



# Motivating towards energy efficiency in small and medium enterprises



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## ABSTRACT

Industry is responsible for about 50% of world energy consumption and therefore for a big impact concerning greenhouse gas emissions and climate change. An important strategy to achieve the target of energy policies in Europe, of reducing the energy consumption by 20% by 2020, must consider reducing energy consumption in industry. When talking about industry, it must be remembered that small and medium-sized enterprises are a central part of economies worldwide, comprising 99% of enterprises and providing about 60% of employment. Increasing their energy efficiency represents considerable value for economies, societies and the enterprises themselves. Together with cost savings, energy efficiency can deliver other benefits that can help those companies grow and develop, for example by improving productivity, profitability and competitiveness and product quality. By reducing reliance on energy imports, and lowering environmental impacts, it increases value, not only to business, but also to society. Despite the benefits resulting from energy efficiency measures, their implementation in companies is not an easy task, due to existing barriers that must be identified in order to define motivation strategies that can fight those obstacles. A project, aiming to identify the situation in medium-sized enterprises and to provide them the necessary conditions to adopt energy efficiency improvements, was developed in Portugal. It enabled to conclude about best practices and technological solutions that answer the energy efficiency problems and to identify the main barriers that prevent that adoption, and measures that can contribute to overcome them. The research within the sectors studied showed that changing individual energy behaviors requires strategies that address both internal and external influences on behavior change and not simply new technologies, price incentives or information campaigns.

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## 1. Introduction

Small and medium-sized enterprises representing 99% of enterprises and providing about 60% of employment are a central part of economies worldwide and therefore in Portugal too. They contribute around 50% of global gross value added and from 16% to around 80% of gross domestic product (GDP), depending on the country's economic structure (IEA, 2015).

Small and medium-sized enterprises are important drivers of economies around the world. In the European Union, they employ almost 90 million people, generate about 1.1 million new jobs per year and contribute to almost 30% of GDP. Despite limited resources they also drive innovation by carrying out nearly 20% of research and

development (R&D) in the United States and the European Union, and they account for more than half of R&D in some OECD countries such as Iceland, Norway, Poland and Portugal (OECD, 2013).

Even if individually small and medium-sized enterprises' energy consumption is not high, when considering them as a whole, their energy demand is considerable and according to IEA estimates, they consume more than 13% of total global energy demand.

With the rising price and the threat of exhaustion of energy and resources, energy management became one of the main worries of industrial management (Petrecca, 1992; Rohdin and Thollander, 2006), and the interest in analyzing and improving the impact of energy consumption of products and processes has been stated by different stakeholders (Thiede et al., 2013). Another important aspect to be considered has to do with consequences in greenhouse gas emissions and climate change (Chai and Yeo, 2012) and the targets that several countries including Portugal are committed to attain by 2020. Therefore the important part played by energy efficiency in industrial enterprises (Worrell et al., 2009), and in a

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special way in small and medium-sized enterprises, considered at the same level as conventional fuels in the global energy balance (Fleiter et al., 2012).

The conclusions of several recent studies on this subject show that the potential for improvement in energy and resources efficiency in manufacturing companies varies in an interval from 10 to 40% concerning possible energy savings (Thiede, 2012; Thiede et al., 2013), and it is higher when considering small and medium-sized enterprises due to its number and to its state of the art concerning energy efficiency (Trianni et al., 2013a, b).

By improving small and medium-sized enterprises' energy efficiency their profitability and competitiveness will increase. By reducing their energy costs, product quality and output can be improved, risks and liabilities reduced, resilience enhanced and new business opportunities enabled. It also contributes to wider policy objectives, such as boosting employment opportunities, expanding the market for energy efficient goods and services, improving energy security, reducing greenhouse gas (GHG) emissions and local air pollution, and enabling investments in additional power generation to be deferred.

The result of increasing small and medium-sized enterprises' energy efficiency will then be translated into value increase for economies, societies and the enterprises themselves. Energy efficiency, besides providing many economic, social and environmental benefits, plays an important part in tackling climate change problem (IEA, 2015).

The Portuguese situation is not quite different from the one presented in the studies at European level: more than 90% of Portuguese industrial companies are small and medium-sized ones and the level of entrepreneurial culture in what concerns energy efficiency aspects is low (Catarino et al., 2015). Portugal is committed, due to European agreements, to reduce energy consumption by 20% by 2020 compared with the baseline modeled scenario (1990 levels) in order to achieve the target of energy policies in Europe.

Although energy efficiency measures are recognized as an important matter and the possibilities of application are wide-ranging, it is still hard to convince companies' top management about the benefits of their implementation. This is not an easy task due to many identified barriers.

According to Sorrell et al. (2000), a barrier is defined as a postulated mechanism that inhibits a decision or behavior that appears to be both energy and economically efficient. The barriers prevent the adoption of energy efficient technologies and practices in the industrial sector, and limit opportunities to attain additional energy savings (US Department of United States Department of Energy, 2015).

As important as to identify and discuss those barriers, which impede deployment of energy efficiency in the industrial sector, is to find measures to overcome them (Trianni et al., 2013a, 2013b), and so a deep discussion about them is an important subject if it can lead to solutions to the problem.

This paper, supported by the Portuguese experience lived in Efinerg project (Catarino et al., 2015), intends to identify the main barriers and also possible ways to overcome them, namely those related with behavioral ones in a small and medium-sized entrepreneurial scenario. It is structured as follows: an introduction presents the problem and its context as well as a summary of existing studies about the subject; identified barriers and possible ways of motivating entrepreneurs to overpass them are then analyzed; the Portuguese experience is referred through the presentation of the methods used and during the development of Efinerg project in Portuguese small and medium-sized enterprises; finally, results are discussed and some conclusions and items for future research and development are presented.

## 2. Barriers versus motivation

### 2.1. Barriers

Energy as a resource has not been used as efficiently as it should and could be and there are cost-effective technologies that could improve energy use and are not implemented yet. This happens in all sectors of society: households, public buildings, institutions and private industries.

The factors that contribute to the non-adoption of energy efficiency measures are referred to as barriers (Apeaning and Thollander, 2013). It is recognized that the potential for energy efficiency improvements in the industry is significant specially in what concerns small and medium-sized enterprises but the implementation of energy efficiency measures is not always possible owing to various barriers to energy efficiency (Paramonova and Thollander, 2016).

Different authors have been identifying barriers to industrial energy efficiency, even if this concept of a barrier to energy efficiency is not always clear. Different taxonomies and different approaches to classify barriers appear in literature, some of them based in statistical methods (Giacone and Mancò, 2012).

An important barrier to investing in energy efficiency, which is often referred, has to do with the restricted access to capital markets and investments which may not be profitable because they imply a high price for capital. As a result, only investments with an expected return that exceeds this (high) hurdle rate will be accomplished (Schleich and Grubber, 2008). Furthermore if improving energy efficiency comes at the cost of other more cost-effective opportunities, the firm will give energy efficiency a low priority.

When speaking about management, some of the barriers included in this item have to do with information problems, and, according to Golove and Eto (1996), they can fall into three categories: lack of information, cost of obtaining information and accuracy of information.

Other barriers faced by small and medium-sized enterprises that make it difficult for them to adopt energy efficiency measures are the lack of time and resources to explore energy efficiency options, the lack of information about where and how energy is used in their companies and the lack of internal capacity to develop and implement energy efficiency projects. Therefore energy efficiency is rarely viewed as a priority.

Another important aspect that may fall into behavior aspects has to do with inertia, which means that both individuals and organizations are creatures of habits and established routines (Andrews and Johnson, 2016). They do not welcome changes in their environments and avoid or ignore problems, which may make it difficult to create changes to such behaviors and habits (Thollander et al., 2010). Those difficulties in getting people to change their behavior are also present in relation to environmental responsibility namely what concerns energy aspects (Bradley et al., 2016).

Small and medium-sized enterprises' managers are focused on their daily business and on solving problems and have little time to develop expertise beyond the essentials, thus often ignoring profitable efficiency opportunities. The Observatory of European small and medium-sized enterprises found that fewer than 30% of small and medium-sized enterprises in Europe had implemented any measures for conserving energy and resources, and only 4% had a comprehensive approach to energy efficiency (European Commission, 2014).

Lack of experience with energy efficiency also gives rise to concerns that energy efficiency measures may disrupt the production process and lead to revenue losses or affect product quality

together with uncertainty about cost savings (Olsthoorn et al., 2015). Such concerns can act as a strong deterrent.

When small and medium-sized enterprises do decide to pursue energy efficiency projects, they may have to rely on external parties for financial and technical guidance. Where appropriate skills are not offered in the wider marketplace – by consultants, or equipment suppliers, for example – this barrier is further reinforced.

A summary of different studies on barriers to energy efficiency is presented on Tables 1 and 2 is a summary of barriers, difficulties and motivation factors that can contribute to energy efficiency in Portuguese enterprises.

## 2.2. Motivations

New energy efficiency technologies often remain unimplemented due to barriers (Thollander et al., 2013). To identify motivation strategies that enable to overcome those barriers is a subject as important as to list them. This implies to understand them, to identify which organizational, economic, behavioral, or other aspects prevent companies to implement energy efficiency measures.

Although a lot has been published about identifying barriers the same cannot be said about motivations to improve energy efficiency.

When besides the adoption of new technologies, energy management best practices are also considered, the potential for energy efficiency is highly increased (Backlund and Thollander, 2011).

Cost reductions, resulting from lower energy consumption as well as direct fiscal subsidies are mentioned in a study conducted in Holland as the most important motivations to which a Swedish report adds the existence of a long term energy strategy (de Groot et al., 2001).

The European strategy for smart, sustainable and inclusive growth states as one of its objectives the improvement of energy efficiency. Improved energy efficiency provides both direct economic benefits and indirect ones such as increased competitiveness and higher productivity.

Other studies present some more aspects that contribute to motivate companies to implement energy efficiency measures such as the potential for improving the energy and resource efficiency in manufacturing companies in intervals that range from 10 to 40% in possible energy savings (European Thiede, 2012; Thiede et al., 2013). When considering small and medium-sized enterprises this potential is higher once they represent the large majority of companies and have improved very little in the field of energy efficiency (Trianni et al., 2013a, b).

Even when information is available, managers have no time and motivation to obtain, process and act on it and therefore those enterprises are often unaware of the options to improve efficiency, and the costs and benefits of those options (European Commission, 2014). Information measures such as energy audits, technology demonstration projects, site visits, case studies, “how to” guidance materials, fact sheets, lists of typical energy efficiency projects, list of energy-efficient equipment, workshops, webinars, advice hot-lines, energy efficiency standards for equipment, and clear marking of efficiency levels on equipment may help small and medium-sized enterprises to improve energy efficiency.

In a study, conducted in some energy-intensive industries, in several European countries (foundry industries in Finland, France, Germany, Italy, Poland, Spain and Sweden), is stated the important part played by energy management in the transformation of industrial energy systems towards improved energy efficiency and increased sustainability. Financial and organizational aspects were the most relevant driving forces detected (Thollander et al., 2013). Anyway nothing will be done if the top management real support does not exist. No energy management strategy will ever be implemented without it.

## 2.3. Ways to overcome barriers

When designing support programmes to overcome barriers to the adoption of energy measures in small and medium-sized enterprises, different aspects must be taken into consideration. One important item has to do with the enterprise profile, its size, sector, location, the ownership structure, the energy consumption (type and quantity) and supplier. If different aspects are associated and integrated, such as those related with information, expertise and financing, the probability of success increases. The same happens when different stakeholders are involved (such as government, associations, financial institutions, service suppliers). If the investment will result in other improvements beyond energy, such as productivity, quality, value, safety, then its attractiveness will increase. Also the easiness in accessing a program contributes to the success of adhesion from small and medium-sized enterprises which by definition have limited resources and therefore are focused on day-to-day operations.

When elaborating energy efficiency programmes and regulations, the political backing of measures and legislation or its opposition or indifference has to be considered due to the part played by government representatives in making pressure for energy efficiency (Langlois-Bertrand et al., 2015). Energy efficiency programmes must be designed in order to overpass these barriers, unlocking a wide range of benefits.

An interesting experience has taken place in several countries namely Switzerland and Germany where the participation in industrial energy efficiency networks proved to be a powerful means of introducing customized energy management practices into small and medium-sized enterprises. In this network, companies get support from an external coordinator to evaluate energy efficiency potential, implement and monitor measures (Paramonova and Thollander, 2016).

Insufficient capacity to develop bankable projects with financial institutions makes small and medium-sized enterprises access to financing for energy efficiency measures quite difficult. To overcome these barriers countries and their governments must develop effective energy efficiency programmes that can reach companies in their diversity.

One important measure to overcome barriers and implement energy management and energy efficiency technologies may be considering energy services that through contractual arrangements can offer financial support in investments in new technologies, support in managing the intervention within the plant and provide information about existing opportunities.

There are some measures to improve energy efficiency that have a negative cost when implemented. This means they are profitable options since they show a positive net present value, which would mean that the option will save money through reduced energy expenditure over the investment horizon assumed in the modeling. This could be because the majority of these measures are operational ones, which require less capital outlay compared to technical measures. Another aspect that must be taken into account is the heterogeneity of enterprises, which means that for example a technology that may be cost-effective on average for a class of users, may not be for others.

The adoption of measures, namely the ones regarding energy potential savings, is dependent on the receiver's perceived credibility of and trust in the information provider (Rehmatulla and Smith, 2015).

The need to maintain profitability and competitiveness with limited resources can make it more difficult for small and medium-sized enterprises to pay attention to energy efficiency and other environmental and business improvement initiatives.

**Table 1**  
Studies on barriers to energy efficiency (Adapted from Catarino et al., 2015).

Barriers (Sorrell et al., 2000; UNEP, 2006)		Studies on barriers to energy efficiency
Organizational	Lack of employees' knowledge or aptitude Lack of physical space	IEA, 2015 de Groot et al., 2001
Management	Resistance to replace existing machinery Distortion and uncertainty about fuel prices Inadequate information Lack of information either at consumption patterns and efficiency measures levels Priorities Lack of time Lack of information: <ul style="list-style-type: none"> <li>• Levels and patterns of energy consumption (information systems, the energy metering, the detail of energy bills, consumption is analysis)</li> <li>• Energy saving opportunities (lack of evaluation opportunities, availability of information on technologies costs and performance)</li> </ul> Lack of staff (and time)	Thollander et al., 2013 Hirst and Brown, 1990  Harris et al., 2000 Rehmatulla and Smith, 2015 Golove and Eto, 1996 Schleich, 2009 Trianni and Cagno, 2012
	Energy efficiency projects are not considered strategic due to the share of energy costs being rather low	Anderson and Newell, 2004 Schleich, 2009 Thollander et al., 2007 Cooremans 2011, 2012 de Groot et al., 2001 Cooremans, 2007
Financing	Lack of budget funding Other priorities for capital investment  Difficulty of access to capital Long return on investment	IEA, 2015 Rohdin and Thollander, 2006 Trianni and Cagno, 2012 IEA, 2015 Thollander et al., 2013 Harris et al., 2000 Trianni and Cagno, 2012 Sutherland, 1996 Nagesha and Balachandra, 2006 O'Malley and Scott, 2004
	Energy efficiency projects with lower priorities in what concerns investments	IEA, 2015 Trianni and Cagno, 2012 Schleich, 2009 Sorrell et al., 2010 DeCannio and Watins, 1998 Rohdin and Thollander, 2006 O'Malley and Scott, 2004 IEA, 2015 Thollander et al., 2007 Anderson and Newell, 2004 Schleich and Grubber, 2008
Government policy	Government fiscal and regulatory policies, codes and standards	Hirst and Brown, 1990 Langlois-Bertrand et al., 2015
Economic	Importance of guaranteeing the continuity of business (cost of production disruption, hassle and inconvenience are possible consequences of a discontinuity)	Nichols, 2000 Olsthoorn et al., 2015
Behavioral	Low priority given to energy issues Risk of energy efficiency investments, Misplaced incentives for the implementation of energy efficiency measures	Hirst and Brown, 1990 Thollander et al., 2010 Olsthoorn et al., 2015
Training and knowledge	Behavioral and attitude changes to energy consumption lead to energy efficiency thus indicating the importance of training and sensitization in these areas	Owens and Driffill, 2008 Stephenson et al., 2010
Technical	Production type Energy intensity Automation degree	Olsthoorn et al., 2015 Waide and Brunner, 2011

Energy efficiency programmes must be designed in order to overpass these barriers, unlocking a wide range of benefits. In order to motivate those enterprises to overcome barriers to energy efficiency improvement, and from the above exposed, there are three

main areas to be explored that have to do with increasing energy efficiency: improving information flow, strengthening capacity and providing financing (IEA, 2015).

If implementing some measures may involve little or no cost, for

**Table 2**  
Barriers, difficulties and motivation factors.

Barriers (according to Sorrell et al., 2000; UNEP, 2006)	Energy efficiency in Portuguese enterprises	
	Difficulties	Motivation
Organizational	Lack of employees' knowledge or aptitude Lack of physical space Resistance to replace existing machinery Lack of internal capacity to develop and implement energy efficiency projects	Enhancing competitiveness More efficient routines and practices Top management effective support Energy services: support the intervention within the plant
Management	Lack of information either at consumption patterns and efficiency measures levels Cost of information Accuracy of information Priorities Lack of time to explore energy efficiency options Lack of staff/resources Energy efficiency projects are not considered strategic due to the share of energy costs being rather low	Credibility of the information provider Improve information flow Energy audits Technology demonstration projects Site visits Case studies "how to" guidance materials Fact sheets Lists of typical energy efficiency projects List of energy-efficient equipment workshops Webinars Advice hotlines Energy efficiency standards for equipment Clear marking of efficiency levels on equipment Long term energy strategy Energy services: provide information about existing opportunities Strengthening capacity Providing financing Rely on external parties for financial and technical guidance Different services and different types of support may be needed for similar-sized companies in the same sector, but in different stages of maturity. Financing measures that help provide SME with access to capital and other financial resources Develop bankable projects Promote financial products for energy efficiency projects Energy services: financial support in investments in new technologies Countries and governments must develop effective energy programmes Energy efficiency programmes must be designed in order to overpass barriers, unlocking a wide range of benefits. If different aspects are associated and integrated, such as those related with information, expertise and financing the probability of success increases. If different stakeholders are involved (such as government, associations, financial institutions, service suppliers) the probability of success increases. Easiness in accessing a program contributes to the success of adhesion from SME The part played by government representatives in making pressure for energy efficiency Direct fiscal subsidies Investment subsidies for technology Cost reduction Reduction production costs
Financing	Lack of capital Restrict access to capital markets and investments Long return on investment Insufficient capacity to develop bankable projects with financial institutions - access to financing for energy efficiency measures quite difficult Lack of budget funding Energy efficiency projects with lower priorities in what concerns investments	
Government policy	Government fiscal and regulatory policies, codes and standards	
Economic	Importance of guaranteeing the continuity of business (cost of production disruption, hassle and inconvenience are possible consequences of a discontinuity) The need to maintain profitability and competitiveness with limited resources	
Behavioral	Individuals and organizations are creatures of habits and established routines	Sensitization to the energy efficiency theme and potentialities
Training and knowledge	Behavioral and attitude changes to energy consumption lead to energy efficiency thus indicating the importance of training and sensitization in these areas	Providing training and support to help SME Training and capacity building for the financial sector to enable it to develop Provide and promote financial products for energy efficiency projects
Technical	Production type Energy intensity Automation degree	Take into account the SME profile, its size, sector, location, the ownership structure, the energy consumption and supplier

others, more far-reaching energy efficiency improvements the enterprises need capital to implement them. Small and medium-sized enterprises face higher hurdles to acquiring capital than do large ones. Most energy efficiency policies and programmes are designed for large enterprises rather than small and medium-sized ones. Developing and implementing such programs for those enterprises is more difficult for various reasons; the small and medium-sized segment is very heterogeneous varying widely in size and is present in every business sector. Therefore ways of improving energy efficiency vary considerably across sectors, so common approaches may not work. Different services and different types of support may

be needed for similar-sized companies in the same sector, but in different stages of energy efficiency maturity.

Financiers may justify a weaker support with small and medium-sized enterprises lack of collateral and less rigorous record-keeping, and may consider smaller enterprises more vulnerable to market changes. The same happens with banks lacking financial products or capacity to deal with those enterprises' energy efficiency. To overpass this situation, financing measures that help provide them with access to capital and other financial resources are necessary (IEA, 2015).

Other measures such as providing training and support to help

those enterprises to develop bankable projects, and training and capacity building for the financial sector to enable it to develop, provide and promote financial products for energy efficiency projects, can also be referred.

### 3. The Portuguese experience

In order to identify the situation in Portuguese small and medium-sized enterprises in what concerns their sensibility to energy efficiency thematic, and to provide those enterprises the necessary conditions to adopt energy efficiency improvements, the project Energy Efficiency in small and medium-sized enterprises (Efinerg) was designed, developed and implemented in more than a hundred enterprises. To implement the project, besides the companies directly involved several stakeholders played an important part in the process: the Portuguese entrepreneurial association (AEP) and the Portuguese institute for small and medium-sized enterprises and innovation (IAPMEI), the National Laboratory for Research in Energy and Geology (LNEG), the entrepreneurial associations of the involved sectors, Technological Centers and the Portuguese Energy Agency (ADENE).

Twenty five companies came from each of the previously defined five industrial sectors: food, agriculture and beverage; ceramics and glass; wood, furniture and cork; metal industry; and textile and clothes. Their energy consumptions should be between 250 and 500 toe (tonne of oil equivalent). Companies with higher consumptions are subjected to specific legislation (Portuguese management system of energy intensive consumption (SGCIE)) and must be submitted to periodical energy audits; therefore, they were not the main targets of this project.

Among the stakeholders involved in the project were the Technological Centers with competences and knowledge about the represented sectors that gave a good input in the companies' selection thus guaranteeing their representativeness in the sample and assuring they would provide the necessary information.

The objective was to have a flash diagnosis about energy use in a three year period, in Portuguese companies belonging to those five sectors. The diagnosis was built with the results of a detailed questionnaire, common to the five sectors, filled by the companies' staff with responsibilities in energy management, assigned by top management with the support of technicians from the project's stakeholders, and covering four main aspects.

The first chapter has to do with a detailed identification and characterization of the company. Having in mind a life cycle approach the second part analyses energy efficiency in the product design process by identifying the companies' knowledge about European Directives (ecodesign and energy labeling), criteria for materials' and suppliers' selection, packaging definition, installation and maintenance, and end of life.

Energy efficiency in the production process is the subject of the third and longer part. Here a lot of information was requested about previous energy audits, kind of energy used and its characterization, energy consumption, production data, higher energy consumers in the process (equipment, unit operations), evaluation of critical items (electric energy network, use of renewable energies, driving force, air conditioned systems, lighting, refrigeration, freezing, thermal energy, boilers and furnaces), and relationship with workers. The aspects connected with human resources were considered in the questionnaire, namely the importance of workers training and motivation in energy efficiency, because this does not only depend on technological aspects but also on the human ones. Finally the aspects concerning the relationship with public policies and financial incentive systems were also subjected to analysis in a fourth chapter. The information was gathered, analyzed, and discussed with several stakeholders involved with in the energy

efficiency subject. As a result of this discussion, those stakeholders agreed in several strategic recommendations about policies to be implemented in order to improve energy efficiency in Portuguese small and medium-sized enterprises. The resulting information is collected in the report of the flash diagnosis study in companies compiled in a Portuguese manual. Efinerg's results enabled to conclude about best practices and technological solutions that answer the energy efficiency problems, to identify the main barriers that prevent that adoption, and to suggest measures that can contribute to overcome them (Catarino et al., 2015).

## 4. Results and discussion

Some of the results obtained in Efinerg project are in accordance with what has been said about barriers and possible ways to overcome them, namely those related with organizational, economic and behavioral aspects, which will now be analyzed in more detail.

### 4.1. Organizational aspects

As Fig. 1 shows, the responsible actor for energy management in most of the companies involved in this project comes from administrative and management staff instead of technical one. This will lead to a lower sensitivity towards those problems and therefore contributes to barriers to the adoption of energy efficiency measures. As a result of this situation, energy management tasks in those companies are centered in invoices' analysis and contracts and ignore other aspects that could contribute to energy efficiency improvements. For example, in the five sectors involved, occasional and regular measurements have a very low expression (Fig. 2).

### 4.2. Economic aspects

Although it cannot be an excuse for the lack of measures' implementation Fig. 3 shows that the percentage of energy costs versus total costs is low in the examined sample. Even if the individual energy consumption in companies is not high, when considering them as a whole and due to the weight that small and medium-sized enterprises represent in industry, their energy demand is considerable. According to IEA (2015) estimates, small and medium-sized enterprises consume more than 13% of total global energy demand.

Although incentives to investment are quite often referred by entrepreneurs when directly questioned about this item, not all the sectors involved have the same degree of knowledge, as shown in Fig. 4.

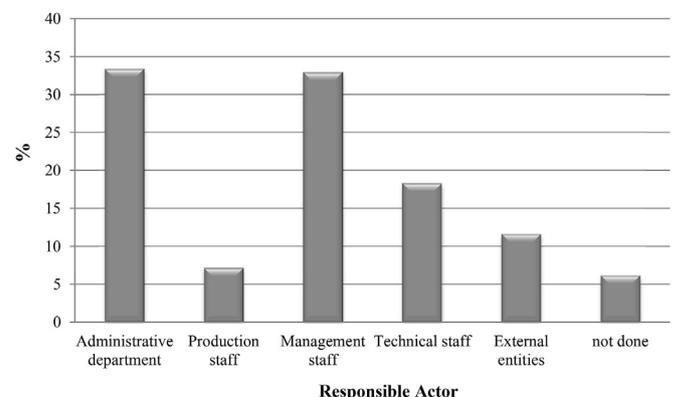


Fig. 1. Responsibility for energy management in the target companies.

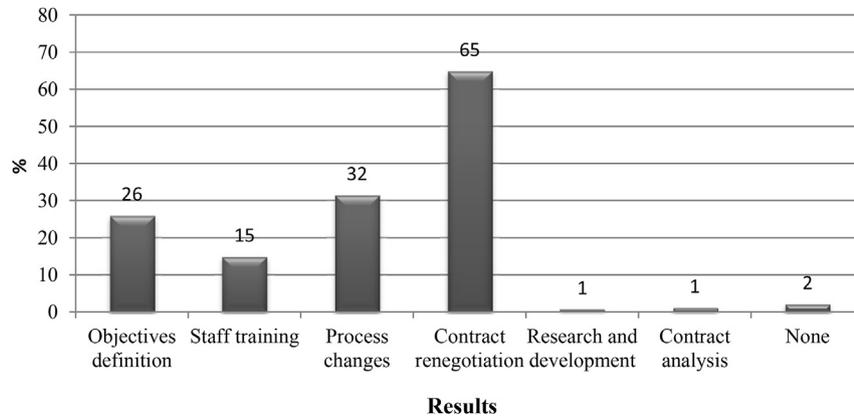


Fig. 2. Measures resulting from energy management activities in companies.

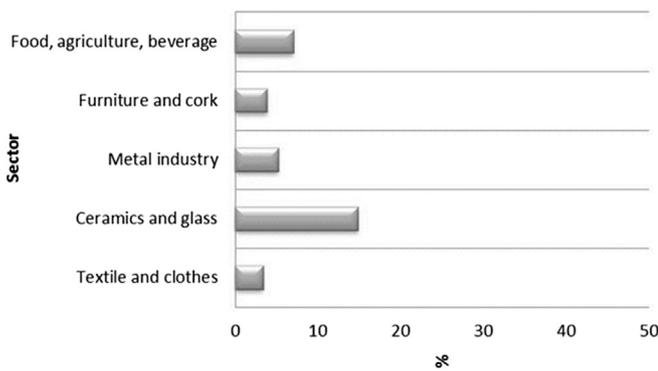


Fig. 3. Weight of the energy costs in the companies of the target sectors.

4.3. Behavioral aspects

Most of the barriers have to do with problems related to workers behavior. The results of the diagnosis show that generally companies consider to have implemented motivation programmes and also that their workers are well trained for the functions they perform (Fig. 5). But the question is if this training contemplates the energy aspects or only the items related with quality and productivity, for example.

Another important aspect is the quality of the available information. When asked about this item the answers given by

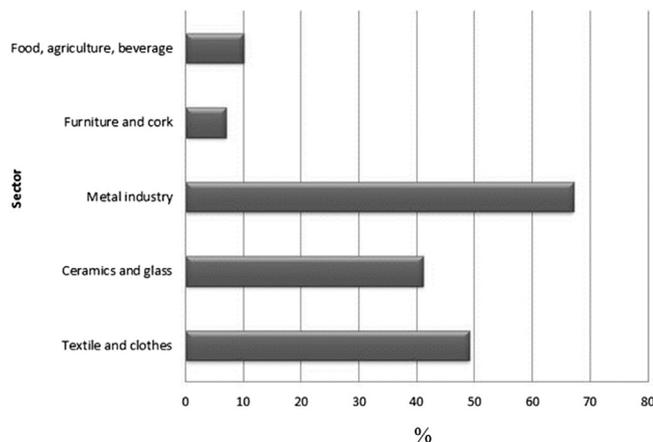


Fig. 4. Weight of knowledge about incentive systems in the companies of the target sectors.

companies about the information sources are listed in Fig. 6.

Not wanting to question the quality of the information providers, the problem is if all those sources are the most adequate in what concerns energy efficiency aspects.

5. Conclusions and items for future research and development

Barriers to energy efficiency, frequently reported in most of small and medium-sized enterprises, have been related to their limited resources, either human or financial ones, which imply that they must focus on their day-to-day problems. Therefore to get their involvement towards other aspects is not always an easy task. Efinerg case studies showed that there are no general approaches to the problems faced by industry but it is essential to take into consideration their different specificities: company size, type of activity (manufacturing, services or agriculture), sector, energy intensity, energy supply issues and ownership structures. Once specific challenges are identified it will be easier to define and develop more effective approaches.

The studies on Efinerg project allowed settling a very important aspect, perhaps the most important one and it has to do with behaviors. Understanding why do people choose to behave in ways that use energy in environmentally damaging ways or in ways that are “greener” in their impacts, will certainly be an important step in order to overcome some barriers. Identifying what has to be changed in energy behavior both externally, such as the availability and costs of greener alternatives, and internally, such as attitudes, beliefs, and values will therefore be an important aspect to be

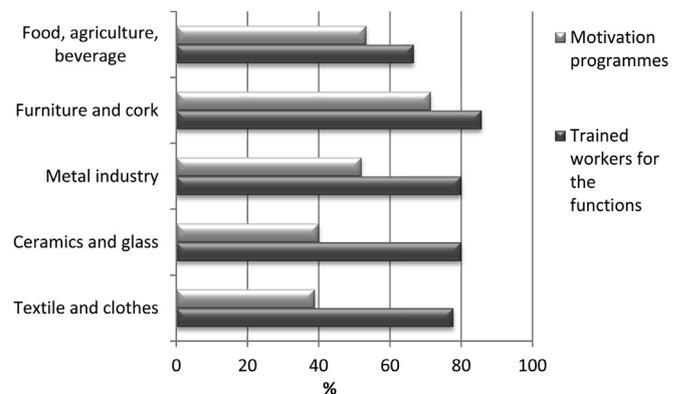


Fig. 5. Workers behavior as a result of motivation or training programs.

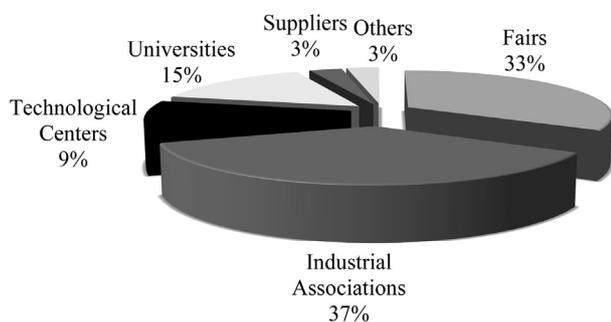


Fig. 6. Companies information sources about incentives.

considered in order to motivate small and medium-sized enterprises to energy efficiency aspects.

In Portuguese companies the major behavioral barriers appear to be limited time, information, and cognitive capacity to process complicated and unfamiliar choices and this aspect is also widely discussed in the literature. Another important question is to know what kind of information and feedback is most effective at influencing businesses' energy decisions.

The research within the five sectors involved showed that changing individual energy behaviors requires not simply new technologies, price incentives or information campaigns, but strategies that address both internal and external influences on behavior change.

It was found that in Portuguese enterprises barriers vary considerably by sector: for manufacturers they include perceived cost and risk of production disruption, lack of time, the cost of obtaining information, competing priorities for capital investments, and information or incentive gaps. Larger and more energy consumer enterprises, in contrast, face limited access to capital, followed by concerns about technical risk and lack of budget funding. For small enterprises the main barriers appear to be lack of information, limited access to capital, and low priority on energy issues.

As other authors have pointed out, the already existing programs that promote small and medium-sized enterprises competitiveness or innovation should be examined to assess whether or not they are exploiting opportunities to improve energy efficiency. There could be opportunities to add an energy efficiency component that could deliver a broader package of benefits to the target market.

With regard to energy efficiency motivation, future research is needed in order to develop and validate those results that were based on surveys in only five sectors. Further studies, involving other stakeholders, may be necessary in order to better understand the complex mechanisms of energy efficiency implementation due to different singularities, approaches and problems that may occur.

Energy efficiency maturity, personal development and the overall development of key competencies for energy efficiency, barriers and motivation are aspects still underexplored and needing special and further attention.

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