Energy Efficiency Barriers in Industrial Operations: Evidence from the Italian SMEs Manufacturing Industry

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ABSTRACT

This paper aims at providing an identification and analysis of the most relevant barriers that limit a widespread implementation of the Best Available Technologies and Practices through the investigation of a large number of case studies of non-energy intensive manufacturing SMEs in Northern Italy. The role of SMEs is particularly relevant in the economy of Western countries (and particularly in Italy), where they cover a consistent share of the energy consumption of a whole National industrial sector. This study, starting from the literature, proposes a more operational definition of the energy efficiency barriers, evaluates the most diffused and perceived barriers and identifies the possible tools in support of manufacturing enterprises to overcome them. The final results put in evidence several barriers as the lack of capital and issues related to the information, and also the importance to avoid bundling together SMEs of different sizes and sectors. This study represents a preliminary contribution for the promotion of National policies that would lead to a widespread increase of the overall energy efficiency of the investigated territory, along with strong benefits for the whole local industrial system.

Introduction

The manufacturing industry, according to the most recent estimates of the International Energy Agency (IEA, 2010), in 2008 accounts for about 79% of the global coal consumption, more than one third of the global gas consumption, and also uses 41.7% of all electricity produced. Moreover, a recent research has shown that the industrial sector uses "more energy globally than any other end-use sector, currently consuming about 50 percent of the world's total delivered energy" (EIA, 2010). Besides the recent "reduction in energy use during the recession, mainly as a result of substantial cutbacks in manufacturing that had more pronounced impact on total fuel consumption than did the marginal reductions in energy use in other sectors" (EIA, 2010), the increase of primary energy consumption and the emissions of green-house-gases coming from the use of fossil fuels has drawn the attention of public policy makers of most developed countries on industrial energy efficiency. In particular, within the European Union, the implementation of the so-called Directive "20-20-20" (i.e., 20% reduction in GHG-emissions, a share of 20% of energy produced by renewable energies and 20% improvement in energy efficiency) (European Council, 2006), will make the implementation of cost-effective energy efficiency measures within industry really of fundamental importance for firms' competitiveness, and especially in countries like Italy, where the electricity price is almost double than other European countries (IEA, 2010).

Considering then the structure of the industrial sector, firstly, it is largely made (>99% in almost all countries) of Small and Medium Enterprises (then SMEs), that also cover a consistent portion of the domestic industrial consumption (in some case, as from recent estimations in Italy, more than 60%); secondly, industry is mainly devoted to non-energy intensive manufacturing activities, defining here non-energy intensive manufacturing industries as firms whose energy costs do not exceed 2% of their turnover, as assumed by other researches in this field (Rohdin & Thollander, 2006).

Thus, in order to promote the most effective policies to enhance industrial energy efficiency, it is crucial to fully understand what the difficulties are and where they are rooted within those kinds of firms (non-energy intensive manufacturing SMEs). These difficulties put in evidence the existence of barriers respect to energy efficiency, and thus a lot has still to be done in understanding why energy efficiency measures are not implemented, especially in SMEs. This research has been conducted through many Northern-Italian SMEs that were involved in a research project for investigating and improving energy efficiency.

Focusing the Problem

A barrier for energy efficiency, as defined by (Sorrell et al., 2000), is "a postulated mechanism that inhibits investments in technologies that are both energy efficient and (at least apparently) economically efficient. Table 1 reports the approach adopted by Sorrell et al. – followed by Rohdin et al. (Rohdin et al., 2007) – through which a single barrier can be classified according to three main categories: economical, organizational and behavioral. But there are still some misalignments in the definition and classification of a barrier: in fact, according to Weber (Weber, 1997) "obviously each barrier will have economic, behavioral and organizational aspects: the three groups form perspectives that highlight particular aspects of a complex situation".

The barriers to industrial energy efficiency have been widely investigated since late 1980s. In particular, it is possible to notice that the research started from the evidence that, even with a very high potential for energy efficiency widely recognized, "[…] many investments in energy efficiency fail to be made despite their apparent profitability […]" (De Canio, 1993). In the first stages, many authors devoted their attention to a deep and rigorous investigation of the reasons behind the failure in the application of the Best Available Technologies / Practices (then BAT/Ps), aiming at providing a description of the existing barriers that limit the industrial energy efficiency (Hirst & Brown, 1990) (Reddy, 1991) (De Canio, 1993) (Weber, 1997) (De Canio, 1998) (Brown, 2001). It is possible to see the development in the research through the evaluation of the identified barriers among different contexts, in terms of industrial sectors - with particular attention towards the energy-intensive sectors (in particular steel and iron) (Rohdin et al., 2007) (Zhang & Wang, 2008), but then moving also towards other sectors - including manufacturing and non- manufacturing - (Sorrell et al., 2000) (Nagesha & Balachandra, 2006) (Massoud et al., 2009), and broad analyses for countries, including also the proposal of policies for the industrial energy efficiency improvement (Levine et al, 1994) (Reddy & Shrestha, 1998) (Sardianou, 2008) (Painuly, 2009) (Schleich, 2009). As briefly introduced in the previous section, even considering the wide literature reported above, the research is, at the moment, limited to a broad evaluation of the barriers that limit industrial energy efficiency: few studies have been explicitly devoted to the evaluation of the barriers and effective policies in case of manufacturing SMEs (Nagesha & Balachandra, 2006) (Thollander et al., 2007).

Moreover, it should be pointed out that, even assuming the taxonomy provided by Sorrell et al. (Sorrell et al., 2000) as the main reference in theory of barriers, the taxonomy has analyzed the barriers from a theoretical point of view; nonetheless, the operational barriers effectively existing in SMEs cannot be recalled uniquely to a single theoretical one: other studies, in fact, (Rohdin & Thollander, 2006) have been forced, in order to consider the theoretical barriers, to refer exclusively the questions to a main barrier.

Table 1. Classification of Barriers to Energy Efficiency Based on (Sorrell et al., 2000) and (Rohdin et al., 2007)

Theoretical Framework	*Theoretical barrier*	*Comment*
Economic non-market failure	Heterogeneity	A technology or measure may be cost-efficient in general, but not in all cases.
	Hidden costs	Examples of hidden costs are overhead costs, cost of collecting and analyzing information, production disruptions, inconvenience, etc.
	Access to capital	Limited access to capital may prevent energy efficiency measures from being implemented.
	Risk	Risk aversion may be the reason why energy efficiency measures are constrained by short pay-back criteria.
Economic market failure	Imperfect Information	Lack of information may lead to cost-effective energy efficiency measures opportunities being missed.
	Split incentives	If a person or department cannot gain from energy efficiency investments it is likely that implementation will be of less interest.
	Adverse selection	If suppliers know more about the energy performance of goods than purchasers, the purchasers may select goods on the basis of visible aspects such as price.
	Principal-agent relationships	Strict monitoring and control by the principal, since he or she cannot see that what the agent is doing may result in energy efficiency measures being ignored.
Behavioral	Bounded rationality	Instead of being based on perfect information, decisions are made by rule of thumb,
	Form of information	Research has shown that the form of information is critical. Information should be specific, vivid, simple, and personal to increase its chances of being accepted.
	Credibility and trust	The information source should be credible and trustworthy in order to successfully deliver information regarding energy efficiency measures. If these factors are lacking this will result in inefficient choices.
	Inertia	Individuals who are opponents to change within an organization may result in overlooking energy efficiency measures that are cost-efficient.
	Values	Efficiency improvements are most likely to be successful if there are individuals with real ambition, preferably represented by a key individual within the top management.
Organizational	Power	Low status of energy management may lead to lower priority of energy issues within organizations.
	Culture	Organizations may encourage energy efficiency investments by developing a culture characterized by environmental values.

Barriers for SMEs

Focusing on SMEs, in this study we considered to exclude in the analysis several barriers that are quite difficult to be investigated, or may cover some aspects of minor interest for SMEs. In particular, it is possible to see some barriers related to the complexity of the organization, as “Principal-Agent Relationship” and “Split Incentives”: in case of SMEs, in fact it seems clear that almost all decisions included the decisions on investing capital for an energy efficiency intervention, are made by a small board or even directly by the entrepreneurs themselves. Thus, those barriers, representing respectively some behavioral aspects related to the control on agents by the principal, or even possible divergent interests between who decides on energy efficiency and who invests, tend to fade in SMEs whereas quite often the entrepreneur his/herself controls directly the operations and especially makes both decisions and investments. Another barrier, i.e. “Moral Hazard”, is represented by a dynamic related to the asymmetry of information with respect to the decisions on energy efficiency: since it implies the relationship between entrepreneurs and technologies/services providers, it is of quite difficulty to be thoroughly investigated with questions solely to the entrepreneur, and for this reason it has not been investigated in this study. In addition to that, the “Power” barrier has not been investigated in this study since, as introduced briefly in the introduction, the firms have been involved in a research project for increasing energy efficiency, thus proving to not consider energy efficiency and energy management as a peripheral issue by top management.

Moreover, it should be pointed out that, as expressed in the previous section, several difficulties representing barriers for SMEs do not seem to be uniquely referable to a single barrier, as already put in evidence by (Rohdin & Thollander, 2006), that, in their study, refer the questions to a "main theoretical barrier", implying, but not investigating, the possible existence of a "secondary" or anyway "not primary" theoretical barrier related to the main one.

As a consequence, in this study, rather than directly asking the single theoretical barrier, some practical aspects of the difficulties in choosing and adopting and energy-efficiency intervention have been investigated. It is clear now that a single question can cover one or more of the theoretical barriers classified by Sorrell et al., and not all of them in the same depth, i.e. a given question can be related primarily to a given theoretical barrier, and secondarily to one or more other theoretical barriers. The results of this operation of re-structuring and rephrasing barriers, as introduced by other researchers (Cagno & Trianni, 2010a) have been reported in Table 2.

Table 2. Operative Questions Respect to Theoretical Barriers as by Sorrell et al., 2000 and Rohdin et al., 2007

Questions		*Description*
Y1	Lack of time or other priorities (comparing energy efficiency efforts respect to production efforts)	Time for investing new energy efficiency opportunities, analyzing data and information is primarily an hidden cost to be considered. Furthermore, the efforts in devoting time for energy efficiency investigations do not lead to certain outcomes: thus, production efforts tend to have greater weighting, since they can lead to certain outcomes.
Y2	Lack of capital - either public or private - to be devoted to energy efficiency investments	Limited access to capital, either internal funds or borrowing, may prevent energy efficiency measures from being implemented
Y3	Lack of internal technical skills	Management and/or personnel may not be able to evaluate energy-efficiency opportunities, thus requiring some additional efforts (also in terms of economic resources) in order to make the needed evaluations. Furthermore, this lack partially explain the "rule of thumb" evaluations that are taken without the needed technical skills.
Y4	Difficulty in gathering external technical skills	Management can face the high additional costs related to gathering external skills, and they may also feel the difficulties in investing resources for not certain outcomes, thus tending to favour the status quo.
Y5	Poor information for decisions regarding energy efficiency	The information on energy efficiency can be perceived by investors as poor and lacking on some important details, thus preventing the investment on cost effective opportunities.
Y6	Lack of personnel awareness	Personnel might resist change primarily since it is committed to what it is doing, since it has established routines that are difficult to be modified. Moreover, it also may not have environmental values, therefore giving a lower priority to efficiency improvements.
Y7	Lack of managerial awareness	Management may not have environmental values, therefore giving a lower priority to energy efficiency improvements. Moreover, it might also resist change since it gives greater weight to certain outcomes (production) respect to uncertain outcomes (energy efficiency).
Y8	Low returns for energy efficiency investments (other priority for capital investments)	Low returns reflect the heterogeneity of energy-efficiency solutions, that might have low savings, or strong variances for savings, preventing them to be cost effective. Moreover, low returns reflect some additional technical or financial risk that might be not under control, thus preventing long time horizons investments.
Y9	Scarce information regarding energy efficiency opportunities and winning solutions	The information might be scarce, i.e. not specific, personalized, vivid, simple and available close in time to the relevant decision.

Moreover, it has been decided to investigate whether the firms would more likely to incur in difficulties for implementing management interventions (DM), or technical interventions (DT) regarding energy efficiency.

Methodology of the Study

The barriers to energy efficiency have been investigated through the involvement of 128 out of more than 200 firms participating in some research projects that, through partially public-sponsored energy audits (i.e. energy audits funded by the Regional Government, the local Chambers of Commerce and with a small monetary contribution by the firms), were interested in identifying, characterizing and evaluating the most important energy efficiency interventions, through the use of a specifically-developed methodology (Cagno et al, 2010b). The firms mainly belong to the most important sectors of the Lombardy Region in Italy (in terms of employees and energy consumption), and classified according to the International Standard Industrial Classification of All Economic Activities "ISIC rev.4", as reported in Table 3.

Table 3. Classification of the Firms Involved in the Projects (Respect to ISIC rev.4 and Number of Employees)

	Distribution by number of employees			
Manufacturing sectors	15-49 (SE)	50-99 (ME)	100-249 (MLE)	*total*
C13 - Textile	11	8	5	24
C16 – Wood	3	2	2	7
C22 - Plastics	14	5	4	23
C24 - Basic Metals	11	8	0	19
C25 - Primary Metals	18	5	4	27
Others	10	13	5	28
total	67	41	20	128

As it can be argued from Table 3, the firms have been divided into 3 classes since there is the possibility that, considering the organizational processes within SMEs, there might be a difference in their behavior, as observed in other issues, e.g. occupational health and safety management (Micheli et al., 2008; Micheli et al., 2010). In particular, in this study Small Enterprises (SE) refer to 15 to 49 employees, Medium Enterprises (SE) from 50 to 99 employees, and Medium-Large Enterprises (MLE) from 100 up to 249 employees.

In particular, more than 70% of the sample (93 out of 128) belongs to four important manufacturing sectors, i.e. textiles, plastics, basic and primary metals, and about 85% of it (108 out of 128) is made of companies with less than 100 employees.

Before the energy audit, the auditor conducted a semi-structured interview to the person in charge of energy issues for the visited site.

The interview aimed at allowing the auditor to have a whole picture of the firm, including the firm's organization, a full description of the production process, and a brief description of the equipment, with the identification of the main equipment installed, the net electrical and thermal power installed for each machinery, etc. This discussion is considered of fundamental importance due to the explorative nature of the study, since, during the interview, it had been possible to understand the critical areas of the firm identified directly by the interviewee: taping the interview proved to be of particular importance since it allowed to catch all the points that emerged during the interview.

After the interview, in 128 cases, the auditor had the possibility to ask the respondent to fill out a short guided questionnaire in which he/she should provide his/her view about the existing difficulties in choosing and adopting an energy efficiency intervention, through the list of questions reported in the section above. A Likert scale score from 1 to 4 has been assigned to each question in order to rank the results from the questionnaire: 1 point if the respondent considered the question to be "not important", 2 points for "scarcely important", 3 points for "important", and 4 points if "very important".

Nonetheless, due to the explorative nature of this study, it has been considered still of interest to investigate this sample of the total population of SMEs in order to get the first understandings, some of which might be further extended.

Results

In Table 4 it is possible to rank the barriers according to the overall average score. As first results, two main problems have emerged:

On the one hand, the lack of capital (either public or private, i.e. Y2) probably reflects the status-quo of industries struck by the global financial crisis. In this sense, it sounds reasonable to think that the financial support of energy-efficiency investments by Governments and/or public administrations might represent the "activation energy" to enhance industrial energy efficiency;

On the other hand, the problem of information emerged, expressed both by the lack of data, as poor information that might support the energy efficiency decisions (Y5), and the form of the information on possible energy-efficiency interventions (Y9).

Table 4. Average Score of the Barriers and Questions Respect to the Whole Sample

Rank (average score)		*Question*	*Comment*
1 (3.03)	Y2	Access to capital (lack of capital - public and/or private - to be devoted to energy efficiency investments)	42 out of 128 respondents considered the access to capital a very important barrier to energy efficiency.
2 (2.85)	Y9	Scarce information regarding energy efficiency opportunities and winning solutions	83 out of 104 considered the scarcity of information as, at least, important.
3 (2.77)	Y5	Poor information for the energy efficiency decisions	More than 70% of the respondents considered this barrier as important.
4 (2.70)	Y3	Lack of internal technical skills	65% of the respondents identified this as, at least, an important barrier that prevents the decisions regarding energy efficiency.
5 (2.61)	Y8	Other priorities for capital investments (low returns for energy efficiency investments)	In general, production-related investments proved to be more important than energy-efficiency investments (almost 60%).
6 (2.53)	Y1	Lack of time or other priorities (comparing energy efficiency efforts respect to production efforts)	18 interviewees perceived this as a very important barrier.
7 (2.35)	Y4	Difficulty of gathering external technical skills	50 out of 128 respondents consider this as an important barrier, although they participate in a project with external energy-efficiency experts.
8 (2.25)	Y6	Lack of personnel awareness	More than 60% of the interviewees consider this barriers as scarcely or not important.
9 (2.03)	Y7	Lack of managerial awareness	Only 6 respondents consider this as a very important barrier.
(2.59)	DT	Difficulty in implementing technical interventions	Only 17 interviewees consider this as not an important difficulty.
(2.35)	DM	Difficulty in implementing management interventions	Only 52 respondents consider this as, at least, an important difficulty.

As a consequence, the respondents highlighted the difficulties both of making decisions on energy-efficiency interventions (i.e., if the intervention is "worthy to be implemented"), and "how to implement it" (expressed in terms of financial availability).

Nonetheless, there is a group of barriers that are underneath the main ones described above; considering the low returns for energy efficiency investments (Y8), this barrier is related to uncertainty and risk: the barrier of capital availability can also remove those

barriers, since it seems to remove the problem of the choice between investing in energy-efficiency interventions or elsewhere (typically production-related investments).

Moreover, considering the lack of internal technical skills (Y3) and the lack of time (Y1), they together contribute to the "hidden cost" barrier. In fact, it seems reasonable to assume that less technical skills would lead to incurring more difficulties when selecting and gathering the needed information to make a choice about an energy efficiency intervention. Moreover, less technical skills would also lead to taking more time to perform a consumption analysis for the equipment, etc.

Considering then the other barriers, it emerged that awareness with respect to the energy-efficiency subject (Y6 & Y7) is not considered as a barrier: this result was expected since each firm had joined the research project and partially co-funded its energy audit. Thus, it sounds reasonable to assume that it is, at least partially, familiar with the energy-efficiency subject, and this may explain the low scores in the "lack of awareness" barriers. This characteristic of the sample can also explain, at least partially, the low difficulties in implementing technical (DT) and management (DM) interventions: the SMEs involved in this study seem to be sensitive, agile, fast in reacting to the topic, and consequently do not seem to find many difficulties in making improvements within their plants.

The considerations drawn above do exclusively reflect the average behavior of the interviewed SMEs: since the sample is not homogeneous for sectors and number of employees, it has been considered as of interest to perform several further analyses in order to evaluate what (if any) are the differences and commonalities among sectors and number of employees.

Analysis by Firm's Size

In Table 5, the results of the major barriers derived from the questionnaire have been reported, mainly putting in evidence some interesting trends, due to different firm's sizes.

Table 5. Average Score for the Barriers Derived from the Questionnaire Divided by Firm's Size

	Number of employees		
Question and average score (by firm's size)	15-49	50-99	100-249
Lack of time or other priorities (comparing energy efficiency efforts respect to production efforts)	2.60	2.67	1.94
Access to capital (lack of capital - public and/or private - to be devoted to energy efficiency investments)	3.03	3.13	2.78
Lack of internal technical skills	2.84	2.76	2.11
Difficulty of gathering external technical skills	2.36	2.42	2.17
Poor information for the energy efficiency decisions	2.77	2.79	2.72
Lack of personnel awareness	2.14	2.13	2.89
Lack of managerial awareness	1.98	2.00	2.24
Other priorities for capital investments (low returns for energy efficiency investments)	2.63	2.53	2.72
Scarce information regarding energy efficiency opportunities and winning solutions	2.90	2.89	2.61
Average score by firm's size	2.58	2.59	2.46
Difficulty in implementing management interventions	2.26	2.37	2.61
Difficulty in implementing technical interventions	2.28	2.89	2.94

In particular, it is possible to appreciate that the lack of time is considered in a different manner by MLE respect to SE and ME: this phenomenon can be explained by the fact that the greater the size, the more structured the firm's organization, thus leading to a "reverse" size effect. Indeed, a "structured" organization will have personnel devoted to the maintenance of the plant's equipment, research of "inefficiencies", and consequently to the

identification of the energy efficiency opportunities. In some of the MLE companies involved in this research, it has been found that the personnel involved in the energy-efficiency related issues had the possibility to participate in training courses, sharing information experiences, showing that although limited, a budget from the firm's top management had been devoted to energy-efficiency issues. Lack of time in MLE does not represent a major barrier with respect to SE, where the person in charge of energy efficiency issues (usually the entrepreneur herself) has also the responsibility of managing the plant, managing clients and suppliers, marketing products, etc. The same size effect can be observed also in the case of lack of internal skills: SE and ME are usually led by one entrepreneur that might be very expert in the production process, but sometimes does not own the skills to identify and fully evaluate the energy inefficiencies that might occur in the whole plant's operations. Vice versa, MLE usually have a team (or, at least one person) devoted to the maintenance of the equipment, as expressed above, thus developing the necessary experience to find, evaluate and propose effective solutions respect to energy-efficiency issues.

Moreover, it is possible to find a direct size effect also in the "lack of personnel awareness" barrier: in particular, it can be inferred that, as expressed in the 'Barriers for SMEs' section, the control on the "good practices" for managing the plant is stricter when the firm has very few employees. In this case in fact it has been observed that the person in charge of energy issues (usually directly the entrepreneur) has the opportunity of better controlling the energy-efficiency behavior of the personnel during the plant's operations. On the contrary, the top management of MLE is not able to maintain such control over the personnel, thus tending to blame the difficulty of implementing the energy efficiency interventions to a lack of the personnel awareness on energy efficiency.

There are then two more cases of direct size effect, represented by the difficulties in implementing either management (DM) and technical solutions (DT): in those cases in fact, larger the firm's size, larger the barriers' scores. This might be explained by the fact that in SE, all decisions (and, thus, also those regarding to energy efficiency) are often taken by one single person, the entrepreneur him/herself. For this reason, there is little difficulty in implementing either management (DM) or technical interventions (DT). On the contrary, in a pair comparison of energy saving, knowledge, information etc., the larger the size, the more difficult will be to implement the decisions, as emerged during the interviews and suggested by the fact that, in both questions, the questions have a score of 2.61 and 2.94 – respectively for difficulty in implementing management (DM) and technical interventions (DT) – considerably higher than the average score of the same firm's size barriers, 2.46.

All questions have been tested through ANOVA in general terms, and a modified Tukey-Kramer test (Miller, 1985; Zwick & Marascuilo, 1984) to identify which levels of firm's size were significantly different (i.e. "**",significant, p-value <0.05, "*", almost significant, p-value<0.10). It can be argued from the p-values that there is a significant difference for the levels investigated in the following questions, as showed in Table 6:

- y1 – Lack of time or other priorities (comparing energy efficiency efforts respect to production efforts);
- y3 – Lack of internal technical skills;
- y6 – Lack of personnel awareness;
- DT – Difficulty in implementing technical interventions

Table 6. *P*-Values for The relation 'Classes of Size' Respect to the Investigated Questions

	y1	y2	y3	y4	y5	y6	y7	y8	y9	DM	DT
Classes of size	0.029 **[a]	0.422	0.008 **[a]	0.545	0.966	0.002 **[b]	0.455	0.147	0.272	0.240	0.001 **[b]

Where (a): lower average for Small & Medium enterprises respect to Medium-Large enterprises;
(b): higher average for Small & Medium enterprises respect to Medium-Large enterprises.

Analysis by Sector

Another analysis has been performed in order to show commonalities and differences (if any) respect to the primary activity (i.e. the sector) of the interviewed enterprises. The results of the average scores for the questions have been reported in Table 7.

It is worth to be pointed out that the scores for the Textiles Manufacturing enterprises (ISIC C13 sector) are lower than the corresponding for the whole sample in all questions.

Table 7. Average Score for the Barriers Derived from the Questionnaire Divided by Sector

		Sectors					
	Av. score	*C13*	*C16*	*C22*	*C24*	*C25*	*Others*
Lack of time or other priorities (comparing energy efficiency efforts respect to production efforts)	2.53	1.95	2.83	2.59	2.83	2.58	2.62
Access to capital (lack of capital - public and/or private - to be devoted to energy efficiency investments)	3.03	2.74	3.14	3.23	3.13	3.12	2.92
Lack of internal technical skills	2.70	2.39	2.86	2.71	2.88	2.84	2.69
Difficulty of gathering external technical skills	2.35	2.13	2.29	2.33	2.27	2.40	2.58
Poor information for the energy efficiency decisions	2.77	2.39	2.86	3.24	2.67	2.64	2.88
Lack of personnel awareness	2.25	2.05	2.33	2.29	2.00	2.36	2.42
Lack of managerial awareness	2.03	1.82	2.33	2.20	1.60	2.17	2.12
Other priorities for capital investments (low returns for energy efficiency investments)	2.61	2.05	3.43	2.62	2.53	2.68	2.81
Scarce information regarding energy efficiency opportunities and winning solutions	2.85	2.68	3.29	3.00	2.59	2.83	2.96
Difficulty in implementing management interventions	2.35	2.14	2.86	2.43	2.07	2.25	2.58
Difficulty in implementing technical interventions	2.59	2.24	3.00	2.57	2.60	2.67	2.69

This is of particular interest, since represents the effect of a deep crisis in the last two decades that occurred at least in Italy within the textiles sector, mostly due to the growing competition of other countries, mainly belonging to emerging economies: as a consequence of this, a lot of industries have closed, changed their main business, or transferred their core activities in other countries. This, coupled with the fact that, in the Textiles sector, energy represents a critical issue with a significant share of the total production costs, seems to represent the driving force for the "survived" companies to be more cost-competitive, thus being more (energy) efficient in the production process. In this sense, Textiles' interviewees did not seem to feel very burdensome barriers, since, and this has been also inferred by the energy audits, they have already moved towards the BAT/Ps. In fact, testing, as done in the previous sub-section, the difference between "Textiles" and "non-Textiles" manufacturing SMEs (i.e. "**",significant, p-value <0.05, "*", almost significant, p-value<0.10), the factor is at least almost significant in 8 out of 11 questions, as showed in Table 8.

Table 8. *P*-Value for the Comparison 'Textiles' Respect to 'Non-Textiles' Enterprises

	y1	y2	y3	y4	y5	y6	y7	y8	y9	DM	DT
Textiles	0.001 **	0.004 **	0.006 **	0.129	0.003 **	0.102	0.052 *	0.000 **	0.074 *	0.017 **	0.112

In order to analyze the possible differences among other sectors, an ANOVA with Tukey-Kramer comparison has been conducted with a reduced sample (i.e. removing textiles enterprises), but it does not allow to draw any other particular conclusion, since a statistical evidence on the questions has not emerged. Considering Italy, it is possible to observe that the phenomenon that interested the textiles sector is now in place for the other sectors, highlighting the perception of lack of competitiveness of those sectors respect to their efficiency, that might lead to the dramatic consequences already happened in the textiles sector. In particular, the growing competition of emerging economies, that necessarily present lower labor costs compared to Italian ones, is driving the attention of the interviewed SMEs towards energy-efficiency: indeed, although energy does not usually cover a consistent share of production costs for their sectors, energy efficiency seems to be one leading path for the their survival.

Conclusions

The paper dealt with one of the most important issues in research of the barriers to energy efficiency; that is to evaluate them in non-energy intensive SMEs, adding some interesting pieces to the puzzle.

First, on one side it has been observed that several barriers, as those related to the organizational and decisional structure, in case of SMEs cannot be investigated, since, indeed, a true decision-chain is missing: the entrepreneur him/herself has the power to decide whether to implement an energy-efficiency intervention or not. On the other hand, to have a closer look to the barriers, it seems to be necessary to move towards entrepreneurs' sensibility, much more concerned on operational issues than theory-driven definitions of barriers to energy-efficiency, thus formulating the questions in more operative terms.

Second, the major barriers found in this study are represented by: access to capital; lack or imperfect information on cost-efficient energy-efficiency interventions; and the form of information. Moreover, it can be argued that the awareness of personnel and management does not really represent a barrier to the implementation of energy-efficiency interventions; nonetheless, as the nature of the sample investigated, that seems to be particularly aware respect to energy-efficiency issues, this result has to be considered with caution, and within its limitation.

Third, and very important for the scientific research, it is necessary to avoid bundling together SE, ME and MLE, when it is likely not correct: this is the case of several barriers investigated, such as *lack of time*, *lack of internal skills*, *lack of personnel awareness*, and *difficulty in implementing* either *management* or *technical interventions.* This is an important contribution to the literature, which, as now, has tended to consider those three different kinds of enterprises, respect to the barriers to energy efficiency, as a whole.

In particular, it has been observed that Medium-Large enterprises suffer from the lack of time or lack of internal skills less than Small and Medium enterprises, due to a more structured organization, e.g. people usually in charge of activities for enhancing energy efficiency. Moreover, it can be argued that Small and Medium enterprises have a more agile

internal structure, that reduces the difficulties in implementing both management and technical energy efficiency interventions, and allows to more closely control the operations of the personnel, developing into it the awareness of the importance of an energy-efficient behavior.

Fourth, but this study represents one of the first contributions in the field, not all sectors within non-energy intensive SMEs can be bundled together: in particular, it has been observed that the textiles sector has a significantly lower perception of the barriers respect to the other investigated sectors. Nonetheless, the findings represents a starting point that requires further research in order to successfully formulate and adopt punctual energy policy instruments within Italy but, as an extension, also within the European Union.

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