped until 2035 [4]. Several researchers addressed barriers to implement EE measures, namely the complexity of energy efficient technology [5], and implementing EE measures is a challenge because of industry's complexity (an industry's characteristics) [6]. Therefore, this challenge makes it difficult to generalize any success stories or programs. Researchers addressed Energy Management (EnM) as a tool for overcoming EE barriers. Energy management means to optimize one of the most complex and important managerial and technical creations that we know: the energy system.

The necessity of EnM for those industries willing to be and stay competitive is mature enough, according to the different type of drivers which lead a particular industry to adopt EnM. Within the last twenty years, with increasing energy prices and a global energy crisis, previous studies addressed its strategic and efficient role in improved energy systems. Fig. 1 shows the most discussed drivers for EnM adoption within industry. Drivers can be classified through EnM's capability to overcome barriers related to implementing EE measures, energy fluctuation trends, through its capability to increase a company's focus on improving energy system and other external pressures like environmental legislation (Fig. 1). To establish a proper EnM program in the body of EnM literature, certain minimum steps must be implemented. Those elements, illustrated in Table 1, are addressed in previous

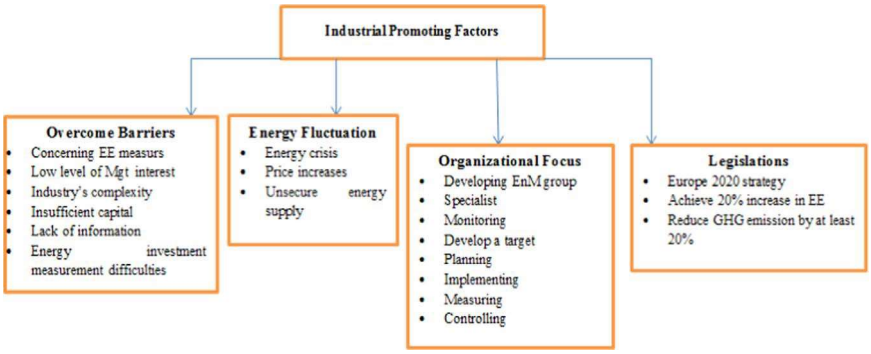

Fig. 1. Industrial drivers to adopt EnM.

Table 1
Minimum required steps to establish the EnM.

Refs.	Required steps	Code
[7,11,36]	Long-term strategic planning	S1
[36]	Energy practices by allocating responsibilities and tasks	S2
[7,10,36]	Establish energy management team by energy manager	S3
[10]	Developing procurement policies	S4
[7,10,36]	Conducting initial energy audit	S5
[7–11,36]	Implement energy-saving projects	S6
[10,36]	Monitoring the project's progress	S7
[11,36]	Monitor energy use by main energy user equipments	S8
[7,10,36]	Develop report documentation	S9
[11,36]	Top management support	S10
[36]	Awareness and training	S11

Table 2
Strategic investment descriptions.

Refs.	Description of strategic investment
[25–27]	Decisions as vital importance.
[28]	Decisions which have a significant effect on the organization as a whole.
[25,28,29]	Decisions which have a significant potential for improving corporate performance.
[30]	Strategic means important and not secondary issue.
[31]	Decisions regarding the goals, domains, technologies and structure of a firm.
[32]	Decisions regarding a firm's development through products-market-technologies triplets
[33]	An investment is "strategic if it contributes to create, maintain or develop a sustainable competitive advantage"

studies [7–11] and cited in [6]. However, improving energy system through EnM is also difficult because of many misconceptions between practitioners (e.g. only big companies can do it, only plants with new equipment can do it, large capital budgets are required, we don't have enough time and staff, we already do everything we can, and everybody manages energy) and the barriers which depend on the geographic location and nature of the industry itself (such as energy intensity and size) [12,13]. Therefore, the maturity level of EnM programs (which can be assessed through EnM programs for policy, organizing, training, performance measurement, communication and investment [Appendix B] with its huge potential for improved energy systems is still far from what it should be in practice based on the adopted highest success levels. That remaining potential has been untapped not only because of the mentioned barriers, but also because of lack of understanding about *how* an EnM program should be planned. Consequently, it causes a weak alignment between energy programs and the company's total strategy or the company's macroeconomic policy and also because of lack of transparency which accordingly increases the nature of risk at different levels.

In EE literature, EnM through its systematic programs and more precisely through its practices is characterized as an industrial energy system support function. However, EnM is not properly implemented and/or not fully adopted in practice, with all its potential, to help companies improve their EnM maturity level and, as a consequence, to enhance the energy system. In a macro perspective, there are two different perspectives in the body of EE literature about investment decision making. A number of earlier researchers [14–17] believe EE investments would be decided upon if the financial analysis conforms to the investment for a particular program (which is in line with finance theory). However, others [18–21] emphasize other contextual factors, such as organizational energy culture, power relationships, EnM system, existence of expertise, managers' mindset as well as external factors such as energy price. Moreover, earlier researchers [13,19,22,23] addressed strategic links between any EE investment with the company's core business as an important driving factor. Fleiter et al. [5] in a study about the low adoption rate argued that the characteristics of EE measures can enhance the adoption rate. Therefore, among other driving factors, the strategic characteristic of an investment is essential to foster its adoption through top management [24]. However, strategic decision making literature did not provide a clear and applicable answer about what makes an investment strategic. Some researchers in this field have described strategic decisions as follows in Table 2.

The definitions provided by strategic process research are not comprehensive enough to understand the strategic character of investment decisions because the aspect of the scope and content of investments is not properly taken into account. Adopting a practice based on how it is aligned with an organization's strategy would not lead us to clear and proper selection and would leave us in a vague situation. The reason is that either the firm's strategy is not often identifiable or it is nonexistent [33]. Cooremans [33] and Sa et al. [34] argued in their papers about enhancing the understanding of the scope and/or target of each practice or investment to make it more strategic and aligned with organization's total strategy. Sa et al. [35] argued that without understanding the scope and target of a particular energy management practice (EnMP) it is not possible to avoid an overlap

Table 3
Case study distribution.

	Iron & Steel	Chemical	Plastic	Food	Foundry	Cement	Sum
Small and Medium	1	1	1	1	2	1	7
Large	1	2	1	1	2	1	8
Sum	2	3	2	2	4	2	15

between EE measures and energy management practices (EnMPs), and it also causes failure in adopting a proper EnM configuration through a single industry's characteristics. Therefore, Sa et al. [34] in another study, with inspiration from Turner [36], classified energy strategies as follows for each subcategory: Reliability, efficiency, low/no cost, funding and awareness and allocate program. It is important to analyze how a particular program enables a firm to strengthen its strategic position [33]. Therefore, in this way energy-related issues would not be seen as a secondary issue but as a strategic issue. Therefore, this paper, in an investigation of 15 Swedish energy-intensive companies of different size and in different sectors, aims to understand the main positive and/or negative driving factors which lead organizations to adopt or not adopt a particular EnM program.

For this, and also to have a better and clearer understanding about establishing a proper EnM, all minimum required steps which should be taken by the company to establish and operate EnM are assessed. Also, the adoption level of EnMPs has been analyzed according to their strategic energy role which was proposed in [36] and presented in [34] and shown here in Appendix A. Moreover, a company's EnM maturity level is tested according to the EnM matrix proposed in the Carbon Trust [37] and shown in Appendix B. Measuring the maturity level of an EnM program is essential because it enables managers to understand and identify the hidden barriers within their ongoing energy program and related practices. At the end, we discuss the impact of positive decision making drivers of successful implementation of an EnM, which could contribute to better understanding of suitable EnM configuration.

2. Methodology

Considering the research aims described above and the nature of the study, this study was carried out as a multiple case study of 15 Swedish energy intensive industrial sectors, where the term “industrial sector” means any sub-sector of the manufacturing sector, in small, medium and large size. Distribution of interviewed cases is shown in Table 3. Case study research is especially advantageous when “how” or “why” questions are being posed [38]. Moreover, multiple case study is preferred over a single case study because it offers more robust analytical conclusions. Since mostly in-house conditions were to be studied, a smaller number of replications was needed [39].

2.1. Adoption driver factors

Literature determines top management support as a key and very important driver to adopt any proposed EnM program [40]. Payback criteriais another driver which gives priority to or leads to rejection of any proposed measure within a program [11,40,41]. Thollander and Ottosson [11] in an empirical investigation within the Swedish pulp and paper and foundry sector showed that companies apply a criterion of three years or less for an EE's pay off. Result from another investigation which was conducted in the developing countries across nine manufacturing subsectors, fell into a time span of 0.9–2.9 years [42]. Pay-off criterion differs through countries and time horizon when we look at what Gruber and Brand showed in 1991 [43]. In an empirical study in Germany with a sample size of 500 SME companies, the average required payback criterion was about four years [43].

Having top management support be seen in a variety of studies as a fundamental and necessary driving factor to implement a program, highlights the need for investigation into managerial perspective. Many state that as long as a program is profitable the possibility of adopting the program would increase [19]. However, this is not the case in every situation. Many EE practices which theoretically are profitable are not adopted in practice [44]. Often it is due to lack of execution, not valuing the project properly and improper definition, as maintained respectively by [6,34,35]. Sometimes, though, it is due to uncertainty and its associated risk, lack of transparency and weaker understandable calculation [23]. Top management is positioned at a strategic level of a company and makes decisions about what is in line with the company's total strategy. In other words, they are dealing with the core business. Improved energy efficiency is considered a non-core business, i.e., non-strategic, but a secondary and peripheral issue for a manufacturing company [19]. Moreover, since energy-related costs may be small in comparison with a company's total costs, energy-related practices thus receive relatively little attention [24].

According to capital investment theory, investments with profitable return would be decided upon, and where there are several proposed projects, the one with highest return would be prioritized [33]. Moreover, according to the organizational finance and decision making literature, financial factors are a pillar in investment decision making. However, organizational behavior literature determines other contextual factors which role is important in this regard: organizational energy culture, power relationships, managers' interest and mindset, and last but not least the characteristics of the investment itself, in other words, how they link with the core business and/or how strategic they are [13,19,23,45–47]. In an investigation of about 100 Australian companies, 35% of respondents mentioned that EE projects often are not adopted because of their weak link to the core business [22]. Therefore, it seems that being profitable, while important, is not a sufficient criterion for an investment to be decided on [23]. Many previous studies tried to list barriers to EE, however, just a few of them focused on the practices' characteristic role as an important barrier and/or driver to EE investment [34]. In a study conducted by Velthuijsen [46] within 70 companies, “non-core business character” was addressed as one of the most important barriers to EE investment. Another important point which results in low levels of EnMPs adoption and/or decision making is due to high levels of EE investment risks. Neoclassical energy economists [e.g. [17,16]] sometimes argue the EE gap is not real because their energy-saving programs technically are energy efficient but not economically so (due to hidden costs and return overestimations). Although the nature of making any decisions involves risk (due to uncertainty), the level of the risk increases if it becomes more strategic. EE investment literature has very little to say in this regard. Apart from financial risk which arises from these investments, Sorrel et al. [19] listed core business risk or technical risk linked to adoption of new technologies as a third important barrier to adoption and/or positive decision making with regard to EE investments. Several strategic risks threaten a company when a decision is made [see [33]]. However, the uncertainty of EE investment outcome leads to negative investment decision making.

2.2. Research methods

The case studies were chosen from small, medium-sized and large companies from different industrial sectors. The study was carried out using semi-structured interviews conducted between August and November of 2014. In each case normally two persons, one from top management and the other from the energy group of the company, were interviewed (for approximately two hours) about the EnMPs, EnM program, the company's energy-related targets and motivating factors. The content of the interviews enabled the researchers to identify the adopted practices in each case.

According to the EnM literature, there are eleven minimum steps (presented in Table 1) required for implementing EnM. During the interview the energy manager in each case was asked about how they considered these eleven steps (fully considered=2, partially considered=1, and not considered=0). The content of the interview about EnM program and related practices which has been adopted so far within the company enabled researchers to understand the status of adopted practices. In Appendix A, an energy strategy classification inspired from Turner [36] is shown. Moreover, the level of adoption for each practice (fully considered=2, partially considered=1, and not considered=0) has been marked.

The maturity matrix (Appendix B) is also developed to assess the current state of EnM program of each company. The matrix consists of six themes from policy through investment, where the user could rate their EnM program on a scale of 0: not important at all to four: strongly important. The matrix enables a conversation about EnM that reflects a wider set of subjects than just technology (the default solution for many). It indicates the aspects of organizing, training, investment, communication and performance measurement. This tool is also a powerful way of understanding where barriers might exist in an organization. Understanding the Industrial EnM Model enables us to design an effective energy cost reduction program and offer services that best match a company's specific needs according to where they are in the overall EE maturity process. The following Eqs. (1)–(5), are used to quantify the consideration level for each energy strategy category and for each sub-category:

$$SMi(average) = \frac{\sum_{i=1}^{7} Sism}{7}, \quad Li(average) = \frac{\sum_{i=1}^{8} Sil}{8} \tag{1}$$

$$Rsm(average) = \frac{\sum_{i=1}^{7} Rism}{7}, \quad Rl(average) = \frac{(\sum_{i=1}^{i=8} Ril)}{8}, \quad Rsm = \frac{Rsm(average)}{5}, \quad RL = \frac{Rl(average)}{5} \tag{2}$$

$$Esm(average) = \frac{\sum_{i=1}^{7} Eism}{7}, \quad Eil(average) = \frac{\sum_{i=1}^{8} Eil}{8}, \quad Esm = \frac{Esm(average)}{4}, \quad El = \frac{Eil(average)}{4} \tag{3}$$

$$Lsm(average) = \frac{\sum_{i=1}^{7} Lism}{7}, \quad Lil(average) = \frac{\sum_{i=1}^{8} Lil}{8}, \quad Lsm = \frac{Lsm(average)}{3}, \quad Ll = \frac{Lil(average)}{3} \tag{4}$$

$$Fsm(average) = \frac{\sum_{i=1}^{7} Fism}{7}, Fl(average) = \frac{\sum_{i=1}^{8} Fil}{8} Fsm = \frac{Fsm(average)}{4}, \quad Fl = \frac{Fl(average)}{4} \tag{5}$$

$$Asm(average) = \frac{\sum_{i=1}^{7} Aism}{7}, Al(average) = \frac{\sum_{i=1}^{8} Ail}{8} Asm = \frac{Asm(average)}{4}, \quad Al = \frac{Al(average)}{4} \tag{6}$$

3. Results

3.1. Factors affecting adoption of EE investments

3.1.1. Minimum required steps

Having classified the minimum required steps to implement EnM, within each study, according to Table 1, we assessed whether all these steps has been taken within a sample of studies and how they were considered within energy-related programs. By allowing the results to provide a quantitative picture (Table 4), it delivers the clearest picture about how industrial sectors move toward implementing EnM. The results are summarized in Fig. 2 as well.

The analysis by firm size has allowed observing that companies with large size are far ahead in comparison with small and medium-sized plants. However, even large companies are in a far from ideal situation. In particular, such differences regarding establishing EnM team by energy manager, conducting the initial audit, and monitoring project progress emerge much more between SM companies and large companies. Consequently, for SM companies each step mentioned with low level of consideration emerges as a barrier to implementing EnM properly. On the contrary, SM companies' behavior for, developing procurement policies, awareness and long-term strategic planning, implementing energy-saving projects, monitoring the main energy-using equipment, and documentation respectively are the same or quite close (Fig. 2). Interestingly, all companies are ranked as fully considered for top management support, however, as is clear except for developing procurement policies, a major gap exists in implementing EnM regarding low average level of consideration for the rest of the steps. This can be explained mainly, but not only, by a major focus on investments in new technology and through low level of consideration regarding awareness and training in Fig. 2. This consequently causes a lack of clear information, expertise and certainty within an organization. About "establish EnM team by energy manager," small and medium-sized companies receive relatively low consideration compared with large companies. Since they do not establish a team, as a result initial auditing, monitoring the projects, and documentation of energy use trends are not planned, organized, implemented and checked properly, as is evident in Fig. 2. It might be first of all because of the industry's characteristic (similar size) and then time and lack of expertise which in consequence causes the imperfect establishment of EnM mainly between small and medium-sized firms.

3.1.2. Energy strategy

Having classified the relevant practices within each energy strategy according to Turner's [36] classification, we identified not only the adopted programs, but also the level of consideration for each practice. The results provide some indication of the relative importance of each barrier in preventing cost-effective improvements in industrial energy efficiency. The results are summarized in Table 5 and Fig. 3. In addition, the individual studies implied a ranking order that some barriers were discussed more prominently than others. The implied importance of barriers for each individual study is captured in Table 5.

Results in Table 5 show in greater detail the level of adoption for each category and their related programs. In particular, we can note that the average value, both for SM and large firms, for each category is quite low and becomes much lower when it comes to funding and

Table 4
Results for minimum required steps to implement EnM (Key: fully considered=2, partially considered=1, not considered=0).

Code	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	SM *(average)*	L *(average)*
S1	1	1	1	1	1	0	1	1	0	1	1	2	1	0	1	0.71	1
S2	1	1	1	1	0	1	1	2	2	1	1	2	1	1	1	1.14	1.13
S3	1	1	0	1	1	0	0	1	1	0	0	2	1	0	1	0.29	1
S4	2	2	2	2	2	2	2	2	2	1	1	2	1	2	2	1.71	1.88
S5	0	1	0	1	1	1	0	1	1	0	0	2	1	0	1	0.29	1
S6	1	1	1	2	1	1	1	1	2	1	1	2	1	1	2	1	1.38
S7	0	0	1	1	1	0	1	0	1	0	0	2	1	0	1	0.14	1
S8	1	2	1	0	1	1	1	1	1	0	0	2	1	1	1	0.71	1.13
S9	1	1	0	1	1	1	1	1	1	1	1	2	1	1	1	0.88	1.13
S10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
S11	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0.29	0.25
Total average																0.83	1.17

* Columns in green present SM companies.

awareness practices. Comparing the results about how large companies behave with respect to SM companies is much easier when we look at Fig. 3. Through "energy strategy" radar in Fig. 3, we can note that larger plants are more focused on EE programs rather than reliability, low/no cost, funding and awareness.

3.1.3. Maturity Level

In Fig. 4, we can note that energy maturity level for both SM and large companies is relatively low and surprisingly, for this aspect company size works as an independent variable. Moreover, we can note that companies are more focused on policy, organizing and performance measurement. On the contrary, training maturity level is quite low and consequently results from lack of expertise and awareness. Results for investment shows that almost all companies, of different size and sector, share close criteria to invest in a particular program. Receiving the maximum mode of 2.5 on the scale of 0–4 shows industry still needs further improvement to enhance its position regarding energy and environmental concerns. Special effort is needed for training and communication, which are observed as two prominent barriers according to Fig. 4.

3.1.4. Barriers and drivers for EnM program investment decision making

Having the results for minimum required steps, classification assessment of EnMPs, and EnM maturity level assessment together with the knowledge we received from the practitioners during the interviews enabled the authors to specify the most relevant and pronounced barriers and drivers to negative and/or positive investment decision making for a particular EnM program. In Table 6, those barriers and drivers have been listed. Absence or presence of each factor in Table 6 arises accordingly as a barrier and/or driver to receive negative and/or positive investment decision making from top management.

Having classified the relevant barriers within each study according to our taxonomy, we recorded the number of times that each of these factors was mentioned within the sample of studies, thereby allowing a quantitative picture to be provided with the results. Although this is a crude procedure, the results provide some indication of the relative importance of each barrier and/or driver in preventing cost-effective improvements and the investment decision making process in an industrial EnM program. The results are summarized in Fig. 5.

While all six of the barriers in our taxonomy appeared in the sample, the two that appeared most prominently were the non-core business character of the programs and awareness and uncertainty which cause relatively high perception of risk. Therefore, increasing the strategic characteristic of the programs which leads to higher alignment with the core business strategy of the organization and decreasing the perception of risk which arises from uncertainty and lack of enough information can be highlighted as two main positive driving factors which foster the adoption rate for EnM programs.

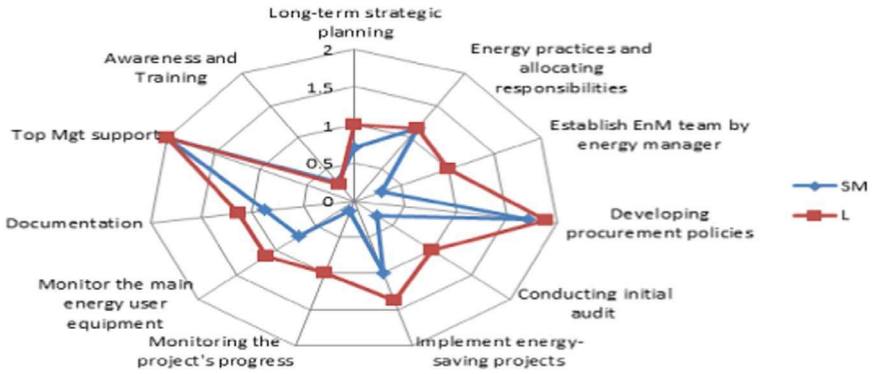

Fig. 2. Results for minimum required steps to establish EnM.

Table 5
Energy strategy and related practice results.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	SM sum	SM average	L sum	L average
R1	1	1	1	1	1	2	1	2	2	1	1	2	1	1	1	9	1.29	10	1.25
R2	1	1	0	1	1	1	1	2	2	1	1	2	1	1	1	7	1	10	1.25
R3	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	7	1	7	0.88
R4	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0.14	1	0.13
R5	0	1	1	0	0	0	0	0	1	1	0	1	0	0	1	2	0.29	4	0.5
Average																	**0.74**		**0.80**
E1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	7	1	9	1.13
E2	0	1	1	1	0	1	0	1	1	0	0	2	1	0	1	2	0.43	7	0.88
E3	0	0	0	1	1	0	0	0	1	0	0	2	1	1	1	1	1.14	7	0.88
E4	0	0	0	1	0	2	1	1	2	1	1	2	1	1	1	6	0.88	8	1
Average																	**0.58**		**0.97**
L1	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1	3	0.43	3	0.38
L2	0	1	0	0	0	0	1	1	0	0	1	1	1	1	1	3	0.43	5	0.63
L3	1	1	1	1	0	1	2	1	1	1	2	2	1	2	1	9	1.29	9	1.13
Average																	**0.72**		**0.71**
F1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.14	0	0
F2	0	1	0	0	1	0	0	1	1	1	1	1	1	0	1	3	0.43	6	0.75
F3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0.14	1	0.13
F4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0.25
Average																	**0.18**		**0.28**
A1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	2	0.29	1	0.13
A2	0	1	0	0	1	1	0	1	1	0	0	1	0	0	1	2	0.29	5	0.63
A3	0	1	1	1	0	1	1	1	1	0	0	2	1	0	0	3	0.43	7	0.88
A4	1	1	1	1	1	2	1	2	1	0	1	2	0	1	1	8	1.14	8	1
Average																	**0.54**		**0.66**

* Key: fully considered=2, partially considered=1, not considered=0.

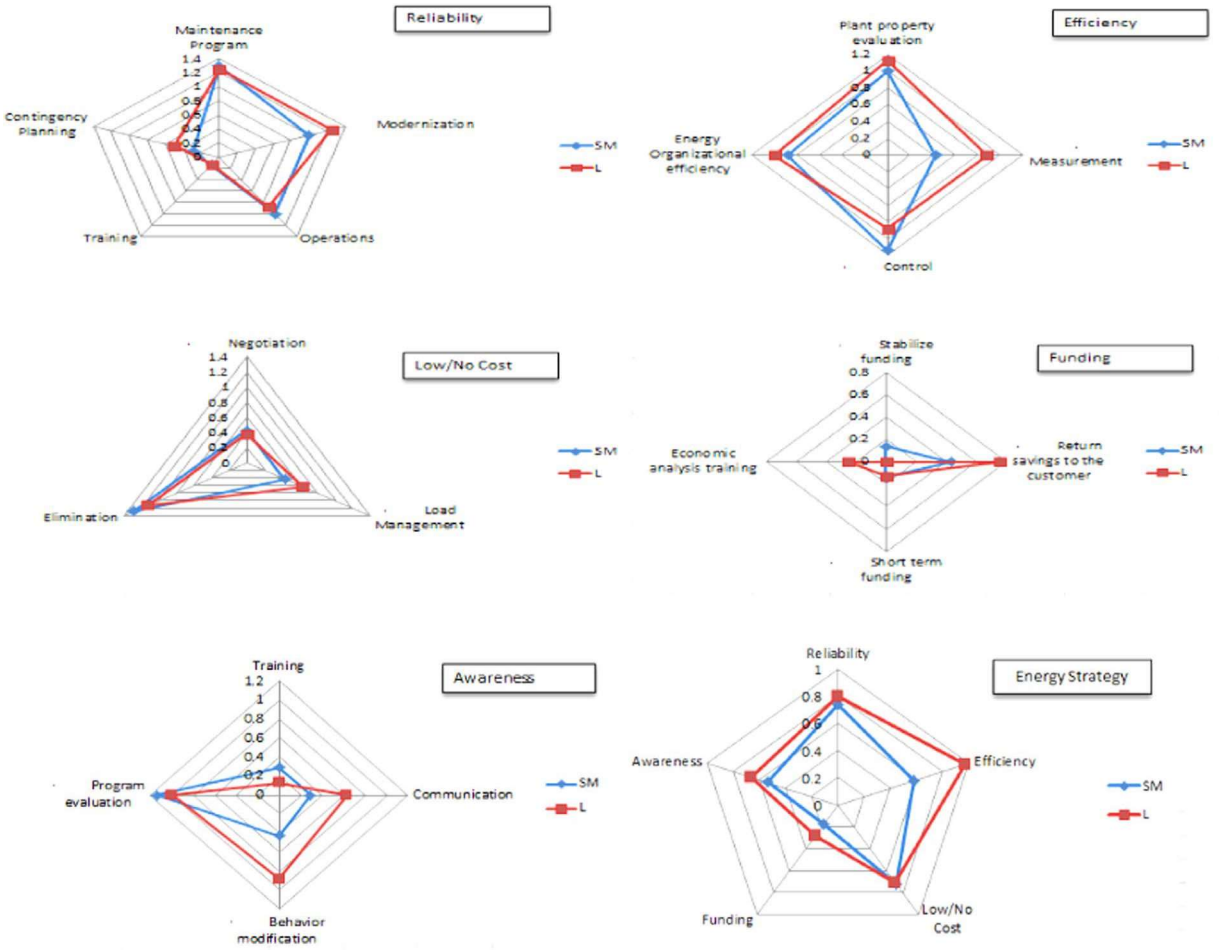

Fig. 3. Energy strategies and consideration level. Each radar reports the consideration level for each sub-energy strategy category, namely: reliability, efficiency, low/no cost, funding, awareness. The chart with "Energy Strategy" title reports in general the consideration level of the energy strategy with respect to the firm size.

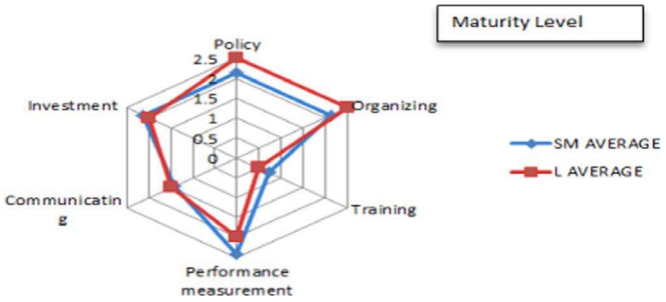

Fig. 4. Maturity level.

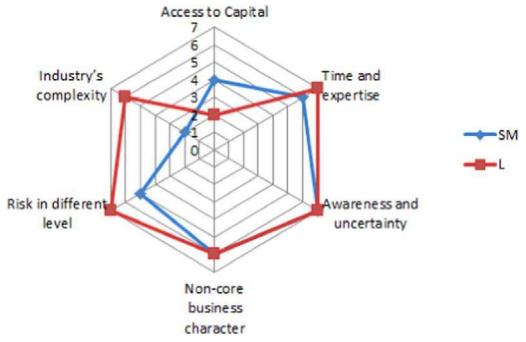

Fig. 5. Simple count of the number of mentions of specific barriers to EnM investment decision making within the sample of studies.

3.2. Impact on successful EnM implementation

The various arguments are discussed here about how an investment would be adopted from top management as a strategic management level. Therefore, according to EE investments literature and what energy managers in 15 studied cases have reported, we determined, contrary to EE literature, that if EnMPs are not adopted it does not mean they do not receive support from top management, but it means they are not strategic enough. The influence of the strategic character of investment in the decision making process and its result (a positive, negative or no-decision), and this same influence on the capital budgeting tools used, as well as on financial requirements for profitability (pay-off criterion), to develop Fig. 6.

Another important aspect of positive decision making is risk reduction. Energy managers need to reduce an EnM program's risk and uncertainty through risk management, which consists of: identify the risk, identify the person in charge and allocate responsibility through planning and resourcing, and then re-evaluate. Risk reduction improves transparency and certainty, and moreover, brings value to the company. According to all these arguments, this paper suggests the following framework for EnM programs which can be adapted to all types of manufacturing companies. Energy managers need to accurately interpret and identify the company's total strategy and capacity in order to implement an energy strategy which is aligned with the company's core business. Moreover, the need to "plan, organize, implement and control" in each step of an EnM program is highlighted

Table 6
Taxonomy of barriers and drivers for EnM program investment decision-making.

Barriers	Comments
Access to capital	A commonly cited barrier to implementing EE projects is lack of access to capital. This might be more relevant for the smaller companies which have low capability in terms of capital investment.
Time and expertise	Time, resources and skilled persons are essential to identify opportunities for cost-saving targets and implement the threats
Awareness and uncertainty	Lack of information about energy use trends, lack of benchmarking with best practice in same sector and lack of proper training are the most pronounced elements which increase uncertainty and decrease awareness between practitioners.
Practice characteristics	Transparency regarding scope, target, and moreover the link to the core business build the characteristics of a particular practice.
Risk	Disruption of a production line, overestimation about turnover, higher investment demand for EE projects in comparison with other type of investment and uncertainty about payback time horizon are the topics of EE-related risk felt regarding time, cost and quality.
Industry's complexity	Characteristic of an industry through its process and operation line even between same sectors are different and makes an industry, mostly in large-sized companies, a complex place.

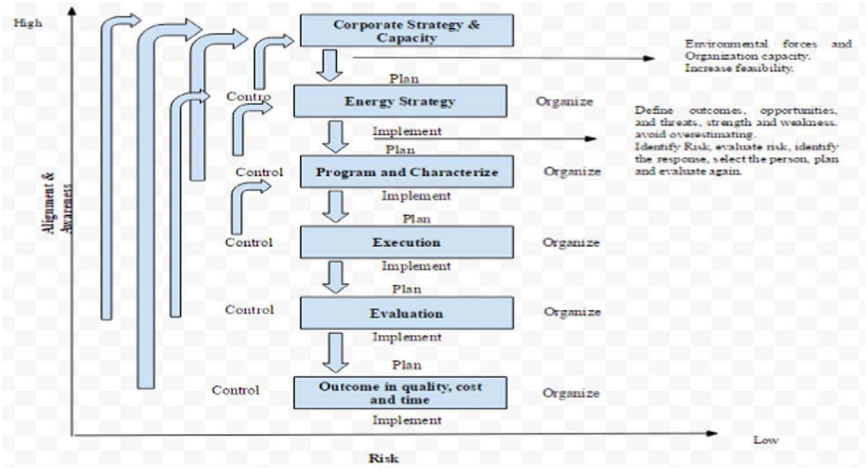

Fig. 6. The contribution of the result of implementing successful EnM.

to improve the transparency and reduce associated risks in each step as much as possible to improve the certainty level. To set the energy strategy, the energy manager always needs to align the program with core business and adopt programs which are more strategic to improve positive investment decision making. Last but not least, besides all the determining factors, the character of the energy manager is the most important element in a successful energy strategy. S/he not only needs to be experienced enough in the field, but being a professional project manager is another strong characteristic for this position. Any energy program can be seen as a project which needs to be completed in proper quality, cost and time, always in alignment with the company's total strategy and capacity. The more alignment with core business, the greater the possibility to receive positive decision making from top management.

4. Conclusion

EnM through its systematic programs and more precisely through its practices is characterized as an industrial energy system support function. However, EnMPs is not properly implemented and/or not fully adopted in practice, with all its potential, to help companies improve their EnM maturity level and, as a consequence, to enhance the energy system. Considering two macro level perspectives regarding energy investment adoption criteria, this paper assessed EnM programs from A to Z to better understand the existing barriers and drivers for energy-related decision making criteria. After assessment of minimum required steps for establishing an EnM program, adopted practices according to their scope and target, and finally assessing the maturity level of EnM programs, the current study developed a taxonomy of the barriers to EnM program adoption. Moreover, two of the listed barriers that appeared most prominently were non-core business character of the programs and awareness and uncertainty which causes a relatively high perception of risk. According to the result in the first step, this study finally tried to make a contribution on the impact of the main driving forces of positive investment decision making in implementing successful EnM programs.

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Appendix A

EnM strategies, programs and related practices (inspired from Turner [36])
Key for each practice (2=fully considered, 1=partially considered, 0=not considered)

Strategy	Program and related Practices	Codes	Weight 0–2)
Reliability	• Maintenance Program	R1	
	• Modernization	R2	
	• Operations	R3	
	• Training	R4	
	• Contingency Planning	R5	
Efficiency	• Plant property evaluation	E1	
	• Measurement	E2	
	• Control	E3	
	• Energy Organizational efficiency	E4	
Low cost	• Negotiation	L1	
	• Load Management	L2	
	• Elimination	L3	
Funding	• Stabilize funding	F1	
	• Return savings to the customer	F2	
	• Short term funding	F3	
	• Economic analysis training	F4	
Awareness	• Training	A1	
	• Communication	A2	
	• Behavior modification	A3	
	• Program evaluation	A4	

Appendix B

EnM matrix (inspired from Carbon Trust [37])

Level	Policy	Organizing	Training	Performance measurement	Communicating	Investment
4	Energy policy action plan and regular review have an active commitment of top	Fully integrated into the management structure with clear accountability for	Appropriate and comprehensive staff training tailored to identified needs,	Comprehensive performance measurement against targets with effective	Extensive communication of energy issues within and outside	Resources routinely committed to energy efficiency in

	management	energy consumption	with evaluation	management reporting	organizations	support business objectives
3	Formal policy, but not active commitment from top	Clear line management accountability for consumption and responsibility for improvements	Energy training targeted at major users following training need analysis	Weekly performance measurement for each process, unit or building	Regular staff briefings, performance reporting and energy promotion	Some appraisal criteria used as for other cost reduction projects
2	No adopted policy	Some delegation of responsibility, but line management and authority unclear	Ad-hoc internal training for selected people as required	Monthly monitoring by fuel type	Some use of company communication mechanisms to promote energy efficiency	Low or medium cost measures considered if short payback period
1	Unwritten set of guidelines	Informal mainly focused on energy supply	Technical staff occasionally attends specialist courses	Invoice checking only	Ad-hoc, informal contacts used to promote energy efficiency	Only low or no-cost measures taken
0	No explicit energy policy	No delegation or responsibility for managing energy	No energy related staff training provided	No measurement of energy costs of consumption	No communication or promotion of energy issues	No investment in improving energy efficiency

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