innoveas
The power of energy audits

Energy culture and energy transition

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Technical References

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[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
RE = Restricted to a group specified by the consortium (including the Commission Services)
CO = Confidential, only for members of the consortium (including the Commission Services)

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1	09.11.2019	Project partners	G. Quinti, A. Declich, P. Signore
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Project summary

The INNOVEAS project is an initiative promoted by 10 partners from 6 EU countries, to build and deliver a capacity building programme, aiming at addressing the major non-technical barriers that most often hamper the adoption the energy auditing practice, in particular among those actors, such as SMEs where such audits are not required by law.

The ultimate goal is to consolidate a structured, permanent and expandable offer to help develop continuous self-sustainable services to raise awareness and build capacity in the field of energy auditing and related energy saving measures in SMEs.

The project therefore aims at designing and deploying staff trainings and capacity building programmes to enhance corporate policy towards energy efficiency, energy culture (motivations, behaviour change, mitigation of perceived risks and barriers) and sustainable supply-chain initiatives. It therefore intends to:

- Advanced analysis of behavioural barriers to energy audits, to identify and analyse the enabling conditions and non-technical barriers hindering the adoption of energy auditing practice;
- Delivery of self-sustainable capacity building programmes, in order to systematise awareness raising procedures to overcome the psychological and organisational barriers to energy audits in SMEs, deliver a training offer to SMEs and formulate a capacity building programme targeting stakeholders such as intermediaries, policy makers and financing institutes;
- Create an institutional structure to sustain the project's objectives and results and lay the basis for the creation and consolidation of a pan-European network of enablers likely to support in the coming years the growth and expansion of the training offer to on energy efficiency for European business.

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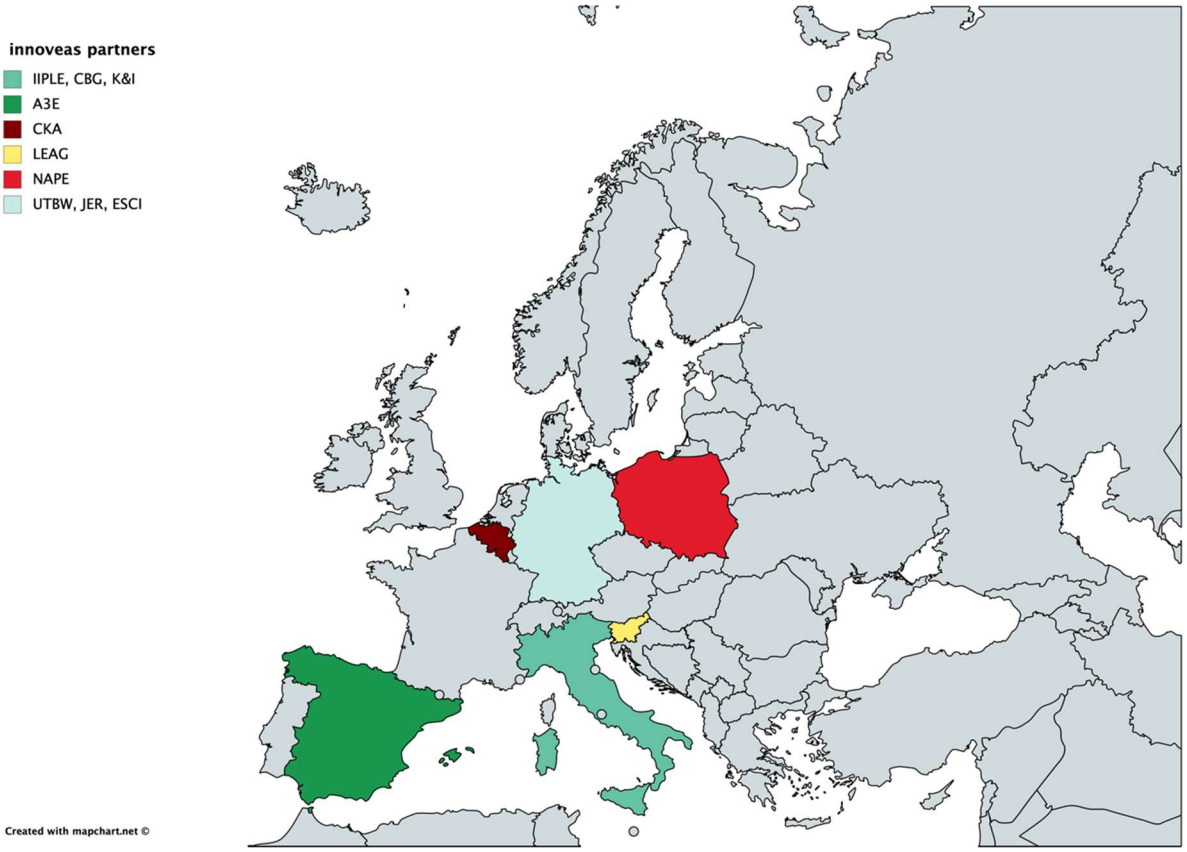
Partners



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Description of work package

WP2 intends to carry out an analysis of the current state of the art of energy culture in SMEs in the participating countries. This entails: - Analysis of the current attitude towards energy efficiency and the perception of energy audits as an instrument to abate costs - Existing non-technical barriers that hinder the diffusion of energy audits as a common praxis in SMEs in the participating countries - Analysis of existing regulatory and financial conditions that influence the use of energy audits and the uptake of energy saving measures.

Description of task

The task 2.1 (State-of-the-art analysis on enterprises energy "culture" and on other concerned actors attitudes in relation to energy audits implementation) is devoted to the preliminary analysis of the current attitudes towards energy saving measures in EU countries in general and considering, as far as possible, specificities of the concerned actors (such as: SMEs of different sizes and sectors and targeting different staff levels; energy auditors; policy makers designing the regulation and incentive schemes for energy audits; financial institutions; consumer association dealing with energy issues). In the case of enterprises and consumers these attitudes are strongly influenced by their "energy culture". All participating countries will be taken into account in this task, as well as the EU level. Phenomena that will be taken into account should be (among others): energy related behaviours (of different actors) as an aspect of a more general concept of "environmental behaviour" (looking at the diffusion of "proenvironmental behaviour" and related values & attitudes, i.e. personal and social values and beliefs that may impact pro-environmental behaviour, such as social norms, individual morals, and biospheric values, individual's political views); awareness of relevant European and international standards concerning energy audits13; the presence or the propensity towards the creation of an energy saving culture (e.g. by involving experts and academics in the development and implementation of programs in the companies); the awareness of experts about modern energy-efficient equipment and technologies. This task will be implemented through a review of scientific literature and documentation at the European level, at the international level and at the level of the selected individual European countries. The findings of this task will inform the two following tasks of the present WP and WP3.

Description of deliverable

The deliverable 2.1 (Energy culture analysis and energy transition) consists in a report structuring the results of the surveys in the aspects dealing with users' behaviours.

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1. Executive summary

This deliverable was prepared after the completion of the Review of the relevant scientific literature and documentation at the European level, at the International level and at the level of the INNOVEAS partner countries (Belgium, Germany, Italy, Poland, Slovenia and Spain), as well as of some other countries in Europe and outside. Chapter One represents an introduction describing the approach and the activities implemented. Chapter Two is dedicated to the actors involved in the process of SMEs energy efficiency improvement. It considers, first, the wide heterogeneity of SMEs in Europe and then mentions the other relevant actors: energy auditors and other experts assisting/assessing SMEs, industrial and trade associations, the financial sector, policymakers and consumers' associations dealing with energy issues, and the scientific community. Chapter Three deals with the "energy culture" in SMEs and, more specifically, on how cultural factors affect energy efficiency and on SMEs disposition towards energy efficiency. It highlights how many SMEs are not, or scarcely, involved in the energy transition process towards a low-carbon society. However, it can be argued that a part of the companies has its own energy culture and has a positive orientation on energy efficiency. Women's leadership seems to have a positive effect at this regard. Chapter Four deals with the relevance and effectiveness of the energy transition process and specific related actions in SMEs. In particular, the attention will focus on what SMEs do (and how they do it) in this regard, with special reference to both the actual and potential barriers making their involvement difficult or even impossible, and conversely the incentives and other drivers that could allow them to overcome these barriers; all this, taking into account the large differentiation that exists in the world of SMEs. The Chapter starts dealing with the improvements in energy efficiency and management (eco innovation included) in SMEs, trying to understand how this process can be started or strengthen (also thanks to energy audits). Later, it focuses on the barriers that hinder these improvements, as a whole and according to some features of the SMEs (country, size, sector, etc.). Finally, it considers the driving forces (or motivations) that, vice versa, can facilitate such improvements, including some specific factors, external to the firms, which can help them attain higher levels of energy efficiency (e.g., specific national programs or similar measures, and the creation of "energy efficiency networks" among SMEs). In Chapter Five the subsequent steps in the WP2 implementation are mentioned and a first list on specific barriers towards the implementation of energy audits is presented. The overall list of the documents analysed in the Literature Review is reported in annex.

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2. CHAPTER ONE INTRODUCTION

2.1 Institutional framework

This document is the first deliverable of the WP2 "State of the art, needs and barriers assessment" of the INNOVEAS project and it is devoted to the analysis of the energy culture about energy transition in the various actors dealing with the practice of energy audits in SMEs in Europe (and beyond).

This analysis is based on a literature review (described below) which allowed firstly identifying and analysing the concerned actors, i.e.:

- SMEs energy-intensive
- SMEs non-energy intensive
- Energy auditors
- Financial sector devoted to SMEs and energy issues
- Industrial associations and other trade associations
- Other experts assisting/assessing SMEs
- Policymakers designing the regulation and incentive schemes for energy audits
- Consumers' associations dealing with energy issues; scientific community.

Afterwards, a set of issues have been considered in the literature review, such as:

- The SMEs attitude towards energy transition (considering internal and external barriers, as well as drivers and facilitating factors, in the energy efficiency/ management improvement process in SMEs)
- Energy efficiency/management improvements in SMEs
- The specificities of the "energy culture" in SMEs and the other concerned actors
- The actual and potential "role" played by the SMEs energy audits in this broad frame.

This is a first step for assessing (later, in the following deliverable) the non-technical (behavioural, organizational, institutional, and psychological) barriers, that hinder the use of energy audit to uptake energy-saving measures.

2.1.1. The INNOVEAS project

The INNOVEAS project intends to build and deliver a capacity building programme, aiming at addressing the major non-technical barriers that most often hamper the adoption of the energy auditing practice, in particular among those actors, such as SMEs, where such audits are not required by law. The ultimate goal is to consolidate a structured, permanent and expandable offer to help develop continuous self-sustainable services to raise awareness and build capacity in the field of energy auditing and related energy-saving measures in SMEs.

The energy audit represents the first necessary step to trigger an energy efficiency process in SMEs. The audit allows to know own consumptions and identify single factors influencing consumption and among these the main factors (production rate, temperature, etc.).

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Consumption rates can then be benchmarked against target values to understand what can be improved. It is therefore generally acknowledged that energy audits do represent an opportunity for companies to optimize management and production costs. However, the state of the art reveals some criticalities in the uptake of audit-oriented practices among those actors who are not legally obliged to do it (such as SMEs).

Main target groups of the INNOVEAS actions are listed below.

- SMEs, the final target group/beneficiary of the action. They are the actors who will have to encounter an environment favouring the implementation of energy audits and therefore the adoption of energy efficiency measures.
- Energy auditors, who are one of the directly involved actors (in the energy audits, beyond the SMEs) and, through their work, contribute substantially in assessing the barriers to SMEs energy efficiency improvement.
- Policymakers, i.e., any institutional actor who can contribute to the creation of a favourable regulatory environment for the implementation of energy audits. Their involvement as stakeholders in the focus groups/panels foreseen in WP2 is necessary to discuss the state-of-the-art and co-create solutions towards a common direction.
- Financial institutions, i.e., all those actors who are involved in financing schemes for SMEs and can, therefore, support them in the implementation of audits and the adoption of energy efficiency measures.
- Industrial associations and other intermediaries who will be responsible for the implementation of an awareness-raising and training programme directly targeting SMEs and who will play a necessary role as impact multipliers. Intermediaries will be the most important hub connecting all the stakeholder typologies addressed by the project, mainly SMEs, policymakers, financial institutions, auditors, energy efficiency technology providers, and the Energy Service Companies (ESCOs).

2.1.2. Work Package 2

In the framework of the project, the WP2 on “State of the art, needs and barriers assessment”, to be implemented from June 2019 to February 2020, is devoted to carrying out an analysis of:

- The current attitude towards energy efficiency and the perception of energy audits as an instrument to abate costs
- The non-technical barriers that hinder the diffusion of energy audits as a common praxis in SMEs in the participating countries, and
- The existing regulatory and financial conditions that influence the use of energy audits and the uptake of energy-saving measures.

For attaining these objectives, WP2 develops through three tasks:

- An analysis of the current state of the art of energy culture in SMEs in the participating countries, entailing, among others, the attitudes of involved actors about energy audits implementation (T2.1)

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- An analysis of the state of the art in EU countries (taking specifically into account the partners' countries, i.e., Germany, Italy, Poland, Belgium, Spain and Slovenia) regarding the existing non-technical barriers, that hinder the use of energy audit to uptake energy-saving measures (T2.2), and
- An analysis of the state of the art for what concerns external factors that are currently in place at EU level and which aim at encouraging the adoption of energy-saving measures in SMEs (T2.3).

The first two tasks have been, until now, duly implemented (T2.1) and partially implemented (T2.2) through a review of the scientific literature and relevant documents at the European level, at the international level and at the level of the partners' countries, as named above. Later, the second task will be completed through a consultation in the partners' countries of key informants, such as SMEs leaders, energy auditors, policymakers, financial institutions representatives, consumer associations' leaders dealing with energy issues, scientific experts and academics (around 40/50 as a whole).

The Task 2.3 consists of monitoring the reception of the 2012 Energy Efficiency Directive a national level and analysing other existing incentives for SMEs.

2.1.3. This deliverable

This deliverable falls under Tasks 2.1 and 2.2. and has been prepared after the completion of the review of the scientific literature and relevant documents at the European level, at the international level and at the level of the selected individual European countries (Germany, Italy, Poland, Belgium, Spain and Slovenia).

Besides this introduction, it includes 4 chapters.

- Chapter Two, dedicated to the description of the involved actors in the process of SMEs energy efficiency improvement.
- Chapter Three, dealing with the "energy culture" in SMEs and the other actors considered in Chapter Two.
- Chapter Four, on the relevance and effectiveness of the energy transition process and specific actions in SMEs and considering, therefore, issues such as:
  - Energy efficiency/management improvements in SMEs
  - Energy audits and SMEs
  - Internal and external barriers in the energy efficiency/management improvement process in SMEs and how these barriers can be overcome
  - Drivers and other facilitating factors (internal and external) in the energy efficiency/management improvement process in SMEs.

In the last chapter, the following steps of the WP2 implementation will be taken into account, devoted to the issue of the energy audits in SMEs (considering also further tools for assisting SMEs in their possible energy efficiency/management improvement process) and the related barriers in their implementation.

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The overall list of the documents analysed in the Literature Review is reported in annex.

This deliverable has been prepared mainly by K&I (Andrea Declich, Paolo Signore and Gabriele Quinti, with the collaboration of Claudia Colonnello) with a precious contribution of the Local Energy Agency of Gorenjska (Slovenia), the National Energy Conservation Agency (Poland), the Asociación de Empresas de Eficiencia Energética (Spain), Dr. Jakob Energy Research GmbH & Co. KG and Umwelttechnik BW (Germany), Crehan and Kusano Associates (Belgium) and, of course, IPLEE as INNOVEAS coordinator.

2.2. The setting of the literature review

To implement the above-mentioned literature review, based on a preliminary analysis of some first studies, a note, shared with all the INNOVEAS partners, was conceived. That note identified "ex-ante" (i.e., before the implementation of the review) some research questions that it was necessary to have in mind to select the texts to be analyzed, as well as some methodological criteria which will be discussed in the next paragraph of this chapter.

The identified research questions were the following.

- The system of actors involved in the promotion of energy efficiency and energy audit among SMEs

A relevant issue is the type of actors and organizations involved in the promotion of energy efficiency and energy audits among SMEs (and other specific aspects of energy policies) and the various ways in which they are organized and cooperate with each other in the various countries (e.g., industrial associations promoting awareness-raising initiatives among SMEs and/or providing associated SMEs with guidance and support in energy audits; energy auditors dealing with SMEs; financial institutes proposing convenient financing solutions to improve SMEs energy efficiency; policymakers designing the regulation and incentive schemes for energy audits and, more generally, dealing with energy issues in relation to SMEs; etc.).

- The "energy culture"

One of the key research questions concerns the "energy culture" of the actors involved and in particular of the small and medium entrepreneurs. The issue is if such a culture is conducive to energy-saving and energy audit. It is, therefore, necessary to gather information on the "energy culture" of the leading players in the various countries and in particular of the SMEs entrepreneurs, taking into account, at this regard, phenomena such as:

a. Awareness of entrepreneurs in SMEs on issues related to climate change (through the adaptation of mitigation measures, e.g., related to the emission of CO2, through the awareness about environmental sustainability, through an interest in environmental goals, etc.)
b. Awareness on actual and potential low-carbon measures in SMEs (e.g., use of photovoltaic or other renewable energy)
c. Awareness about modern energy-efficient technologies and equipment, among the various actors involved (actually or potentially) in energy-audit programs concerning SMEs
d. Awareness of other measures (e.g., in the management, in the energy behaviour of their employees) for improving internal energy efficiency in SMEs

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e. Level of information on what an energy audit is, which its benefits could be as well as on European energy policies (and, in this frame, more specifically, energy audit rules and policies)
f. Level of trust in national and European institutions who deal with energy policies concerning SMEs.

- "Energy culture" and innovation

It could be assumed that there are relations between the presence of an energy culture among SMEs entrepreneurs and their general propensity towards technological innovation.

- Diverse systems of actions

Energy behaviours are meant as systems of actions related to energy consumption and use implemented by various actors based on given sets of assumptions, beliefs, values, objectives, resources, and interests.

They could be seen as an important aspect of energy-saving and a component of a broader "environmental behaviour", in particular, but not exclusively, inside SMEs of different sizes and sectors and targeting different staff levels as well as inside industrial associations and other intermediaries with SMEs.

In this framework, some best practices and actual experiences of implementation of energy-saving activities (e.g., use of modern energy-efficient technologies and equipments; adoption of mandatory energy-saving rules in SMEs management and/or in relation to the energy behaviour of their employees, etc.) should be singled out in order to know what are the differences and commonalities among the various experiences and actors who carry out such initiatives. Such differences could also be of a regional type.

- Internal barriers

It is generally acknowledged that energy audits do represent an opportunity for companies to optimize management and production costs. However, the state of the art reveals some criticalities in the uptake of audit-oriented practices among those actors who are not legally obliged to do it (such as SMEs). Only a few SMEs have implemented an energy audit. This is apparently due to barriers mainly internal to SMEs (partially related to a lack of an advanced energy culture).

As for internal barriers we refer to those barriers originated within the SMEs. Moreover, the barrier originated in other organizations and/or firms that are involved in the implementation of energy-saving policies are also relevant for this project and should be considered too.

It is noteworthy that some of the barriers examples (e.g., lack of awareness) are similar to other aspects we are interested in, for example, the "energy culture". This is not a contradiction. Energy culture is something concerning the orientation of actors regardless whether such an orientation has been impacting the practices of SMEs or other relevant actors. We should consider that barriers are not only connected to operational factors (e.g., costs, technological appropriateness) but also to cognitive factors, i.e., the actors' perception about the fact that a certain factor can produce a value for the firm.

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Examples of barriers are listed below.

a. Lack of awareness due to weak interest and involvement in energy efficiency measures; low status of energy efficiency; lack of interest in energy efficiency; more specifically, lack of awareness of relevant European and international standards concerning energy audits.
b. Limited information on energy efficiency improvement opportunities: SMEs are often unaware of their options for raising efficiency, and the costs and benefits of those options. Where information may be available, it may not be readily accessible, and SME managers may lack the time and motivation to obtain, process and act on it.
c. Limited in-house skills and expertise to identify and implement projects: SMEs typically focus their resources on their daily business, leaving little time to develop expertise beyond the essentials, so they often bypass profitable efficiency opportunities. 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.
d. Imperfect evaluation criteria; scepticism on the efficacy of the proposed measures and therefore reluctance to invest (also based on the idea that in the end, at best, the saving would have been small compared to the company's turnover or profits).
e. Difficulty in accessing the capital to finance energy-efficiency improvements.
f. The general reluctance in changing own working routines and practices.
g. Scepticism on the efficiency of the audits, comparing the total cost saving of all energy-saving measures identified during an energy audit against the time and capital outlay in undertaking an audit.
h. Lack of trust/confidence in the external actors who provide consultancy services.
i. Reluctance to adopt measures which may disrupt the production process and lead to revenue losses or affect product quality.
j. As only companies bigger than SMEs are legally obliged to conduct an energy audit, SMEs unfortunately received the message that energy audits are only interesting for these companies.

- External barriers

For external barriers, we mean those that originate outside the firm. Also external barriers may be divided into cognitive and operational ones. Examples of external barriers are:

a. Lack of attention from local/regional authorities (and other target groups), for the definition of financial incentives to be granted to SMEs for the implementation of energy audits and, more generally, for the promotion of energy efficiency programs
b. Energy price fluctuation, low diffusion of technologies and information, difficulties to find external skills
c. Substantial changes in fiscal policies
d. Rather low awareness of experts (beyond SMEs, e.g., among auditors, etc.) about modern energy-efficient equipment and technologies
e. Technology suppliers not updated and with a lack of interest in energy efficiency
f. Distortion of energy policies and weak interest to promote energy-efficiency schemes among the energy suppliers
g. Limited effectiveness in energy audits (in relation to how do auditors stay up to date on the kind of advice they give and, on the options available for better energy management

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practice; how much the audit report can be “capitalized” and what does it look like; and which kind of advice is normally given).

- Facilitating factors

In the framework of this literature review, both the measures of actors in support of the SMEs and those initiated by the SMEs that have decided to join the auditing programs have been considered. These measures can be called “facilitating factors”. Here below some examples of facilitating factors emerging from the literature are given:

a. Information and awareness programmes of SMEs on audits, promoted by public administrations or trade associations
b. Training programmes
c. Ad hoc assistance services to SMEs or “turnkey audits”
d. Specific activities carried out by SMEs to implement energy audits.

- The milestones of the process for undertaking energy audits

In the study of literature and national documentation, it may be useful to pay attention to the aspects that are considered decisive in the decision-making process of SMEs entrepreneurs, concerning energy audits. The question we ask ourselves is: what are the elements that could make an SME entrepreneur decide to engage in energy audits? In this sense, milestones are considered as turning points in a process of awareness-raising and transition to an operational phase. To give some examples:

a. Circumstances in which a change of opinion occurred regarding the economic convenience of an energy audit
b. Circumstances in which the adhesion to systems of value or significance that foresee the realization of energy audits took place
c. Circumstances in which trust has developed in some intermediate institutions/bodies
d. Procedures and circumstances in which solutions of specific doubts or questions regarding energy audits were identified.

Even though it is not possible for this document to treat or respond to all of these research questions, this document covers them partially. Conversely, these research questions have represented the compass to identify the texts to be incorporated into the Literature review and therefore to orientate the analysis underpinning this document.

2.3. Methodological framework

For investigating the above-mentioned research questions, a two-step methodology has been adopted in WP2:

- Step 1 - a literature review
- Step 2 - key-informants consultation.

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In this deliverable, we can go in the details only of the first step.

The literature review was supposed to consider:

- The European level (with some references at the international one)
- The national level in the six countries of the INNOVEAS partners (Belgium, Germany, Italy, Poland, Slovenia, and Spain).

However, during its implementation, interesting documents and studies referring to further countries were found. More specifically:

- Further European countries, such as Finland, France, Netherlands, Norway, Portugal, Sweden, Switzerland, Turkey, and the UK
- Countries outside Europe, such as Australia, China, Japan, Pakistan, US, and Zimbabwe.

Documents written after 2009 have been mainly considered, but also prior texts – in particular, scientific literature that is mentioned often in more recent texts – have been analysed.

The documents taken into account were written mainly in English, but also French, German, Italian, Polish, Spanish, and Slovenian.

The following sources were taken into account:

- Scientific texts and papers (dissertations included)
- Policy documents/policy papers/strategic documents
- Reports/documents on specific cases
- Evaluation reports
- Legislative and regulatory texts
- European and national statistics documents
- PPT presentations at conferences, seminars, etc.
- Articles from newspapers and social media
- Web-pages/blogs.

Authors/editors of the documents/texts are from:

- Scientific community
- Public administration (national, regional, local)
- European Union entities (European Commission, European Parliament, European Investment Bank, etc.)
- International organisations
- The business world (e.g., industrial associations)
- Citizens/consumers/Civil Society Organisations (CSOs) working on issues, such as climate change and energy transition
- Financial institutions.

The texts were mainly found on the Internet (more than 90%).

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Some of the analyzed texts (less than 20%) addressed other issues that are not of specific interest to INNOVEAS; they have been still considered as they deal with individual points such as the INNOVEAS project.

For each document considered (or relevant to INNOVEAS research questions) the following information has been reported.

- Title
  a. (in case of articles) journal in which the document has been published
  b. (In case of books) publisher and place of publication

- Authors/Editors
- Date
- Web-link (if available) and the date the document has been accessed
- Document language
- Why the document is considered interesting
- Interesting quantitative data (if available; e.g., the number or the percentage of SMEs considered oriented to the Audit practice)
- Long summaries on interesting information contained in the text concerning the research questions (i.e., if the document deals with more than one of the INNOVEAS issues, more than one "long summary" should be prepared)
- Relevant bibliographic references.

When books, journals, websites or other publications containing more than one text, the unit considered was the single text (e.g., an essay).

Globally, more than 200 texts were identified; nearly 100 texts were considered relevant and, therefore, deeply analysed (and reported in the references).

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3. Chapter Two SMEs energy efficiency improvement: the involved actors

This second chapter is devoted to the results of the literature review which can contribute to answering the question: "which actors are or should be taken into consideration by the support policies for small and medium-sized enterprises on energy efficiency programs?"

Without going too much into the dynamics of the individual actors, in this chapter we will limit ourselves to a review of who they are, briefly dwelling on some aspects considered useful for the work that will be carried out later by the INNOVEAS project. Some aspects will be reconsidered (and, in some cases, deepened) in the following chapters.

3.1. 1SMEs

The small and medium-sized enterprises (SMEs) are the main actors. They have been "thematized" in various ways within the literature. We are talking about a vast and articulated universe that should be understood to the fullest to make any energy-efficiency policy effective.

First of all, we recall that according to the European Union (and all its member countries as well as many other ones), SMEs are defined as Title I of the Annex to Commission Recommendation 2003/361 / EC of 6 May 2003; the category of micro, small and medium-sized enterprises is up of enterprises which employ fewer than 250 people and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.

Approximately 23 million SMEs in Europe are esteemed, which employ more than 100 million people and produce 60% of the EU's gross domestic product. The International Energy Agency (IEA) considers that SMEs consume one-third of the continent's energy demand. This is an approximation since in some cases data are not available at the national level. For example, while the IEA estimates that 70% of the energy consumed in the Italian industrial sector relates to consumption in the manufacturing sector of SMEs1, other sources report only a percentage of "over 60%", without further specific references2.

[1] International Energy Agency (2015). Accelerating Energy Efficiency in Small and Medium-sized Enterprises.

[2] Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.

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In Europe, SMEs produce between 60% and 70% of the total environmental impact[3], which, according to some sources[4], could be reduced between 10% and 25% with short-term energy efficiency measures, of which 40% would not require capital investments. Against this, however, it must be considered that as many as one-third of European SMEs offer "green" products and about 75% of European companies as a whole are undertaking circular economy activities, often self-financed[5].

SMEs in some countries are often exempt from certain tax and regulatory obligations, with the declared intention of protecting them from the burden of bureaucracy, perceived as a barrier to growth and productivity[6]. This soft approach is also reflected in energy policies, where, for example, SMEs are exempted from various obligations, including energy audits, except in the case of so-called energy-intensive SMEs.

The latter corresponds to an energy consuming company, an entrepreneurial entity that uses more than 2.4 GWh of electricity and for which the cost for energy equals to or greater than 3% of the total costs[7].

Taking into account this issue, Bulgaria, the Czech Republic, Ireland, Italy, Portugal, and Romania have even changed the definition of SME used by the European Union, to include a larger number of firms in the target of the subjects required to carry out the energy audits, enlarging the financial entry thresholds. In Luxembourg, moreover, companies that have an energy cost of over 3% must develop an energy balance and constantly check the savings rate achieved. In Croatia and Slovenia, the financial threshold for energy consumption which makes audits mandatory is even lowered. All of this, potentially, should expand the number of SMEs to which mandatory energy audits apply. Among SMEs, the small retailers or the artisans are considered, as well as the companies with 249 employees producing sophisticated technologies, through complex procedures.

All in all, SMEs are entities very differentiated (and not only according to these criteria) and each SME (or each kind of SME) has specific problems in putting on the agenda and implementing energy efficiency programs.

Many classifications have been developed in the literature to describe SMEs. Categorizations concern, in particular, the distribution of SMEs by:

[3] Fresner, J., Morea, F., Krenn, C., Uson, J.A., Tomasi, F. (2017). Energy efficiency in small and medium enterprises: Lessons learned from 280 energy audits across Europe. *Journal of Cleaner Production*, 142.

[4] Eurochamber (2017). National Support Schemes for Energy Audits and Energy Management Systems as required by Art. 8/2 of the Energy Efficiency Directive (2012/27/EU); Thollander, P., Backlund, S., Trianni, A., Cagno E. (2013). Beyond barriers – A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden. *Applied Energy*, Volume 111, November 2013, Pages 636-643.

[5] Robins, N. (2017). Mobilizing Green Finance for SMEs in the G7. Available at: https://www.minambiente.it/sites/default/files/archivio/allegati/sviluppo_sostenibile/G7_egf_SMEs_all_presentations_venezia05042017.pdf

[6] Hampton, S., Fawcett, T. (2017).Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.

[7] Zinetti, S. (2017). Energy audit in SMEs could unlock great energy efficiency potential in Europe: a model. Available at: https://www.eeip.org/articles/detailed/?article=100069&cHash=999325585c33f81f2b421390498a8124

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- The industrial sector, distinguishing between manufacturing, services or other
- The number of workers employed, dividing the SMEs into groups such as: within 5 employees; between 5 and 75; over 75
- The volume of business, such as: up to 300,000 Euros; between 300,000 and 15 million (for the manufacturing sector for example); over 15 million8.

More interesting – for the INNOVEAS project – it seemed to us a classification set up considering the process of enterprise creation as any form of social activation, which therefore foresees the presence of three main aspects[9]:

- The perception of a relative deprivation, which triggers the need to take action
- The ability to mobilize resources, and
- The search for an identity through the pursuit of specific goals.

According to this approach, "the profound reasons for the differences between companies must be sought, above all, in the complexity of the process of business creation, in the social and relational dynamics that are established in it (or through it), in the implicit attitude to social responsibility, and also in the role that the cognitive dimension assumes. The intra-sectoral difference may be deeper, for example, about the expectations and objectives of the entrepreneur, than between two companies belonging to two different sectors. What is important to emphasize, in this regard, is the need to understand the substance of the difference between companies, because only in this way it will be possible to identify the different needs of entrepreneurs ... [10]".

Also referring to the work of the GEM[11] – Global Entrepreneurship Monitor – programme (which gives greater weight to the detection of an entrepreneurial agency, rather than on the physical characteristics of the company itself) a classification of companies can be reported based on a combination of success level and maturation level:

- Companies in survival conditions
- Successful companies/disengagement
- Successful/growth companies
- Companies taking off
- Companies maturing resources.

A further dynamic classification[12] of companies considers companies according to their basic orientation:

[8] See: mine.bizs.com
[9] Mastropietro, E., Quaranta, G. (2002). Le condizioni del successo. Linee guida per la creazione d'impresa destinate alla consulenza e alla formazione. Available at: http://www.cerfe.org/public/ManualeRACRI.pdf.
[10] Ibid.
[10] https://www.gemconsortium.org/
[11] https://www.gemconsortium.org/; see also Churchill N.C., Lewis V.L., (1983). The five stages of small business growth. *Harvard Business Review*, May-June 1983.
[12] Mastropietro, E., Quaranta, G. (2002). Le condizioni del successo. Linee guida per la creazione d'impresa destinate alla consulenza e alla formazione. Available at: http://www.cerfe.org/public/ManualeRACRI.pdf

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- A growth orientation characterized also by the aspiration of small and medium-sized enterprises to become medium or large in the future, and
- An orientation that can be defined as “maintenance orientation” or an orientation towards specific “lifestyle” linked to the personal and professional satisfaction of the entrepreneur and the people who work in the company and to the maintenance of a certain standard of life.

This approach relates these two main trends to two other fundamental factors:

- On the one hand, the orientation towards innovation understood in a “relative” sense, that is, an innovation linked not only to real inventions but also to the ability to interpret in a new way also traditional elements
- On the other hand, the consideration of the “knowledge factor”, as an increasingly important element in the production of modern enterprises.

Crossing these factors, and their presence (+) or absence (-), leads to the following classification of companies (IN=orientation towards innovation; CC=centrality of the knowledge factor):

I – Growth-oriented companies

i. Ultra stable (+ IN, + CC)
ii. Shy (-IN, + CC)
iii. Casual (+ IN, - CC)
iv. Employee (-IN, - CC)

II – Lifestyle-oriented businesses

i. Hyper qualitative (+ IN, + CC)
ii. Artistic (+ IN, - CC)
iii. Cognitive/professional (-IN, + CC)
iv. Minimalist (-IN, - CC)

We focused on these different types of classification because we considered them useful in order to understand the complexity of the SMEs world and, above all, to calibrate training, assistance and monitoring programs, for example in the context of energy efficiency improvement.

3.2. Other actors

At this point, we can take into consideration some elements emerging from the literature on the system of actors who revolve around the small and medium enterprises (with specific reference to energy issues).

To make the production and distribution of goods and services possible, it is necessary to meet different intentions, which however can produce conflicts and misunderstandings, together with cooperation and opportunities. The actors involved in the entrepreneurial process are

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manifold, from the clients to the consultants, to those who finance the enterprise up to the same family members of the entrepreneur, who in various capacities often affect the life of the company. Through the systems of relationships, small entrepreneurs can often balance and mitigate the vulnerability due to the small size or their firm.

It is an articulated and changeable system of relationships with more or less important actors in the environment in which the company operates, such as industry associations and other intermediary policymakers, financial institutions, the actors of university and non-university research centres, citizenship organizations, energy auditors or other consultancies, training and assistance personnel. All of them can play a role in the decision-making processes of SMEs, not least in the case of issues concerning energy-efficiency processes.

3.2.1. Energy auditors and integrated consultants

Concerning this vast and complex system of actors that revolves around small and medium-sized enterprises, many elements have emerged in the literature regarding the energy auditors involved in controlling the implementation process of energy audits to companies and other operators involved in the programs of energy efficiency.

That of the Energy auditors is a work that has been gradually becoming established over the last two decades. Energy auditors (or Energy raters or Energy consultants) deal not only with energy audits for enterprises but also with those relating to buildings, which in many cases are a condominium. This is a growing job with more than satisfactory incomes: in the United States alone there are 1,023,900 energy auditors (especially in California, Texas and Florida), with an estimated demand growing by 8% by 2023[13]. Often, entrepreneurs deal with energy auditors employed by companies that perform energy consultancy services, offering turnkey tools or sectoral energy efficiency services.

Although it has not been possible to find overall European data on energy auditors, it must be said that, especially at the level of member states, some work has been done to define professional standard criteria and system of competencies related to them. Moreover, national registers[14] have been established (for which, however, it was not possible to find the numbers of the members) and networks built. It is interesting to note that among the numerous and articulated competencies foreseen for the auditors, on which numerous subsidies have been developed both at European level and that of member states, none concerns the social dimension of the company (of which we have dealt with above).

The only European country that has produced a report on energy auditors is Italy. Some results can be mentioned that can also provide indications for other Member States.

In Italy, 320 energy efficiency auditors have been identified, especially in the regions of Lombardy, Piedmont, Veneto, Emilia Romagna and Lazio (there is a substantial difference between the South, where there are only 64 operators and the rest of the country). These are

[13] https://www.careerexplorer.com/careers/energy-auditor/job-market/
[14] E.g., in the Republic of Ireland: https://www.seai.ie/register-with-seai/auditor/

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either "specialized operators" (56%), performing a subset of activities including those normally related to energy-efficiency programs or "integrated operators" (the remaining 44%), which instead tend to offer turnkey services to the end customer. Among the most recurrent activities carried out by specialized operators, amongst others the energy audits, which are personally managed by 49% of the professionals. Other activities performed are the planning, installation and monitoring of Energy Efficiency Measures, and management of incentives, even if they often carry out only some of these activities and not all of them. The integrated operators – who instead offer turnkey systems or in any case guarantee a much wider range of activities – not only personally manage all the audits and feasibility studies, but can follow the incentive planning and management operations. Only 28% of operators integrate all the activities related to energy efficiency interventions. It must be borne in mind that 90% of the 320 operators considered assume the related responsibility of the energy audit and 78% have internal resources that perform energy audits. The least "integrated" activity within companies seems to be the installation of energy efficiency systems, of which only 55% of companies take responsibility. The audit, therefore, becomes a core business not only for operators who offer integrated solutions but also for those who specialize in single activities (such as the installation of specific instruments)[15].

It also emerges in the literature, regarding Europe in general, that energy audits help to reduce most of the existing barriers. Moreover, audits conducted by engineers tend to be more effective than those conducted by utilities or industry sector organizations. This indicates that the quality of the audit also affects barriers and hence the adoption rate of Energy Efficiency Measures (EEMs). Findings also provide evidence that the quality of the energy audits (measured by satisfaction with the audits) affects the adoption of EEMs16.

As for the skills of auditors, it emerges that the wide variety of energy processes limits the versatility of auditing procedures, which should describe only a general frame for the audits. Additional procedures can detail (i) usage of standard meters, loggers or other equipment and (ii) auditing of the most typical processes and systems (compressed air, pipe insulation, lighting, etc). Variety in non-typical energy analysis practically eliminates the possibility of framing them by any formal description. From this perspective, energy audits become very subjective to the auditor and mostly rely on their expertise level. Nevertheless, the use of standardized auditing methodologies should lead to the same conclusions if correctly applied. The cases studies indicate various levels of fundamental knowledge required in performing energy audits. The most typical recommendations are very well recognized and there are many software tools and large amounts of literature available which can be used in energy savings assessments. In these cases, the most basic technical knowledge and skills are required. However, some non-standard recommendations require deep fundamental knowledge in various areas as thermodynamics, heat transfer, fluid dynamics, circuits, and metrology, with its application to real energy systems. Experience in energy audits can develop professional skills and a deep understanding of energy conversion processes and an increase in fundamental knowledge.

[15] Energia media, 2016, "Diagnosi energetica, primo passo verso un'Industria 4.0 - Efficienza Energetica. Paper 10/2016".
[16] Fleiter, T., Schleich, J. (2017). Effectiveness of energy audits in small business organizations. *Resource and Energy Economics* XXX.

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We will discuss energy auditors again in Chapter Four (speaking of the various approaches to energy audits and similar procedures).

3.2.2. Business and similar associations

For what concerns industrial associations and other trade entities, it has been noted that the role of Chambers in SME's energy efficiency improvement is to provide information and services information and services on energy. Chambers are already being widely consulted, but companies indicated the need for more activities and services. Chambers should consider ways to develop further the energy information and services they offer to SMEs, tailoring them to specific national or regional needs.

Providing information or support is an important role for business environment organisations, chambers and sectoral organisations. Companies expect more information and more support activity from the chambers of commerce, which are in their immediate vicinity, in facilitating access to support services or offering them17.

Many EU Member States try to maintain close contact with industrial associations and representatives, e.g., trade organizations or chambers of commerce, setting up or organising joint events on energy-related matters. Many Member States rely on less formal systems for information exchange both between companies and the government. These approaches include discussion platforms, websites and portals, information events (e.g., conferences, seminars, presentations and workshops), awards, helplines or helpdesks, printed and online resources and the provision of local contacts/offices18.

In Chapter Four, a specific section will be devoted to external assistance to SMEs for the improvement of the energy efficiency and management and, therefore we will deal with again this kind of actors.

3.2.3. Consumers' associations

The literature stresses two aspects regarding the consumers' associations dealing with energy issues. The first active roles played by users in the development of new uses of technologies that are not foreseen by producers. Furthermore, interactions between supply and demand may be facilitated by intermediary actors (e.g., consumer organizations, patient organizations, marketing and testing agencies, retailers, auto clubs, salespeople) and by the institutional places where users, mediators and producers can meet to negotiate and align technical design and user preferences19.

[17] CHANGE – Chambers Promoting Intelligent Energy for SMEs, 2010, "Energy Efficiency in SMEs: Success Factors and Obstacles".
[18] AA.VV. (2015). A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems – European commission report.
[19] Geels, F.W., Schwanen, T., Sorrell, S., Jenkins, K., Sovacool, B.K. (2018). Reducing energy demand through low carbon innovation: A sociotechnical transitions perspective and thirteen research debite.E*nergy Research & Social Science*, 40.

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The second aspect concerns the relationship between consumers' preferences and the decisions of firms' leadership about sustainability. "It is striking to note how lowly companies currently rate environmental concerns as a driver of change in consumer preferences. In an Economist Intelligence Unit survey of 275 business executives in August 2013, just 2% of respondents rated environmental concern as the single most important driver of changes in their customers' preferences. It was ranked much lower than technology (37%), economic factors (27%), and demand for greater convenience (25%). Similarly, an Ipsos/MORI study from 2013 indicates that the proportion of consumers rating 'responsibility' as very important to their purchasing decisions stood at 31% in 2013. While this is up from the 2009 low of 26%, this is still some way off the 43% recorded in 2008, perhaps indicating the impact more pressing economic concerns have had on purchasing decisions. It seems that despite mounting evidence about the importance of making the business sustainable, the business case for change is still not strong enough to enable transformative action20."

3.2.4. Further actors

Many references to other actors have been found in the literature and will be discussed later, analyzing the obstacles to energy efficiency. In particular, the role of financial actors such as banks or other institutions that can help SMEs in terms of cost coverage (e.g., the initial investment costs which would then be widely recovered within a few years) should be noted here. Few references, on the other hand, have been found on other actors that could play a role in this regard, such as universities and research centres, or the complex world of local administrations in daily contact with businesses (a hint will, however, be made at the end of the fourth chapter about the relationship between SMEs and research in relation to energy efficiency).

More generally, it should be noted that no systematic studies have been found focusing on the complex system of relations involving SMEs, which probably plays a role in the decision-making processes, especially when SMEs face with the opportunity to initiate innovative processes such as those concerning energy efficiency. Seven forms of relationships have been identified, all necessary for the launch and management of entrepreneurial activities.

- The pre-business relationships, that is to say, the system of relations before the foundation of the company and which help the entrepreneur to develop the idea of starting his own business.

- The pro-business relations activated precisely about the establishment of the company and which in the future can contribute to supporting and developing it (incentive agencies, the credit system, the world of consulting and training, entrepreneurial associations, etc.).

- Business relationships, such as those between leadership and staff or those between employers and employees.

[20] Carbon Trust (2014). Opportunities in a resource constrained world. How business is rising to the challenge.

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- The relationships developed at the local level, which allows the company to know, interpret and respond adequately to the context in which it is inserted (relations with the services and structures of the territory, etc.).

- The relations with other companies, ranging from consortia to clusters, from industrial districts to virtual networks (often it is precisely in relations between companies that important innovation processes can be activated).

- The relations with the market in the strict sense, ranging from customers to suppliers, aimed at facilitating the distribution of services and goods offered by the company.

- Finally the political relations with local administrators, governmental bodies and the same business associations, aimed at reducing the vulnerability of the company from risks connected to bureaucracy or variables external to the company itself (e.g., political decisions concerning business life, etc.)21.

It is to be noted that many of these kinds of relationships have been poorly investigated in the literature, but it may be useful to take them into consideration when implementing the future work of the INNOVEAS project.

[21] Mastropietro, E., Quaranta, G. (2002). Le condizioni del successo. Linee guida per la creazione d'impresa destinate alla consulenza e alla formazione.

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4. Chapter three Energy culture

4.1. The relevance of "culture" in energy efficiency

Before going in-depth into the energy innovation culture, it is necessary first to provide an operational definition of the term "culture".

The term has very different meanings that change according to authors and disciplines. This report is not the appropriate place to discuss and decide what the right definition is. Nevertheless, we are interested in the concept of culture and, particularly, of energy culture, to classify the possible barriers to the implementation of energy-saving innovation and energy audits that are different from those of a clear economic and organizational nature.

For this reason, we will refer to culture not as a very strictly defined concept but – based on a widely accepted idea – as a mostly cognitive dimension of social actors that concern the sets of values, symbols, beliefs, and behavioural patterns that are at the basis of their activities[22]. Such a definition, that entails also representations of reality, could be considered too wide, but it is a reasonable choice given the wide array of scholarly conceptions of culture used in dealing with the factors affecting energy efficiency investments by SMEs.

The typologies of barriers provided by some authors show, on the one hand, the relevance of factors that we have (just) defined as cultural for dealing with energy efficiency issues and, on the other hand, a high degree of variability among the different conceptions of what cultural factors could be. Trianni et al.[23], quoting Sorrel et al.[24] provide a list of barriers to energy efficiency which can be seen below. According to this list, culture is just one of the possible barriers/factors of a cognitive nature; note that values, or conceptions of business, are clearly not included in culture[25].

[22] Item "Cultura" in the Treccani Encyclopedia, see http://www.treccani.it/vocabolario/cultura/ (accessed on 23/10/2019); Jary, J., Jary, D. (2000). Collins Internet Dictionary of Sociology.

[23] Trianni, A., Cagno, E., Thollander, P., Backlund, S. (2013). Barriers to industrial energy efficiency in foundries: a European comparison. *Journal of Cleaner Production*, *40*, 161-176.

[24] Sorrell, S., Schleich, J., Scott, S., O'Malley, E., Trace, F., Boede, U., et al. (2000). Reducing Barriers to Energy Efficiency in Public and Private Organisations.SPRU.Final report, 2000. Available at: http://www.sussex.ac.uk/Units/spru/publications/reports/barriers/final.html.

[25] This table is on barriers to energy efficiency, but the notion of barriers – at the core of the WP2 – will be analysed in the next chapter of this document).

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Table 1 - Barriers to energy efficiency: the Sorrell et al. taxonomy

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 payback criteria.
Economic market failure	Imperfect Information	Lack of information may lead to cost-effective energy efficiency 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.
Behavioural	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.

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The table below, developed by Trianni et al. , provides another list of barriers in which the term "culture" is not included. Nevertheless, according to the (wide) definition provided above, some of the barriers listed could be easily considered of a cultural type, as it is in the case of "behavioural" barriers, which include "other priorities", "lack of interest", or organizational barriers, which include "lack of time" or "Low status of energy efficiency". These barriers could be considered connected to culture, not just as the result of how a firm is organized or of the mere "lack of awareness" of energy issues. On the contrary, they can be seen also as the result of a culture that does not include energy efficiency as a valuable item; consequently, energy-saving never becomes a priority or something to which effort could be devoted.

Table 3 - Taxonomy of barriers adopted for empirical investigation

Categories	Barriers
Technology-related	Technologies not adequate Technologies not available
Information-related	Lack of information on costs and benefits Information not clear by technology providers Trustworthiness of the information source Information issues on energy contracts
Economic	Low capital availability Investment costs External risks Intervention not sufficiently profitable Intervention-related risks Hidden costs
Behavioural	Other priorities Lack of sharing the objectives Lack of interest in energy-efficiency interventions Imperfect evaluation criteria Inertia
Organizational	Lack of time Divergent interests Lack of internal control Complex decision chain Low status of energy efficiency
Competence-related	Implementing the interventions Identifying the inefficiencies Identifying the opportunities Difficulty in gathering external skills
Awareness	Lack of awareness

In our view, deciding about the definition of culture is just a matter of how to "organize" and name concepts and phenomena. Nevertheless, we consider relevant to include openly the category of "cultural factors" (therefore, also "cultural barriers" – see the next Chapter) so that factors being connected to world visions, values, symbols, beliefs and behavioural patterns could be explicitly and systematically considered.

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From the literature, it emerges – also in those publications that do not pay big attention to cultural factors – that the perceptions of the actors involved in the implementation of energy efficiency matter. Cagno et al.26, indeed, state that barriers to energy efficiency have to be distinguished between real and perceived ones. Some decision-makers, for example, tend to consider certain energy-saving technologies as fitted for their firms, while others not, even if this should not be the case. The reasons behind these differences in perceptions, therefore, are of the utmost importance and, at least in part, could be considered as having a cultural origin. Indeed, in some cases, different perceptions are identifiable as distortions, which could be corrected through an information campaign (e.g., the idea that financial support is not available, whereas it actually is available). In other cases, differences in perceptions conceal some characteristics of the actors (concerning, for example, the way they understand their environment and take decisions) that cannot be simply interpreted as due to a lack of correct information.

4.2. How "cultural factors" work in energy efficiency

Under the category of culture, we can classify several phenomena that are mentioned in the literature and that can be considered very important to draw a picture of the overall set of factors affecting the promotion of energy efficiency within SMEs and – in this framework – the practice of energy audit.

According to the literature reviewed, what makes "Cultural factors" interesting is that they affect decisions concerning energy saving. Such decisions, also those based on the calculation of cost and benefits, are based on the assumption that promoting energy efficiency is in the interest of the firm, for some reasons. Such assumptions, indeed, depend also on the values being pursued, beliefs of the entrepreneurs concerning their core business, what they think about its strength and weakness and about the possibility to thrive and not only to maximise profits. Therefore, as noticed by Beckert27 they are based on specific visions of the future that provide the context for conducting the calculation concerning the pursuit of certain objectives. In the end, what does compose the picture of the future and of what is considered as the most likely scenario relevant for each firm is also a matter of beliefs and not only of a rational considerations28.

It is important to stress that cultural factors emerge from social interactions in general and are not just the "resultant" of the behaviour of single individuals. As it is stated by Geel et al.:

[26] Cagno, E., Worrell, E., Trianni, A., Pugliese, G. (2013). A novel approach for barriers to industrial energy efficiency. *Renewable and Sustainable Energy Reviews*, *19*, 290-308.
[27] Beckert, J. (2016). *Imagined futures*. Harvard University Press.
[28] Declich, A. (2014). Aspettative e narrazioni: spunti per una riflessione interdisciplinare. *Quaderni di Sociologia*, (64), 111-138.

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> "reducing energy demand involves more than improving individual technologies or changing individual behaviours, but instead requires interlinked and potentially far-reaching changes in the systems themselves – or 'socio-technical transitions'29".

Particularly, according to these authors, the emergence of low carbon innovation should include also processes having a cultural dimension, including the articulation of expectations and visions. They stress that significant changes imply uncertainty, and this in turn implies the emergence of governance issues. As Palm and Thollander30 say, "energy efficiency thus also depends on social relationships and discussion, negotiations, and agreements developed in actor networks". In general, such literature highlights that the interaction among various actors (therefore among firms and other stakeholders outside the firms) is relevant. As reported by Hampton and Fawcett31 "energy behaviours and efficiency investments are embedded in the 'socio-technical landscapes' of organisations, which in turn are framed by broader social, material, market and regulatory domains". Culture, that includes visions, beliefs, and representations of reality, is of the utmost importance.

The practical relevance of culture can be understood by using the reflection proposed by Geel et al. when they say that "an energy efficiency and demand 'revolution' will (…) require dedicated campaigns to create a sense of urgency and excitement about low carbon innovations. To alter cultural preferences, such campaigns need to go beyond information provision and aim to create positive discourses and increase competencies and confidence among (potential) users". Furthermore, such an action – aimed at acting on public goods, could require also collective action.

The entrepreneurs' decision to consider energy efficiency investments "strategic" is analysed by Cooremans32. She says that such a decision is affected by cultural factors that drive organizations. These would be hidden barriers to energy-efficient investments, operating sometimes in a subconscious way.

On this basis, we can term as cultural those factors of cognitive nature concerning the conception of energy and energy-saving that affects the behaviours of the actors.

The phenomena emerged in the literature review that we classified as cultural could be divided into other areas.

- The general propensity towards technological innovation (in general, any intervention favouring the improvement of energy efficiency should be considered a technological innovation for the firm that implements it).

[29] Geel, F.W., Schwanen, T., Sorrell, S., Jenkins, K., Sovacool, B.K. (2018). Reducing energy demand through low carbon innovation: A socio-technical transitions perspective and thirteen research debates. *Energy research & social science*, *40*, 23-35.
[30] Palm, J., Thollander, P. (2010). An interdisciplinary perspective on industrial energy efficiency. *Applied Energy*, *87*(10), 3255-3261.
[31] Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.
[32] Cooremans, C. (2012). Investment in energy efficiency: do the characteristics of investments matter? *Energy Efficiency*, *5*(4), 497-518.

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- The awareness about climate change and related issues; such an awareness concerns not only the issue in itself but also the existence of an entire set of policies, technologies and managerial practices connected to climate change; of course, awareness includes also a basic set of information concerning climate change and the related issues.
- The position of energy efficiency concerning the core business of the firm i.e., the interpretation that is provided, particularly by decision-makers within enterprises, of the relation and relevance of energy efficiency for the firm.

Under these large sub-areas, various factors could be classified that are cultural and non-economic in nature that is reported as affecting the choice to promote environment-oriented initiatives.

In the following paragraphs, we provide a summary of factors of a "cultural" nature that are relevant in affecting environmental efficiency within SMEs. Of course, being these factors also "barriers" or "drivers/motivators" towards the involvement of SMEs in any kind of energy transition process, they will be taken into account also in the next chapter (under these categories of barriers/drivers). In this chapter, our interest is focused on their "cultural" nature.

4.2.1. The propensity towards technological innovation

In the reviewed literature, we found some specific factors that are relevant for the promotion of energy efficiency. Some scholars33 found that European SMEs who are more prone to collaborate with research institutes, agencies and universities significantly favour eco-innovation. The European Investment Bank found that: "'Innovative firms' are also more likely to conclude an energy audit. This decision might be driven not only by financial and operational objectives but also by strong environmental concerns. Most of them include in their production, function elements of energy efficiency as a means of bridging the 'energy efficiency gap'34".

Therefore, eco-innovation orientation – logically a specific type of orientation to innovation – seems to be connected to the orientation to be open towards other actors, specifically those active in the science and technology sector. This is confirmed also by Trianni and colleagues quoted by Johansson et al.35, who "investigated 20 primary metal manufacturing SMEs in the Lombardy region to understand how firm size and innovativeness affect the perception of barriers. A higher level of market innovation reduced the barriers significantly and more innovative enterprises faced fewer barriers related to technology, external risks and lack of information". We have not found data that measure this orientation towards eco-innovation. However, this orientation should be limited given that, as mentioned in chapter one, the green

[33] Triguero, A., Moreno-Mondéjar, L., Davia, M.A. (2013). Drivers of different types of eco-innovation in European SMEs. *Ecological economics*, *92*, 25-33.
[34] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs' energy efficiency investment (No. 2019/02). EIB Working Papers.
[35] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, *12*(7), 1338.

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economy affects "only" one third of SMEs (in other respects an important percentage, certainly not to be overlooked)36.

4.2.2. Awareness

One of the factors that many authors consider as very relevant for the practice of energy efficiency is SMEs' awareness of the issue, as emerges from a review of literature carried out by Cagno et al.37. This is only in part an expression of a particular cultural orientation since it includes a certain level of knowledge of the matter. Lack of awareness is synonymous of status of ignorance of the decision-makers about the possible benefits coming from the implementation of possible initiatives for energy saving. Robins38 stresses that awareness concerns the potential of energy saving and, according to a report for the European Commission39, can be promoted through specific activities aimed at building knowledge with the idea that "the particular challenge in SMEs is thus to convince individual decision-makers of the benefits of improving energy efficiency with credible information". In a research project in Poland aimed at determining the readiness of Polish enterprises in the industrial sector to implement solutions in the field of energy efficiency, lack of information and awareness about the possible benefits of energy efficiency have been found among the most relevant factors40. A similar conclusion was reported in other studies in Poland41,42 and in Slovenia43. Little awareness among SMEs has been reported in some studies also in China44 (in a sample of 480 SMEs in the Zhejiang province 43 percent of all enterprises admitted that they are not aware of energy-saving equipment or practices in their respective business area). From another

[36] Robins, N. (2017). Mobilizing Green Finance for SMEs in the G7, UN Environment (PPT presentation) https://www.minambiente.it/sites/default/files/archivio/allegati/sviluppo_sostenibile/G7_egf_SMEs_all_presentations_venezia05042017.pdf (accessed 29 July 2019).

[37] Cagno et al. (2013). Op. cit.

[38] Robins, N. (2017). Mobilizing Green Finance for SMEs in the G7, UN Environment (PPT presentation) https://www.minambiente.it/sites/default/files/archivio/allegati/sviluppo_sostenibile/G7_egf_SMEs_all_presentations_venezia05042017.pdf (accessed 29 July 2019).

[39] Hirzel, S., Nabitz, L. Wohlfarth K., Rohde C., Behling, I., Clarke D., Perera, N., Turner R. (2016). A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems, Report on the fulfilment of obligations upon large enterprises, the encouragement of small- and medium-sized companies and on good-practice, Report prepared for the European Commission, https://ec.europa.eu/energy/sites/ener/files/documents/EED-Art8-Implementation-Study_Task12_Report_FINAL-approved.pdf (accessed 25 July 2019)

[40] Leszczyńska, A., Curie-Skłodowska, M. (2016). Sources and barriers to the energy efficiency of Polish enterprises. *Annales Universitatis Mariae Curie-Skłodowska*, section H – *Oeconomia*, Vol 50, No 3.

[41] Korczak, K. (2015). Master Thesis on "Energy efficiency improvement in small and medium-sized enterprises" at the Warsaw University of Technology, Faculty of Power and Aeronautical Engineering, Division of Rational Use of Energy.

[42] Kuceba, R., Koszarek-Cyra, A., (2015). Directions, barriers, factors energy management in SMEs organisations, *Scientific notebooks of the Silesian University of Technology*, Series: Organization and management no. 83, https://www.infona.pl/resource/bwmeta1.element.baztech-b80c7b9f-8f56-423f-bbc8-190ae2f0d413/content/partContents/6c30467a-d522-39fc-85d4-d1b429d6b707 (accessed on 27/10/2019)

[43] Špacapan F., (2015). Graduation thesis on "Energy management and efficient use of energy in companies" http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf (accessed on 27/10/2019)

[44] Kostka, G., Moslener, U., Andreas, J. (2013). Barriers to increasing energy efficiency: evidence from small-and-medium-sized enterprises in China. *Journal of Cleaner Production*, *57*, 59-68.

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study, concerning China[45] on data collected from 170 respondents mainly from iron and steel, cement and chemical sectors, emerges that there is a significant correlation between awareness and acceptability for market-based instruments (MBIs) for energy saving and firms' dimensions.

The issue of awareness (or, contrarily, of the lack of awareness) according to some authors is useful for making a typology of SMEs according to their orientation to practice energy efficiency. Palm[46] says that the less oriented are those ignorant of the matter.

The issue of awareness is therefore very relevant even if it is difficult to ascertain empirically. Hampton and Fawcett[47], indeed, criticize Trianni and Cagno[48] when they "unsurprisingly find that their interviewees reported that 'lack of managerial awareness' was their least significant barrier, compared to access to capital or information on investment payback times relating to energy-efficient technologies. It seems unlikely that owners and managers would identify their lack of awareness as a significant barrier, as it is difficult to have insight into personal unawareness".

In Sweden, as reported by Paramonova, and Thollander[49], industrial energy efficiency networks resulted important since they are a tool that helps, among other things, to promote awareness among entrepreneurs and deal with cultural aspects of energy efficiency promotion.

4.2.3. Closeness to the core business

We consider as an aspect of the culture of producers and decision-makers within enterprises the ideas they have of the relevance of energy efficiency for the firm, therefore the interpretation they give of the core-business.

Is energy efficiency related to the activities carried out by the firm? Does energy efficiency have to do with the possibilities the firm has to thrive, survive, or make a profit? If environmental concerns are considered as far from the core business by the entrepreneurs/managers, we could say that the environment is not strongly relevant for the culture of that particular firm. It is important to state that the core business of a firm is not just the activity that produces the most significant part of the firm's revenue. It goes together with an interpretation of what this activity means for the overall objective of the firm and therefore has to do with the future of the firm. Being environmentally innovative does play a role in the future firm's life and operations? If this is not the case, we could consider that the

[45] Liu, X., Wang, C., Zhang, W., Suk, S., Sudo, K. (2013). Awareness and acceptability of Chinese companies on market-based instruments for energy saving: a survey analysis by sectors. *Energy for Sustainable Development*, *17*(3), 228-239.
[46] Palm, J. (2009). Placing barriers to industrial energy efficiency in a social context: a discussion of lifestyle categorisation. *Energy Efficiency*, *2*(3), 263-270.
[47] Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.
[48] Trianni, A., Cagno, E. (2012). Dealing with barriers to energy efficiency and SMEs: Some empirical evidences. 7thBienn. Int. Workshop, *Advances Energy Studies* 37, 494–504. doi:10.1016/j.energy.2011.11.005
[49] Paramonova, S., Thollander, P. (2016). Energy-efficiency networks for SMEs: Learning from the Swedish experience. *Renewable and Sustainable Energy Reviews*, *65*, 295-307.

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firm's culture is not particularly oriented to environmental and energy efficiency. All the decisions able to offset such an orientation have to be based on a reframing of the ideas the entrepreneurs have of the future of their activities. Rational consideration based on calculation, cannot be considered as sufficient for this purpose (see above).

The closeness of energy efficiency to what people within enterprises consider as the core-business can be indicated by several phenomena, that are discussed in the literature reviewed (e.g., lack of time or low priority that could indicate the belief that something is not considered relevant for the main activities a firm is carrying out). Such phenomena could be considered as cultural since they are connected to a representation of reality. They represent, to a certain degree, "assumptions" (i.e., not to be demonstrated) adopted by the decision-makers concerning the nature of the firm.

Several of the reviewed papers report the issue of "lack of time" as one of the factors that hamper energy efficiency. Baranova50, for example, states that "the data confirms that for many SMEs, efforts to reduce carbon emissions seem expensive in terms of time, staff allocation and the necessary accreditations. Environmental/carbon accreditations are often seen as time consuming to obtain, maintain and renew. Many SMEs and micro businesses still consider low carbon initiatives and accreditations as 'nice to have, but not critical' to business success or survival".

Henriques and Catarino51 reported the lack of time for SMEs in Portugal, also considering it as associated with low priority given to energy efficiency. The same position is expressed by Fleiter, et al.52. They studied the experiences carried out in Germany and the hypothesis – that is very common in the literature they reviewed – according to which lack of time is one of the factors affecting the adoption of energy efficiency measures among SMEs resulted confirmed. The relevance of this factor emerges also in another study by Fleiter, et al.53. Cagno et al.54 consider lack of time a consequence of the fact that "SME does not own an internal structure able to be focused on energy consumption (...)" Therefore, "the time devoted to energy efficiency activities is usually quite limited". Thollander and Dotzauer55 consider lack of time as one of the barriers to energy efficiency indicated by the literature that has to be considered in an ex-ante evaluation for the promotion of a programme for energy efficiency in Sweden. Johansson et al.56 confirmed the relevance of this factor highlighted by a study of 2017 by Backman57, according to which the major barriers to energy efficiency

[50] Baranova, P. (2017). Environmental capability of SMEs: Capability building towards a low carbon economy.
[51] Henriques, J., Catarino, J. (2016). Motivating towards energy efficiency in small and medium enterprises. *Journal of Cleaner Production*, *139*, 42-50.
[52] Fleiter, T., Schleich, J., Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs - An empirical analysis based on energy audit data from Germany. *Energy Policy*, *51*, 863-875.
[53] Fleiter, T., Gruber, E., Eichhammer, W., Worrell, E. (2012). The German energy audit program for firms - a cost-effective way to improve energy efficiency? *Energy Efficiency*, *5*(4), 447-469.
[54] Cagno, E., Trucco, P., Trianni, A., Sala, G. (2010). Quick-E-scan: A methodology for the energy scan of SMEs. *Energy*, *35*(5), 1916-1926.
[55] Thollander, P., Dotzauer, E. (2010).An energy efficiency program for Swedish industrial small-and medium-sized enterprises. *Journal of Cleaner Production*, *18*(13), 1339-1346.
[56] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, *12*(7), 1338.
[57] Backman, F. (2017). Barriers to energy efficiency in Swedish non-energy-intensive micro-and small-sized enterprises - A case study of a local energy program. *Energies*, *10*(1), 100.

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were lack of time, other priorities, slim organisation and lack of technical skills. This kind of barrier has been registered also in Poland58. An extensive research among American SMEs59 confirmed the hypothesis that recommendations concerning energy efficiency60 are lower when needs high managerial attention. Lack of time could be understood as an indicator of the scarce interest of SMEs for improving energy efficiency. In some cases, it could be also the consequence of the relative lack of resources (that, in general, depends on the dimension of a firm).

Thollander et al.61 highlights that the major barriers found in the implementation of public policies for promoting energy efficiency among SMEs were the low priority that the issue represented for these actors (the suggestion was "to reduce this barrier there is a need for a strong public policy targeting these types of companies"). There are other phenomena, quoted in the literature, that indicate a general tendency of SMEs to assign lower priority to energy issues and, sometimes, a more "conservative" approach to management. Leszczyńska and Lee62, for example, indicate the "unwillingness to change" of SMEs as one of the possible barriers. Various typologies of barriers mention the low priority attached to energy saving as a possible factor; it is mentioned also in Trianni63; see the table presented above). Johansson et al. (2019) refer to various studies that detected the low priority assigned by SMEs to energy saving. Fleiter et al.64 for the case of Germany confirm the relevance of such a factor too. Similar conclusions can be drawn from studies concerning Slovenia and Poland.

4.3. Disposition towards energy efficiency

Lack of time and low priority (as well as scarce awareness of environmental/energy efficiency issues in many SMEs and a limited propensity towards eco-innovation) could be considered as clues of a culture that is not conducive to the promotion of energy efficiency. However, they are not the only phenomena relevant to the matter and the literature reports other phenomena that suggest the existence of such a culture.

A study of SMEs in Slovenia65 stresses their narrow orientation toward production. According to the author, this is due to a "mentality" shared by the firms pushing them to perceive energy efficiency not as an opportunity but as a burden.

[58] Korkzac, K. (2015). Op. cit.
[59] Muthulingam, S., Corbett, C. J., Benartzi, S., Oppenheim, B. (2011). Investment in Energy Efficiency by Small and Medium-Sized Firms: An Empirical Analysis of the Adoption of Process Improvement Recommendations.
[60] Recommendations provided to more than 13,000 small and medium sized firms under the Industrial Assessment Centers (IAC) program of the US Department of Energy (DOE).
[61] Thollander, P., Danestig, M., Rohdin, P. (2007). Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs. *Energy policy*, *35*(11), 5774-5783.
[62] Leszczyńska, A., Lee, K.H. (2016). Op. Cit.
[63] Trianni, A. et al. (2016). Op. cit.
[64] Fleiter, T. et al. (2012). Op. cit.
[65] Špacapan, F. (2015). Op.cit.

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Moreover, according to some studies66, there is a more preference to invest in energy efficiency in the firms' support processes (e.g., insulation, lightening) than in the production processes. Kalantzis and Revoltella also stress that "most energy audit programmes (…revealed that 60-90% of the measures implemented by industrial SMEs concern support processes". This fact highlights a sort of reluctance of "touching" the core business with initiatives aimed at promoting energy efficiency (it is probably "easier" and maybe safer to invest in support processes).

From the above, it can be deduced that in many cases the European SMEs appear little interested to the energy efficiency and to the transition towards a low-carbon society and far they are from a "pro-environmental" energy culture. On this regard, it may be of interest to report the categorization suggested by Palm67 on how and why companies improve energy efficiency. According to Palm, SMEs can be classified into four categories:

- Ignorant companies have no special focus on energy-related issues, and they generally lack anyone working on these issues
- The sceptical company is quite aware of the easy and relatively cheap measures to reduce their energy use. They are fairly satisfied with their activities in the energy area and believe that only expensive and complicated measures remain, which they may take into account given appropriate economic incentives
- The economically interested company invest in easy measures, focus strongly on the pay-back time and the need for the investment to give economic benefits (increased energy efficiency as a means to cut costs). Measures that have a 5-year payback time or longer do not interest these companies. The starting point is the economic benefit of all activities undertaken. Behavioural issues are too 'fuzzy' and just for idealists
- The innovative environmentalist companies, aware of both energy and environmental issues in general, and have worked successfully on these issues for some time. These companies often have one or several people who are enthusiasts and constantly come up with new ideas, invested in efficient systems for ventilation, lighting, heating and production processes. Energy efficiency is not seen as a problem but a challenge. They face customers who require that they take into account environmental concerns, and their managers are supportive of all kinds of environmental activities.

How could it be possible to react to this situation and to reach as fast as possible the SMEs that fit in the third and fourth category?

Baranova68 suggests that SMEs should be open to create or re-design their business model so that they can include sustainability issues. At this regard, Spence et al.69 identify a range

[66] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs energy efficiency investment (No. 2019/02). EIB Working Papers.

[67] Palm, J. (2009). Placing barriers to industrial energy efficiency in a social context: a discussion of lifestyle categorisation. *Energy Efficiency*, 2(3), 263-270.

[68] Baranova, P. (2017). Environmental capability of SMEs: Capability building towards a low carbon economy.

[69] Spence, L.J., Agyemang, G., Rinaldi, L. (2012). Environmental aspects of sustainability: SMEs and the role of the accountant. ACCA (the Association of Chartered Certified Accountants; the global body for professional accountants).

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of capabilities that need to be developed among the energy consultants supposed to support SMEs in providing environmental sustainability advice, such as:

- The confidence to adapt their accounting skills to environmental accounting tasks such as cost analysis in areas such as energy, waste, water, transport and environmental protection
- Detailed knowledge of environmental sustainability issues and regulations
- Awareness of potential information sources on environmental sustainability (including relevant regulation)
- Education to understand specific environmental sustainability issues for business, such as the implications of resource depletion and energy scarcity.

The discussion made so far highlights that many SMEs are not, respectively not enough, affected by the energy transition process towards a low-carbon society. However, despite the considerable limitations indicated in the previous pages, it can be argued that a part of the companies has its own energy culture and has a positive orientation on energy efficiency. To tackle the problem of how to deal with these cultural aspects of energy efficiency, the concept of "disposition" (proposed by sociologists and economic sociologists) is particularly fruitful. It allows us to go beyond the approach that represents entrepreneurs exclusively as agents that respond rationally to the information available on the reality in view of maximizing their profit (as we saw above, this approach is largely unable to interpret many of the entrepreneurial choices regarding energy efficiency).

Disposition of entrepreneurs "refers to a subjective system of expectations and predispositions acquired through experience". Mauss70 defined as habitus those aspects of culture that are anchored in the daily practices of individuals, groups, societies, and nations. The concept of habitus includes the totality of learned habits, bodily skills, styles, tastes, and other non-discursive knowledge that might be said to 'go without saying' for a specific group71. The particular contents of habitus are a complex result of embodying social structures – such as the gender, race, and socio-economic status – which are then reproduced through tastes, preferences, and actions for future embodiment72. In this connection, it is important that "dispositions" are characteristics of a specific group and not of individuals and do not correspond to a psychological attitude. This idea has been often used for studying enterprises. Recently, it was used to analyse the orientation to the growth of British SMEs73.

This concept is therefore particularly interesting since it allows to identify those SMEs that have a specific disposition towards environmental sustainability (some have some such a disposition) that is – to a certain degree – independent from economic consideration and convenience. In this framework, it is to consider that the overall disposition of firms could be the results of the orientation not only of their leaders and managers but also of their

[70] Mauss, M. (1934). Les techniques du corps. *Journal de Psychologie* 32: 3–4.
[71] Bourdieu, P. (1990). *The Logic of Practice*. Cambridge: Polity Press.
[72] Theodorakopoulos, N., Hart, M., Burke, G., Stephan, U., Braidford, P., Allinson, G., Jones, S.A. (2015). Sociology of enterprise., BIS RESEARCH PAPER NUMBER 238.
[73] An economic discourse, if taken narrowly, would avoid even the issue of the orientation to the growth of an enterprise, since growth would be the consequence of the assumed obvious objective of maximising profits. In the same way, the literature suggests that we could look at energy efficiency as a disposition see Theodorakopoulos et al., 2015).

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employees. The literature reviewed does not focus too much on this aspect. One of the exceptions is a study carried out in Poland74, based on a sample representative of the entire country. It investigates the orientation and experience of workers within SMEs on energy efficiency initiative. For example, the study highlights that the interviewees, while being in favour of energy efficiency promotion, also recognise that the efforts made by enterprises are not in line with their expectations on this matter.

Indeed, 74% of enterprises do not promote energy-saving knowledge among their employees (but this value decreases year by year); furthermore, just 25% of companies from the SME sector are reported to have conducted educational activities among employees (with an increase compared to the previous year). The role of workers and employees in the promotion of energy efficiency should be further investigated and should be included in the analysis of the factors affecting energy efficiency practices. In general, SMEs should be considered in all their diversity, since such diversity depends not only on the economic sectors and value chain, or on the size (that are very important, anyhow), but also on the diverse orientation of the employees and workers. A couple of reviewed articles stressed this aspect. Palm and Thollander75 say that:

> "The barrier approach could benefit from, for example, in-depth studies of what energy efficiency discourse is like in a company, i.e., how employees talk about energy efficiency and how the discourse relates to environmental issues and cost allocations in regard to energy efficiency measures (how barriers are valued by the actors, and it is possible to problematize the grounds on which these barriers exist)".

In another article76 is stressed that some energy efficiency practices, such as working from home, are considered as very effective but require a deep involvement of the workforce and their consensus.

The issue of consensus is relevant also if an approach based on a "socio-technical transition" is adopted. As mentioned above, Geels et al.77 hold that radical innovation (also in the use of energy) imply a pervasive uncertainty and therefore social acceptance and negotiation become relevant. This approach could be relevant also if dynamics internal to the enterprises are considered.

As suggested above, dispositions towards energy efficiency (beyond the cultural factors presented above) could be also influenced by the same belonging to a specific industrial sector. A research in Spain78 reports that "the hospitality sector is one of those that have traditionally been more active implementing energy efficiency measures". According to the

[74] RWE Polska (2012). Raport RWE Polska "Jakoszczędzamy energię w miejscupracy?" (RWE Polska report "How do we save energy in the workplace?"https://www.cire.pl/pliki/1/Raport_RWE_13_12_20-12.pdf(accessed on 28/10/2019).

[75] Palm, J., Thollander, P. (2010). Op. cit.

[76] Hampton, S., Fawcett, T. (2017). Op. cit.

[77] Geels, F.W., Schwanen, T., Sorrell, S., Jenkins, K., Sovacool, B.K. (2018). Reducing energy demand through low carbon innovation: A socio-technical transitions perspective and thirteen research debates. *Energy research & social science*, 40, 23-35.

[78] Fundación Gas Natural Fenosa (2017). "9º Indice de Eficiencia Energéticaen las PyMEs", June https://prensa.naturgy.com/noveno-indice-de-eficiencia-energetica-en-las-pymes/

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study data, "71% of the restaurants and coffee shops surveyed, and 65.3% of the hotels carry out or plan to carry out some type of energy-saving action to reduce costs". This sort of "natural" propensity to eco-efficiency could be explained in several ways (e.g., the hospitality industry is more interested in staying attuned with the ecological orientation of the costumers). Nevertheless, the figures provided seem to suggest that the actors in this sector tend to have a disposition towards energy efficiency.

The very interest of entrepreneurs to energy efficiency is often interpreted adopting the notion of disposition. Based on a wide analysis of barriers, Cagno et al.[79] consider the lack of this interest as one of the "behavioural barriers". Entrepreneurs could consider energy cost as not having sufficient weight with respect to the firm's production costs, or they could consider their firm as efficient. Lack of interest is considered important also by other authors, for example, Johannson et al.[80] who reported some empirical evidence produced by Trianni, et al.[81].

The approach based on the concept of culture and disposition is in line with some authors who worked on the orientation to SMEs toward energy efficiency, like Paramonova, and Thollander[82]. In particular, such an approach would help avoid the problems often met by "energy audits based on economic evaluation that do not consider transaction costs and risks intrinsic to longer-lasting investments" and, in general, that do not represent well the complexity of the real world. These authors also stress that the most important issue in terms of improving energy efficiency is making energy a strategic organizational issue. Cooremans[83] stresses this concept: "strategicity is more influential than profitability in corporate investment choices. Investment profitability appears as a generally necessary but insufficient condition. Unfavourable diagnosis regarding strategicity entails several negative consequences, the most important being that upper management is not interested and that more stringent selection criteria – or routines – apply to non- or low strategic investments". Cooremans talks of firms in general, i.e., regardless their dimension. Therefore, the issue is understanding if an actual disposition of SMEs is present and how, and at what conditions, could develop.

The literature reviewed stresses that this set of "non-economic" factors – let's term them cultural, disposition or behavioural, as sometimes they are called – make relevant the context in which firms, especially SMEs, operate. Vicker et al.[84] argues that they are more embedded within the local economy and this could be relevant for sustainability and responsibility, since it implies trust, commitments towards employees, etc. On this regards, Palm and Thollander[85] talk of "social construction" of barriers to industrial energy efficiency, referring to the fact that such barriers are also the result of complex social interactions typical of certain contexts.

[79] Cagno, E. et al. (2013). Op. Cit.
[80] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, *12*(7), 1338.
[81] Trianni, A., Cagno, E., Worrell, E., Pugliese, G. (2013). Empirical investigation of energy efficiency barriers in Italian manufacturing SMEs. *Energy*2013, 49, 444–458.
[82] Paramonova, S. and Thollander, P. (2016). Op. Cit.
[83] Cooremans, C. (2012). Investment in energy efficiency: do the characteristics of investments matter? *Energy Efficiency*, 5(4), 497-518.
[84] Vickers, I., Vaze, P., Corr, L., Kasparova, E., Lyon, F. (2009). SMEs in a low carbon economy: final report for BERR enterprise directorate.
[85] Palm, J., &Thollander, P. (2010). Op. Cit.

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These are all issues to be taken into account in the design and implementation of capacity-building and awareness-raising actions aimed at entrepreneurs of SMEs in the field of energy efficiency (which are the "heart" of the INNOVEAS project).

4.4. Gender and orientation to environmental aware behaviour

The literature reviewed on energy efficiency in general did not mention gender although it is well known that there is a lot of research focused on the role of women in SMEs[86] on women entrepreneurship and the role of women for the promotion of environment. A strand of literature that proved interesting concerns the existence of green-stereotypes. The idea is that some pro-environment behaviours are considered as feminine. Their adoption is not a matter of a simple rational calculation and asks for specifically oriented actions. In particular, Brough et al.[87] carried out some experiments to explain the fact that men are less likely than women to embrace environmentally friendly products and behaviours. The authors state about their research that:

> "Whereas prior research attributes this gender gap in sustainable consumption to personality differences between the sexes, we propose that it may also partially stem from a prevalent association between green behaviour and femininity, and a corresponding stereotype (held by both men and women) that green consumers are more feminine. Building on prior findings that men tend to be more concerned than women with gender-identity maintenance, we argue that this green feminine stereotype may motivate men to avoid green behaviours to preserve a macho image.
>
> A series of seven studies provide evidence that the concept of greenness and femininity are cognitively linked and shows that, accordingly, consumers who engage in green behaviours are stereotyped by others as more feminine and even perceive themselves as more feminine. Further, men's willingness to engage in green behaviours can be influenced by threatening or affirming their masculinity, as well as by using masculine rather than conventional green branding. Together, these findings bridge kinds of literature on identity and environmental sustainability and introduce the notion that due to the green-feminine stereotype, gender identity maintenance can influence men's likelihood of adopting green behaviours".

Similar stereotypes have been studied also in the financial sector. Balachandra et al.[88] state that: "investors are biased against the display of feminine-stereotyped behaviours, men and

[86] OECD/EU (2018), Policy Brief on Women's Entrepreneurship, Paris.
[87] Brough, A.R., Wilkie, J.E., Ma, J., Isaac, M.S., Gal, D. (2016). Is eco-friendly unmanly? The green-feminine stereotype and its effect on sustainable consumption. *Journal of Consumer Research*, *43*(4), 567-582.
[88] Balachandra, L., Briggs, T., Eddleston, K., Brush, C. (2019). Don't pitch like a girl! How gender stereotypes influence investor decisions. *Entrepreneurship Theory and Practice*, *43*(1), 116-137.

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women alike. (…) decisions are driven in part by observations of gender-stereotyped behaviours and the implicit associations with the entrepreneur's business competence, rather than the entrepreneur sex".

These studies are very recent and it is impossible to say if a wide consensus among the scholars has emerged. Nevertheless, they have demonstrated the need to consider the gender dimension as one of the "cultural" aspects of entrepreneurs "green-behaviour". What is interesting is that these gender-based differences are produced in a social context. Meek and Sullivan89 have studied the environmental orientation of some entrepreneurs and looked at the importance of gender as one of the independent variables. The hypothesis that gender was relevant was not supported by their data, but the authors state that this could be the result of the specific sample the study was based on. The entrepreneurs studied were, indeed, part of the same group of franchisees and this means that female franchisees/entrepreneurs were "consistently exposed to a large peer group of male franchisees who are more likely to focus on economic and agentic outcomes. This exposure might result in women's perceptions being swayed to focus more on outcomes emphasizing a stronger economic orientation at the expense of environmental sustainability".

5. Chapter Four SMEs towards energy transition

This chapter deals with the relevance and effectiveness of the energy transition process and specific related actions in SMEs. In particular, the attention will focus on what SMEs do (and how to do it) in this regard, with special reference to both the actual and potential barriers making their involvement difficult or even impossible, and conversely the incentives and other drivers that should allow them to overcome these barriers; all this, taking into account the large differentiation that exists in the world of SMEs (see Chapter Two).

We will start dealing with the improvements in energy efficiency and management (eco-innovation included) in SMEs, trying to understand how this process can happen (also thanks to energy audits). In Paragraph two, which is the "core" of the chapter, we will analyse the barriers that hinder these improvements, as a whole and according to some characteristics of SMEs (country, size, sector, etc.). Similarly, Paragraph three will consider the driving forces (or motivations) that, vice versa, can facilitate such improvements. Paragraph four will consider some specific factors, external to the firms, which can help them attain higher levels of energy efficiency. In particular, two aspects will be mainly considered, i.e., the forms of external assistance that SMEs (also through specific national programs or equivalent) receive or can receive from other actors and the creation of "energy efficiency networks" among SMEs. All

[89] Meek, W.R., Sullivan, D.M. (2018). The Influence Of Gender, Self-Identity And Organizational Tenure On Environmental Sustainability Orientation. *Journal of Developmental Entrepreneurship*, *23*(03), 1850018.

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aspects that can allow SMEs (or some among them) to overcome the barriers that hinder their ability and/or willingness to act for their energy efficiency and management improvement.

5.1. Energy efficiency/management improvements in SMEs (towards the adoption of EEMs – Energy Efficiency Measures)

5.1.1. The magnitude of EEMs in SMEs

In the previous chapter, we highlighted that SMEs are little affected by the energy transition process towards a low-carbon society and that most of them have not a consolidated energy culture and do not share the objective of environmental sustainability (although, as we have seen, there are positive points that can be strengthened in the future). Therefore, it is not surprising that only a few SMEs in Europe have implemented energy efficiency measures.

The Observatory of European SMEs found that fewer than 30% of SMEs in Europe had implemented measures for conserving energy and resources, and only 4% had a comprehensive approach to energy efficiency[90].

Similarly, a 2012 study by the Association of Certified Chartered Accountants (UK) showed that only 29% of SMEs had introduced measures to save energy or raw materials compared with 46% of large enterprises and only 4% had comprehensive energy efficiency systems in place compared with 19% of large enterprises. The data confirm that, for many SMEs, efforts to reduce carbon emissions seem expensive in terms of time, staff allocation and the necessary accreditations. Environmental/carbon accreditations are often seen as time-consuming to obtain, maintain and renew. Many SMEs and micro-businesses still consider low carbon initiatives and accreditations as 'nice to have, but not critical' to business success or survival[91]. And according to a government research, more than 60% of SME owners do not regard energy efficiency as a key priority, and only 1 in 10 had made energy savings in the previous 12 months[92].

A study conducted in 2014 in the North of Italy (Pavia province – manufacture of fabricated metal products; and manufacture of machinery and equipment) show a higher percentage – 40.6% – of SMEs conducted interventions in energy efficiency[93].

[90] European Commission (2014). Observatory of European SMEs. Analytical Report. Available at: https://ec.europa.eu/commfrontoffice/publicopinion/flash/fl196_en.pdf
[91] Baranova, P. (2017). Environmental capability of SMEs: Capability building towards a low carbon economy.
[92] Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.
[93] Trianni, A., Cagno, E., Farnè, S. (2014). An empirical investigation of barriers, drivers and practices for energy efficiency in primary metals manufacturing SMEs. *Energy Procedia*, 61, 1252-1255.

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In Spain, SMEs participation in energy efficiency programs is very low (4%)[94]. However, a 2018 study prepared through interviews with 2,000 SMEs throughout Spain, notes the effort that, during the last years, companies have made in terms of energy efficiency and shows in which direction they should work to reduce their energy consumption: 69% of organizations are paying more attention to investment in energy efficiency and smart building technology and 56% of organizations plan to increase energy efficiency and renewable energy investments[95].

In Poland a 2016 research covering a group of 50 companies highlighted that if, on one hand, all companies declared that they identified some measures to reduce energy consumption (60% of them have set goals in this area; 80% declared that they monitor energy consumption), on the other hand, 80% of them have no energy strategy defined and none have energy audit performed[96]. Going more in-depth, another study implemented in Poland in this same country one year before (in 2015) is meaningful.

"Despite the created support systems for such activities, as well as the continuous increase of ecological social awareness, the number of investments related to reducing energy consumption in the SME sector is small, both in Poland and throughout the European Union. This is mainly due to the lack of own resources that enterprises could allocate for this purpose, as well as the low awareness of external sources of financing and possible additional benefits that can be obtained by carrying out optimization actions."

The research described in this article was conducted in a group of 55 enterprises, including 33 micro-enterprises (60% of the research sample), 18 small enterprises (33%) and 4 medium-sized enterprises (7%). The study showed that:

- Over 25% of the surveyed companies had not conducted any activities until then
- 7% of the surveyed companies had conducted an energy efficiency audit before starting the investment
- the surveyed companies had not implemented an energy management system in their organisations
- 20% of the surveyed companies had conducted audits of the existing construction infrastructure[97].

As for Slovenia, the situation for the near future seems to be promising (although the financial commitment is expected to remain limited).

[94] Fundación Gas Natural Fenosa (2017). "9º Indice de Eficiencia Energéticaen las PyMEs". Available at: https://prensa.naturgy.com/noveno-indice-de-eficiencia-energetica-en-las-pymes/

[95] Johnson Controls (2018). 2018 Energy Efficiency Indicator Survey – Spain. Available at: https://www.johnsoncontrols.com/media-center/news/press-releases/2018/11/15/~/link.aspx?_id=4B3426E1445A4F4FB85C6D504D000D2F&_z=z. This study underlines also that the Energy Efficiency Index (IEE), measuring the overall performance of SMEs in energy savings, in 2017 reaches 5.9 points out of 10, compared to 5.6 points recorded in 2015 and 3,1 in 2005; so there is a clear trend of improvement over recent years. However, in 2018, 37% of SMEs plan to keep their investment level the same.

[96] Leszczyńska, A., Curie-Skłodowska, M. (2016). Sources and barriers to the energy efficiency of Polish enterprises. *Annales Universitatis Mariae Curie-Skłodowska*, section H – *Oeconomia*, Vol 50, No 3.

[97] Kucęba, R., Koszarek-Cyra, A. (2015). Directions, barriers, factors energy management in SMEs organisations". Scientific notebooks of the Silesian University of Technology, Series: Organization and management no. 83.

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"About 37% of companies are ready to invest in renewable up to € 10,000, 24% of companies are willing to invest between € 10,000 and € 50,000, and 19% of companies are willing to invest between € 50,000 and € 100,000. A tenth (12%) of companies are ready to invest between € 100,000 and € 500,000 in renewable, and a relatively large proportion (11%) is willing to invest more than € 500,000. Most companies (54%) believe that investments in renewable energy should be repaid within five to 10 years. Approximately 34% of companies believe that investments should be repaid in less than five years, and more than 15 years only 1% of companies are willing to pay back the investment[98]."

Going outside Europe, another study depicts a similar situation also in a non-European country, i.e., the People's Republic of China.

"A primary finding is that only a minority of SMEs in China have had direct involvement with any decision related to investment or implementation of energy-saving projects. For example, just 21 per cent of surveyed enterprises have installed energy-efficient equipment in their premises to date, while only four per cent of SMEs have ever taken a loan for financing energy-efficient measures, and less than three per cent have appointed an energy manager. A more promising finding is that 54 per cent of firms plan to either purchase additional or replace existing equipment, suggesting that there is a demand for energy-efficiency-related investments in the SME sector[99]."

Sector-specific features are also worth mentioning: low-technology manufacturing firms are significantly little likely to perform eco-product innovation. Given this, we note that SMEs in the construction and agriculture sectors are slightly less prone to undertake it as well as medium-low technology manufacturing[100]. Vice versa, energy-efficiency measures are higher for SMEs in the high technology manufacturing and services sectors (e.g., higher quality standards of their buildings and to some extent in the quality of their machinery)[101]. And, of course, SMEs that are large users of electricity, are most likely to monitor their energy use and actively work to reduce the use (e.g., as it emerges in a survey on 112 SMEs in UK)[102].

Regardless of the countries and sectors of reference, many SMEs remain idle because they do not "perceive that the nature of their business leads to significant GHG (greenhouse gas) emissions or offers the potential to reduce the emissions"; and are also de-motivated because

[98] Špacapan, F. (2015). Graduation thesis: energy management and efficient use of energy in companies. Available at: http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf

[99] Kostka, G., Moslener, U., Andreas, J. (2013). Barriers to increasing energy efficiency: evidence from small-and medium-sized enterprises in China. *Journal of Cleaner Production* Volume 57, 15 October 2013, Pages 59-68.

[100] Triguero, A., Moreno-Mondéjar, L., Davia, MA. (2011). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, August 2013, Volume 92, Pages 25-33. Authors noted that "There are no relevant differences in the probability to undertake eco-organizational innovations across sectors, but plenty of differences arise as regards eco-process innovation: firms in every single sector except food services report a higher probability to perform eco-process innovation than construction firms".

[101] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs' energy efficiency investment (No. 2019/02). EIB Working Papers. This paper confirms also the construction sector as less involved.

[102] Johnson Controls (2018). 2018 Energy Efficiency Indicator Survey – Spain. Available at: https://www.johnsoncontrols.com/media-center/news/press-releases/2018/11/15/~/link.aspx?_id=4B3426E1445A4F4FB85C6D504D000D2F&_z=z

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of the low costs of the energy (in many industrial companies, energy expenditures are often less than 5% of total production costs[103]).

Lastly, it should be noted that many SMEs do not consider, beyond the expected reduced energy costs resulting from energy efficiency investments, other non-energy benefits. Examples of such benefits are provided by Kluczek and Olszewski[104] in a 2017 study: "better working conditions, improved product quality and increased productivity, reduced cost of environmental compliance, raw material savings, reduced emissions, extended equipment life and reduced maintenance requirements".

That said, let see which are, according to the literature review we implemented, the SMEs improvements in the management of energy i.e., the adoption of EEMs – Energy Efficiency Measures – and, before, how it can happen.

5.1.2. Steps in the implementation of EEMs

How improvements in energy management can be performedis well explained by Máša, Stehlík, Touš & Vondra.

The authors, in particular, highlight the importance of external assistance that can be provided by specialized companies known as Energy Service Companies[105] (ESCo) and identify two sets of procedures usually provided by the ESCOs: Energy management (EM) and energy performance contracting (EPC).

"EM is a general tool that manages and reduces energy consumption effectively. EM systems do not provide saving actions tailored to a particular energy system. EM implementation is usually investment-free. EPC may be a helpful tool for financing the investments which are always useful when there may be a shortage of capital. Improving the operation of such

[103] Catarino, J., Henriques, J., Egreja, F. (2015). Portuguese SME toward energy efficiency improvement. *Energy Efficiency*, 8(5), 995-1013.

[104] Kluczek, A., Olszewski, P. (2017). Energy audits in industrial processes. Journal of cleaner production, 142, 3437-3453. Authors specify that a multidimensional approach is therefore needed for analyzing the different types of benefits. Non-energy benefits are mentioned also in other researches, such as one in Switzerland on 302 enterprises (197 SMEs). "The highest score was obtained by "reduction of maintenance cost and technical control of equipment" entailed by energy efficiency investment (selected by 133 companies), followed by "impact on reputation and corporate image" (115 companies). "Improved security and working conditions" comes in third position (113 companies) and "Lower CO2 tax or tax exemption" in fourth position (110 companies). Cfr. Cooremans, C., Schönenberger, A. (2019). Energy management: A key driver of energy-efficiency investment? *Journal of Cleaner Production*, *230*, 264-275.

[105] Energy Service Company, the companies that practically carry out the Energy Audits and other connected services. The problem is those small enterprises do not know how the incentives system works and, particularly, the system of ESCos (Energy Service Company, the companies that practically carry out the Energy Audits and other connected services). Carrying out initiative for improving energy efficiency is an opportunity also for the SMEs that provide services and have relations with international companies that are particularly sensitive to energy-saving issues (Vascellaro D., L'efficienza energetica è un'opportunità per le PMI (Energy efficiency is an opportunity for SMEs) , in Il giornale delle PMI, interview to Patrizia Malferrari, Seaside, November 9th, 2018, https://www.giornaledellepmi.it/lefficienza-energetica-e-unopportunita-per-le-pmi/).

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systems is rather an R&D activity and is outside the scope of the ESCo or pose a serious risk for the ESCo[106]."

Moreover, they identify four phases for systematizing the design and the implementation of the energy-saving measures.

- Phase I: Analysis of a current state of the energy system and all appliances (in this phase data acquisition is critical: "Sufficient amount of reliable data helps develop top-quality energy savings measures. Data acquisition of high quality also plays a crucial role in the verification of the actual impact of the saving measures. If no operational data are available a short-term measurement of crucial parameters with portable measurement devices might be performed" [107]).
- Phase II: Selection of suitable saving measures.
- Phase III: Support during implementation of the saving measures.
- Phase IV: Evaluation of impact of the saving measures.

Further studies underlines the importance of the external assistance, such as the North Italy SMEs study quoted above, which highlight that 37.5% of the investigated SMEs (as answered by the interviewed persons) took advantage of an external expert (energy efficiency) consultant[108]. This figure is in line with another one, taken from a study carried out in Slovenia according to which more than 60% of SMEs do not employ a person who is responsible for the field of energy in the company (however, this last percentage has raised in the last 5 years for up to 20%)[109]. According to a broader study implemented in Italy 3 years later (2017)[110], concerning, however, all the enterprises implementing energy efficiency improvements and not only the SMEs, this percentage is lower (16%). Although the differences between the two studies, they both make clear that SMEs, compared to larger companies, have a greater need for external personnel (engineering companies and/or technology suppliers and/or consultants; we will be back on this specific issue later in Paragraph 4 of this Chapter).

Coming now back to the phases described above a similar one is suggested in a further paper from Johansson, Mardan, Cornelis, Kimura, Thollander.

"Making decisions about energy efficiency measures is a process with the following steps: initial idea, diagnosis, build-up of solutions, evaluation and choice, and implementation.

[106] Máša, V., Stehlík, P., Touš, M., Vondra, M. (2018). Key pillars of successful energy-saving projects in small and medium industrial enterprises. *Energy*, 158, 293-304.
[107] Ibid.
[108] Trianni, A., Cagno, E., Farnè, S. (2014). An empirical investigation of barriers, drivers and practices for energy efficiency in primary metals manufacturing SMEs. *Energy Procedia*, 61, 1252-1255.
[109] Špacapan, F. (2015). Graduation thesis: energy management and efficient use of energy in companies. Available at: http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf
[110] Chiaroni D., Frattini, F. (2018). Energy Efficiency Report 2018 - Il mercato dell'efficienza energetica in Italia dalla prospettiva degli utenti finali (The energy efficiency market in Italy from the end user perspective). Available at: https://www.federesco.org/images/EER_2018.pdf*("70% of the companies relied on their internal organizational unit to carry out energy efficiency measures without relying on any external expertise. Following are the external operators with 16%, a very significant percentage that highlights how, within the market, engineering companies and / or technology suppliers are increasingly expanding their business to enter the world of energy efficiency").*

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Relating Cooremans' model to research on energy efficiency in industry, research on improved energy efficiency in industry can be categorized into the following primary areas: studies of the energy efficiency potential, company-specific measures and methods to improve energy efficiency, policy-specific measures and methods to improve energy efficiency, and barriers to and drivers for adoption of measures for greater energy efficiency[111]."

Anyway, procedures are often complex and differentiated among SMEs, as stressed by Hampton and Fawcett.

"There is disagreement as to how SMEs make decisions around energy, and therefore how policy can be best designed to influence their choices. Given their huge diversity in business sectors, types of buildings occupied, equipment used, forms of organisation, and so on, using empirical evidence on SMEs to improve understanding and policy design is inherently difficult[112]."

Furthermore, outside Europe, also in an Australian study ...

… "Upgrading an SME's or community organisation's energy efficiency requires a complex series of steps that includes decision-making, engaging third-parties and implementation. Impediments at any stage of this process will prevent energy efficiency improvement, and programs that only tackle a sub-set of the barriers will have limited impact[113]".

It appears already clear how much the improvement of energy management (energy efficiency enhancement, eco-innovation, etc.) in SMEs depends (also) from the relations of a wide set of actors, as better specified below.

"Energy efficiency thus also depends on social relationships and discussion, negotiations, and agreements developed in actor networks. Experiences, routines and habits established and negotiated in a particular network will then determine what energy efficiency measures will be implemented. These negotiated agreements can thus serve as both possibilities and constraints. Focusing on social negotiations and agreements helps explain why energy efficiency technologies are rejected or adopted in different sectors…. What is needed are new forms of discussions, new alternatives, that challenge existing regimes, and to try new approaches by letting different social networks learn from each other. That would enable discussion of whether the barriers in each sector can be overcome by bridging and by elucidating any prejudices, bad habits, or thoughtless routines that may affect the various activities in the sector[114]."

[111] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, 12(7), 1338.
[112] Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.
[113] Energy Efficiency Council (2017). SME and community organizations – enabling best practice energy efficiency. Available at: http://www.eec.org.au/uploads/Projects/EEC2017_SMENFP_enabling_best_practice_energy_efficiency.pdf
[114] Palm, J., Thollander, P. (2010). An interdisciplinary perspective on industrial energy efficiency. *Applied Energy*, 87(10), 3255-3261.

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5.1.3. Which are the measures?

There are many measures that, in principle, can be taken, more or less, everywhere (with the different adaptations to the specific situation, let us remember how different SMEs are with each other), as shown by the following example referring to Slovenia.

"In the eight years since we (…), moved to new business premises, we made exceptional progress in this field. For comparison, let us state that we spent almost 61,000 kWh of electricity in 2007 and about 3,000 litres of heating oil for heating. At the beginning of 2008, we decided to use exclusively renewable energy in the company by 2018. We can proudly state that in the past year, electricity was the only source of energy in our company. It was used for heating, cooling, ventilation and also for production. In total, we spent about 43,000 kWh in 2014, which means that with the implementation of various measures we have saved more than 30% of electricity, and have also completely eliminated use of heating oil. We have implemented following measures:

- We replaced all the lights in our office building with LED lights.
- In addition, we isolated the facade of the building and the roof.
- We have renovated all windows and doors in the building.
- For heating and cooling we installed a ground-water heat pump.
- We have replaced all electric motors with more efficient ones.
- We installed a ventilation device by returning the heat of the spent air with efficiency of more than 75%[115]."

The measures described above appear to have taken into account the whole use of energy in that SME (both energy spent on production and energy spent on everyday life). However, this study concerns only a single SME. Another study[116] implemented in 2015 on Slovenian 115 SMEs confirms these results, showing that the most commonly implemented measures are: installation of new luminaries, education of users, shutting down machines, new equipment, frequency regulation, and other smaller measures.

According to a study implemented throughout Spain on 2,000 SMEs[117], the most widespread energy efficiency measures are the use of flat monitors in computer equipment (85%), the management of the consumption of cold rooms (more than 70%), the use of furnaces in the industry (more than 70%), the use of boilers in the industry (72%), the cleaning of burners (94%) and lighting (79%). LED technology has become predominant, from 26% in 2015 to 53.1% in 2017. However, there is still room to improve the energy efficiency of SMEs, with the use of monitoring and telemetry equipment. Some interesting details by activity sector and

[115] Center of Energy efficient solutions Slovenia (2018). Further incentives for new investments in energy efficiency and renewable resources for small businesses. Available at: http://www.cer-slo.si/dodatne-spodbude-za-nove-nalozbe-v--energetsko-ucinkovitost-ter-obnovljive-vire-malih-in-srednjih-velikih-podjetij-11-09-2018.html

[116] Špacapan, F. (2015). Graduation thesis: energy management and efficient use of energy in companies. Available at: http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf

[117] Fundación Gas Natural Fenosa (2017). "9º Indice de Eficiencia Energéticaen las PyMEs". Available at: https://prensa.naturgy.com/noveno-indice-de-eficiencia-energetica-en-las-pymes/

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size are added, highlighting which are the kinds of SMEs characterized by many improvements (e.g., hospitality) and the ones where the potential for saving is greater (e.g., professional services).

"By sectors of activity and size, the highest energy efficiency is recorded in the hospitality industry (restaurants, cafes and hotels), with a 6.2 out of 10 score. On the opposite side, the sector with the greatest savings potential is the professional services, which can still save 26.3% of its energy bill thanks to energy efficiency measures. Commerce also has great savings potential, with 25.1% of its energy bill. The industry, with a score of 5.6 out of 10, currently only has a 12% energy saving potential. The hospitality sector is one of those that have traditionally been more active implementing energy efficiency measures. According to the study data, 71% of the restaurants and coffee shops surveyed, and 65.3% of the hotels carry out or plan to carry out some type of energy saving action to reduce costs. In addition, it is the hotels that control the temperature of the air conditioning systems in winter more effectively. On the contrary, the most efficient in adjusting comfort temperatures in summer are shops, while there are few hotels that in summer maintain adequate control over temperature. The potential for savings is greater in smaller companies (less than 10 employees), reaching 24.32%. Whatever the size of the company, the greatest savings potential is not usually associated with lighting (...) Furthermore, there is still a path to improve the energy efficiency of SMEs, with the use of monitoring and telemetry equipment. Only 32.2% of companies have made a rate optimization or power adjustment in the last year, something that would allow them to save considerably on the energy bill. In addition, participation in energy efficiency programs is very low (4%)[118]."

According to another study implemented in Spain in 2018 by Johnson Controls[119], the main energy efficiency measures implemented in 2018 have been "heating, ventilation and air-conditioning improvements" and this trend is continuing in 2019. Next measures in importance are "energy focused behavioural programs" which will work much better around the globe (55%) compared to 50% in Spain. "Building systems integration" is on the rise with almost half of the respondents in Spain indicating they would invest over the coming 12 months, and "electric energy storage" will be present in the top 10 energy efficiency measures for 2019, with 43%, while in 2018 it was not in the list.

Moving now in a third "INNOVEAS" country, Poland, we can consider the study already mentioned above on measures adopted and on measures expected[120], which are largely similar to those mentioned in the studies above. They concern both the productive cycle and the life environment of the company (in all its aspects).

Within the framework of the study, the degree of intensification of selected energy efficiency measures was determined. The most frequently declared and carried out activities were:

[118] Fundación Gas Natural Fenosa (2017). "9º Indice de Eficiencia Energéticaen las PyMEs". Avaialble at: https://prensa.naturgy.com/noveno-indice-de-eficiencia-energetica-en-las-pymes/

[119] Johnson Controls (2018). 2018 Energy Efficiency Indicator Survey (Spain). Available at: https://www.johnsoncontrols.com/media-center/news/press-releases/2018/11/15/~/link.aspx?_id=4B3426E1445A4F4FB85C6D504D000D2F&_z=z

[120] Kucęba, R., Koszarek-Cyra, A. (2015). Directions, barriers, factors energy management in SMEs organisations". Scientific notebooks of the Silesian University of Technology, Series: Organization and management no. 83.

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- Replacement of heating devices (40%)
- Replacement of lighting with more energy-efficient (40%)
- Insulation of the building (26.7%)
- Production processes optimization (26.7%)
- Most of the activities were financed by the companies' resources. However, these were low-investment
- Planned Sources of financing environmental investments in the research group
- 47 companies (85%) declared co-financing of new pro-ecological investments with external capital
- The remaining 8 surveyed enterprises (14%) plan to finance the indicated activities from their resources.

These actions will be financed from:

- European funds – 26 enterprises (47%)
- Low-interest, preferential loans – 10 enterprises (18%)
- Subsidies and/or preferential loans from the Polish National Fund for Environmental Protection and Water Management – 9 (16%).

Inter-alia, we can note that retrofitting SMEs buildings (mentioned just above and also before) is a measure at the "crossroad" among the "housing sector" and the "enterprise sector". Specific guidelines on how to do this in SMEs buildings were tracked in the frame or our literature review[121].

In this paragraph devoted to the analysis of the measures adopted in SMEs towards a better use/management of energy, it could be useful to report some findings of a study published in 2011 on eco-innovation[122] (eco-product, eco-process or eco-organisational), i.e., environmental innovations accelerating the energy transition. The propensity to adopt these various types of measures is uneven across Europe.

"Concerning eco-product innovation, only firms based in Italy and Cyprus are significantly more likely to be innovators, and only firms based in Hungary and Estonia are less likely to perform this type of innovation. As regards eco-process innovation, the differences are more pronounced, so that firms located in Belgium, Czech Republic, Germany, Estonia, France, Cyprus, Lithuania, Hungary, Slovenia and Bulgaria are less likely to innovate in process than Spain, whereas Polish firms are the only ones with a higher proneness to eco-innovate in process. Finally, eco-organizational innovations are less likely in Denmark, Germany, Estonia, Greece, Italy, Cyprus, Latvia, Lithuania, Hungary, Austria, Slovenia, Finland, Sweden, the UK and Bulgaria than in Spain and no relevant differences are found between Spain and the

[121] Barbara, J., Marcus, P., Stijn, D., Hide, B. (2018). Retrofitting the building envelope of SME industrial buildings: hygrothermal risk assessment. Available at: http://kmoreno.be/sites/default/files/2019-03/Barbara%20Joseph%20Retrofitting%20the%20building%20envelope%20of%20SME%20industrial%20buildings%20hygrothermal%20risk%20assesment.pdf

[122] Triguero, A., Moreno-Mondéjar, L., Davia, MA. (2011). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, August 2013, Volume 92, Pages 25-33.

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remaining countries. The relatively high incidence of eco-innovation in Spain (in comparative terms) is a very interesting result, which deserves further attention and analysis. We have tried to disentangle it by looking at levels of regulation stringency and public expenditure on eco-innovation but no direct relation may be found between those indicators and environmental innovation."

Eco-innovation mainly characterizes SMEs having a significant potential to develop innovative solutions for green products and services as well as sustainable business products. Of course, as already stated in the previous chapter, these SMEs have a much higher propensity towards the adoption of measures related to energy efficiency, as stated by Hirzel et al.[123] in 2016.

"The trend of combining product-service propositions to deliver more sustainable solutions represents a strategic shift for SMEs as they need to develop their competences to match demands for sustainable product and service solutions… These include ICT (telematics, tracking and 'smart' infrastructure), logistics (for reverse logistics of used products, collection/distribution of asset-sharing models), and financial services (insuring and financing leased assets) (...). Sustainable business models present opportunities for new solutions in organisational design and infrastructure. SMEs could take a lead in developing such bespoke solutions and in crafting new and unexplored 'niches' for competitive success taking advantage of their flexibility and close proximity to the customer base."

This trend in this kind of SMEs is facilitated by well-developed learning capabilities and appropriate behavioural attitudes, such as flexibility, or their commitment to their employees characterizing these enterprises. This aspect is highlighted by Vickers et al.[124].

"Although smaller firms are resource constrained, limiting their ability to make significant innovations, they possess certain behavioural advantages, notably that they can respond more rapidly, flexibly and efficiently to customer needs than can larger organisations. SMEs (including social enterprises) have other characteristics which, it is argued by some, are supportive of sustainability and responsible behaviour: they are more likely to be embedded in their local economy and environment, not necessarily driven by profit maximisation, rely on reputation and trust for many of their business transactions, and often show a strong commitment to their employees. Small hi-tech start-ups and SMEs have been playing a particular role in the development of novel low carbon technologies. Particularly important here has been the role of supportive contexts, including venture capital, public sector and other forms of support. Case studies of low carbon start-ups in the recent literature also demonstrate the origins of novel technologies in research-intensive universities. For most SMEs there is a need to increase the application of existing knowledge and (affordable) technologies for improving their sustainability."

Many measures were adopted in European SMEs following the implementation of an energy audit. This is the case of a Slovenian SME.

[123] Hirzel, S., Nabitz, L., Wohlfarth, K., Rohde, C., Behling, I., Clarke, D., Perera, N., Turner, R. (2016). A study on energy efficiency in enterprises: energy audits and energy management systems. European Commission Report. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/EED-Art8-Implementation-Study_Task12_Report_FINAL-approved.pdf

[124] Vickers, I., Vaze, P., Corr, L., Kasparova, E., Lyon, F. (2009). SMEs in a low carbon economy: final report for BERR enterprise directorate.

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"On the basis of a thorough energy audit carried out by Resalta, company Iskratel decided to implement some of the proposed measures to improve their energy efficiency. The first project involves improving energy efficiency in a data center that requires year-round cooling. Previously installed old, unreliable and energy-inefficient HVAC system was replaced with a new system that allows the function of free cooling. Ambient temperatures to 18 ° C allow for complete free cooling, as the outside air is directly injected through the filters. During the heating season, heated air is used by the servers to heat the adjacent repository. Thanks to this solution, energy consumption decreases as most of the year electricity is only consumed by an air inlet fan, and the waste heat is reused in the heating season. The moisture in the air is controlled by the ultrasonic humidifier. The second project is aimed at improving working conditions for employees. New cooler aggregate and a recuperation climate, as well as an internal divider with convectors were installed in order to improve the ventilation and cooling of the rooms for comfort. Thanks to these measures, Iskratel saves 637 MWh of electricity a year and obtains a reliable cooling system. In addition, employees in the company have better working conditions, recuperation of waste heat will bring financial benefits, and the environmental impact of the company will be reduced due to the abandonment of the refrigerant R22 and the transition to an environmentally friendly solution[125]."

Moving from this single case to a European sample, in the frame of the EU funded PINE[126] the project, 140 SMEs having participated in an energy audit were investigated. Here, we refer not to the adopted but only to the suggested measures (almost 500). More than 50% were cross-cutting technologies, such as compressed air (leakages, optimized pressure level, control of compressors), lighting (control, energy-efficient bulbs), motors (optimized size, control), boilers (return of condensate, pressure level, air/fuel ratio, size, control, preheating of combustion air and/or feed water), cogeneration, and energy recovery (from hot wastewater from washing, to preheat freshwater, from hot exhaust air, to preheat air or product). Other improvements, which are strongly dependent on the requirements of the individual processes in each company and their annual operating hours, are: dealing with the use of renewable energy, the installation of monitoring and controlling systems, reactive power compensation, replacement and exchange of single production plants. Finally, photovoltaic electricity generation, and heat recovery from production processes and building refurbishment[127].

[125] Center of Energy efficient solutions Slovenia (2018). Further incentives for new investments in energy efficiency and renewable resources for small businesses. Available at: http://www.cer-slo.si/dodatne-spodbude-za-nove-nalozbe-v--energetsko-ucinkovitost-ter-obnovljive-vire-malih-in-srednjih-velikih-podjetij-11-09-2018.html

1. [126] Promoting Industrial Energy Efficiency (PINE) – Intelligent Energy. PInE aims to increase energy efficiency in industrial SMEs employing auditing schemes and subsequent provision of professional technical advice for the implementation of customized measures, with the long-term goal to create a self-sustaining model capable of expanding project-specific measures.

[127] Fresner, J., Morea, F., Krenn, C., Uson, J.A., Tomasi, F. (2017). Energy efficiency in small and medium enterprises: Lessons learned from 280 energy audits across Europe. *Journal of Cleaner Production*, 142, 1650-1660.

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Thollander et al.[128], in a study published in 2015, report on measures proposed in energy audits on Italian, Belgian and Japanese SMEs (per sector).

We can note a high variability among the sectors. However, air compression and management of the power system appear among the most suggested measures.

Figure 1 - Number of measures per sector and per process type at medium-sized companies (N = 218), Flanders, Belgium

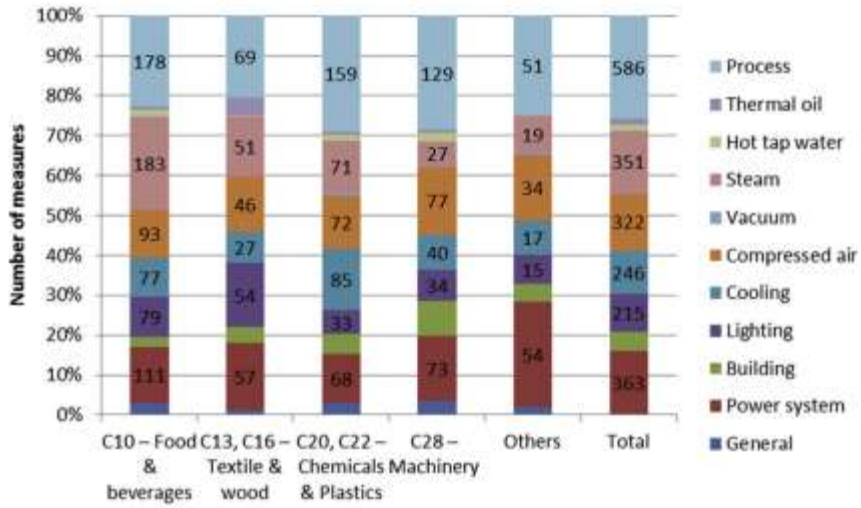
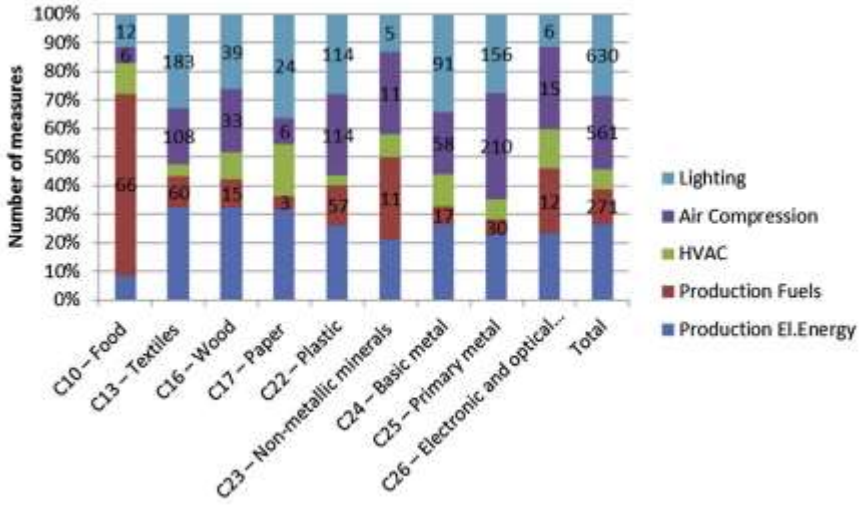


Figure 2 - The number of proposed measures in energy audits in industrial SMEs for different processes and sectors (N = 255), Italy



[128] Thollander, P., Paramonova, S., Cornelis, E., Kimura, O., Trianni, A., Karlsson, M., Navarro, J.P.J. (2015). International study on energy end-use data among industrial SMEs (small and medium-sized enterprises) and energy end-use efficiency improvement opportunities. *Journal of Cleaner Production*, 104, 2.

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Table 3 - The number and types of proposed measures in industrial SMEs for different processes (N = 3139), Japan

Category	Measure	# of proposed measures
A/C and refrigerators	management of air-conditioning system	345
	temperature setting of air-conditioners	144
	management of freezers and refrigerators	36
Fans, pumps and compressors	management of air pressure	268
	introducing variable-speed drives	246
	operation improvement	220
	avoiding leakage of air	110
	reduction of demand	46
Boilers and furnaces	insulation	260
	combustion management	178
	operation improvement	125
	waste heat recovery	41
	reduction of steam pressure	41
	avoiding leakage of steam	40
	steam drain recovery	33
Lighting and other electric equipment	management of power receiving equipment	248
	introducing high-efficiency lightings	218
	operation improvement of lightings	196
	management of power conversion equipment	128
	improving motor efficiency	90
	operation improvement of electric equipment	73

As stated in a recent (2019) European Investment Bank (EIB) study[129], in 2018, the EU average proportion of total investments for measures to improve energy efficiency in SMEs was around 8.6%. Firms in Slovakia represent the highest proportion in the EU with 14.3%, which is more than twice as large as the lowest proportion documented in Lithuania, with 6.3%. However, for most countries (24 out of 28) this proportion ranges from 7% to 11% and increases with firm size.

Of course, the capacity of SMEs "to improve their energy efficiency cannot be viewed in isolation. Regulatory and market contexts strongly affect their capacity to improve their energy efficiency. Governments and other parties can influence this context and therefore make it easier and cheaper to improve energy efficiency"[130]. Recalling also the contents of the first chapter in this deliverable, we can add that many actors (beyond SMEs and the public sector) should play a role. We will discuss again this issue later in this chapter.

5.1.4. Energy audits

The energy audit is a measure towards energy efficiency/management improvements in SMEs; as stated in the just above mentioned EIB study, it is "an effective tool for overcoming the information barriers to energy efficiency and facilitating the implementation of energy-efficiency measures in SMEs[131]". It is a "special" measure, supporting to identify other EEMs

[129] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs' energy efficiency investment (No. 2019/02). EIB Working Papers.
[130] Energy Efficiency Council (2017). SME and community organizations – enabling best practice energy efficiency. Available at:
http://www.eec.org.au/uploads/Projects/EEC2017_SMENFP_enabling_best_practice_energy_efficiency.pdf
[131] Kalantzis, F., Revoltella, D. (2019). Op Cit.

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to be implemented for improving energy efficiency/management considering the specific characteristics of each SME, its present energy management and its context. We cannot dwell upon now the essence of energy audits and how they are or can be done. It is enough to consider here the multiple implementation schemes adopted, even with significant differences[132] among them (more than 100 audit programs in place worldwide)[133]. Obviously, then, we are interested only in the energy audits for SMEs and not in those for larger companies, let alone those for residential buildings (e.g., condominiums) or for other entities.

According to the already quoted EIB study, "implementing an energy-efficient support process measure seems easier than implementing an energy-efficient production process measure (firms may be unwilling to disrupt their production process by changing their machinery and equipment, especially when they are subject to quality control issues)", i.e., an energy audit appears more functional to act on the "boundary" of energy management in an SME than in its "core"[134].

This same 2019 study provides useful information on energy audits.

- Croatia had the highest participation rate in SMEs, a large difference from most EU countries. Its level accounted for 53%, almost five times higher than in Estonia (11%), which had the lowest participation rate in Europe. Most countries were evenly distributed around the average EU participation rate of 30%. Western European countries ranked above the EU average while Southern European countries and the Baltic countries are placed below it. Firms operating in the central, eastern and south-eastern European countries are less keen to conclude an energy audit, except for Croatia.
- Larger SMEs present higher average participation rates (40%) than smaller SMEs (15%). However, energy audits appear to be more beneficial for smaller firms. Beyond size, energy-intensive use, higher energy costs, productivity and capital intensity appear to be determining factors in energy audit participation.
- Audit participation rates are higher in the manufacturing sector (42%), which is more energy-intensive than any other economic sector. The services and infrastructure sectors follow (respectively, 31% and 28%) whereas the construction sector is substantially far behind (20%).
- Innovative firms are also more likely to conclude an energy audit. This decision might be driven not only by financial and operational objectives but also by strong environmental concerns. Most of them include in their production function elements of energy efficiency as a means of

[132] In the literature different types of audit are listed; the energy audit can be performed with different focuses of analysis depending on the needs of the firm and can be categorized into the following types: walk-through, mini-audit, and maxi-audit described three types of energy audits: a walk-through audit, an intermediate audit, and an extended energy audit (see Kluczek, A., Olszewski, P. (2017). Energy audits in industrial processes. *Journal of cleaner production*, 142, 3437-3453).

[133] Schleich, J., Fleiter, T. (2017). Effectiveness of energy audits in small business organizations. *Resource and Energy Economics*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846. According to another source, a total of 65 instruments have been identified, thereof 50 in the EU-28 and further 15 instruments across Brazil, Canada, China, India, Japan, Norway, Switzerland and the USA. The promotion of energy audits and/or energy management systems in SMEs is also an essential element in Australia, South Africa and Turkey (Nabitz, L., Hirzel, S., Rohde, C., Wohlfarth, K., Behling, I., Turner, R. (2016). How can energy audits and energy management be promoted amongst SMEs? A review of policy instruments in the EU-28 and beyond. Proceedings of the ECEEE Industrial Summer Study, 401-415).

[134] Kalantzis, F., Revoltella, D. (2019). Op. Cit.

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bridging the "energy efficiency gap". For innovative firms, the information provided by the energy audit plays a crucial role in overcoming the existing numerous market failures and economic, organisational and behavioural obstacles, especially when the energy audit identifies measures that offer great savings, require limited capital and are financially profitable (innovative firms are twice as likely to invest in energy-efficiency improvements after an energy audit than such firms without an energy audit).

- Countries that transposed the Energy Efficiency Directive (EED) requirements into their national legislation the fastest have positively influenced firms' decisions to conduct an energy audit.
- Only the development and diffusion of information tools (on the opportunities, subsidies, other incentives, etc. concerning the adaptation of EEMs) have a positive and statistically significant impact on energy audit decisions.
- The introduction of an energy management system (EMS) in some countries acts as a substitute for energy audits. Therefore, most are active the EMS, the lower the propensity to implement energy audits.
- The decision of firms is positively associated with the age of the capital stock. To proceed with an accurate refurbishment or replacement of any type of asset, it is crucial to conduct an energy audit to identify the energy savings potential of feasible interventions and their related costs.
- The probability of an energy audit is also higher for subsidiaries of multinational firms, likely driven by the parent company's effort to reduce costs.

According to an older study[135] (in 2010) figures are more or less on the same order. While 93% of SMEs perceive energy audits as useful, only 25% of them indicated that they have undertaken one. Energy audits are less frequent in small companies. The percentage is higher with larger companies and in those countries where funding is available for such checks.

[135] Change (2010). Energy Efficiency in SMEs: Success Factors and Obstacles. Available at: https://drive.google.com/drive/folders/1HUXUybF-caQ6EkpF-ylbeFu3fU1MDkWu

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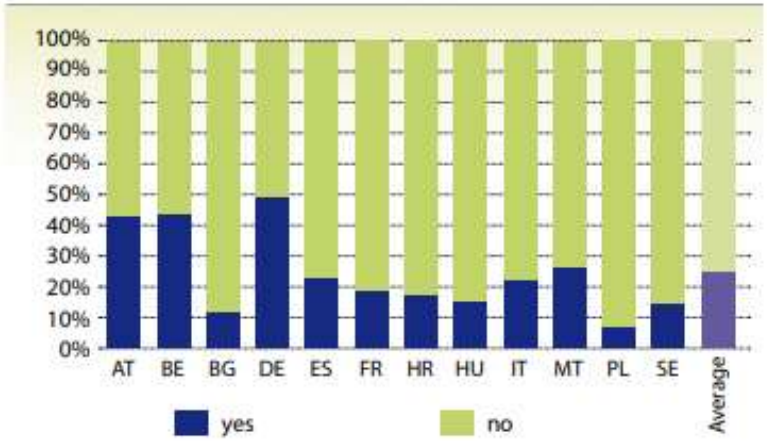
Figure 3 - Energy audit taken by country



We can add that in 2013:

- In the Pavia province in Italy[136], 40% of SMEs carried out an energy audit in the last four years
- In Poland's foundries sector, 58% of SMEs carried out an energy audit[137].

Which is the attitude of entrepreneurs in front of the results of an energy audit? In this regards, three points can be highlighted.

- Conviction: After reviewing the energy audit, most of the entrepreneurs confirm the correctness of observations and the possibility to implement the recommended measures in their companies[138].
- Briefing: Entrepreneurs affirm that they were not aware of the measures recommended before the audit (as it resulted from a survey implemented in Germany, where this was declared by 62% of them)[139].
- Implementation: The measures suggested are reviewed by the company's top management and are prioritized according to the availability of financial and other resources. The measures are usually implemented on a project basis and are often characterized by the rather limited implementation of 50% or lower[140].

[136] Trianni, A., Cagno, E., Farnè, S. (2014). An empirical investigation of barriers, drivers and practices for energy efficiency in primary metals manufacturing SMEs. *Energy Procedia*, 61, 1252-1255.
[137] Thollander, P., Backlund, S., Trianni, A., Cagno E. (2013). Beyond barriers – A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden. *Applied Energy*, Volume 111, November 2013, Pages 636-643.
[138] Korczak, K. (2015). Master Thesis - Energy efficiency improvement in small and medium-sized enterprises. University of Technology, Faculty of Power and Aeronautical Engineering, Division of Rational Use of Energy. Of the respondents, 73% stated that the energy audit confirmed their earlier planning and intentions, while 62% said that they were not aware of the measures recommended before the audit
[139] Fleiter, T., Gruber, E., Eichhammer, W., Worrell, E. (2012). The German energy audit program for firms - a cost-effective way to improve energy efficiency? *Energy Efficiency*, 5(4), 447-46.
[140] Paramonova, S., Thollander, P. (2016). Energy-efficiency networks for SMEs: Learning from the Swedish experience. *Renewable and Sustainable Energy Reviews*, 65, 295-307.

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5.1.5. Recommendations adoption (based on energy audits)

Sometimes no measures recommended in the audits are implemented (not even partially) and often only a few of them and the cases of full respect (or almost full respect) of all the recommendations are rare. Conversely, some SMEs have implemented energy efficiency measures in the absence of audits[141]; even, in a study on 222 manufacturing SMEs in northern Italy, it was discovered that most of the implemented measures did not come from the energy audits[142].

Going more in details on this issue, based on our literature review, the following can be reported.

- According to the already mentioned EIB study, in the US, adoption rates of suggested measures by energy audits were close to 50% based on the data offered by the US Department of Energy's Industrial Assessment Centre; and in Australia, firms decide to take almost all (80%) measures identified as cost-effective by the audit[143].
- The energy audit programs in Germany[144] offered to SMEs and non-energy intensive industries, and in Sweden[145] were also considered successful, with estimated implementation rates at 77% and 40%, respectively (in the figures below the adoption rate according to the type of measure, first in Germany and later in Sweden).
- In Poland (2015) SMEs entrepreneurs "are declaring willingness to implement the majority of the recommended measures in the future (depending on the type – from 67% to 100%)"[146].

[141] Schleich, J., Fleiter, T. (2017). Effectiveness of energy audits in small business organizations. *Resource and Energy Economics*. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846
[142] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, 12(7), 1338.
[143] Kalantzis, F., Revoltella, D. (2019). Op. Cit.
[144] Fleiter, T., Schleich P., Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs – An empirical analysis based on energy audit data. *Energy Policy*, Elsevier, 51, pp.863-875. hal-00805748.
[145] Thollander, P., Danestig, M., Rohdin, P. (2007). Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs. Energy policy, 35(11), 5774-5783.
[146] Korczak, K. (2015). Op. Cit.

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Figure 4 - Distribution of adopted and non-adopted EEMs by end use

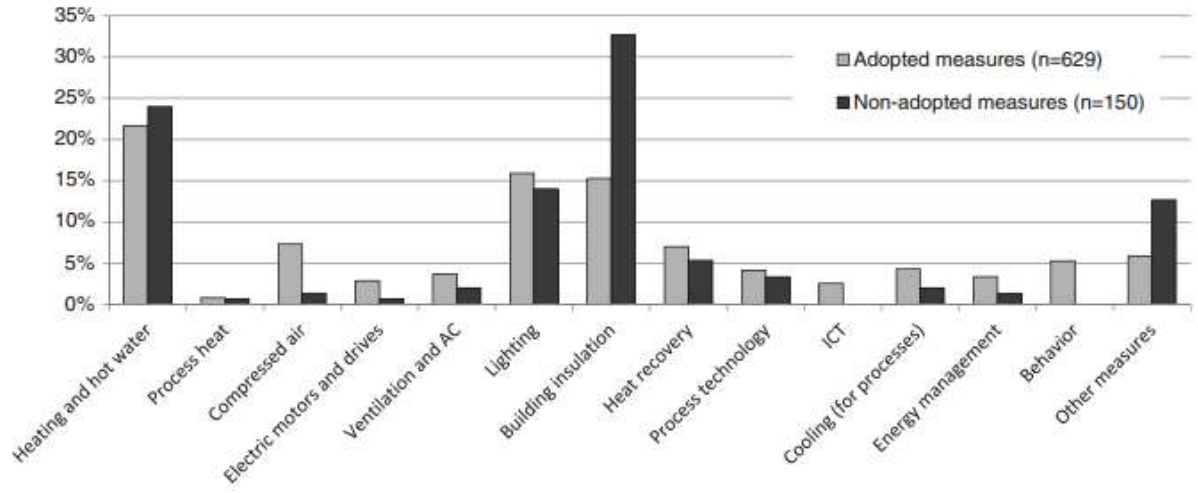
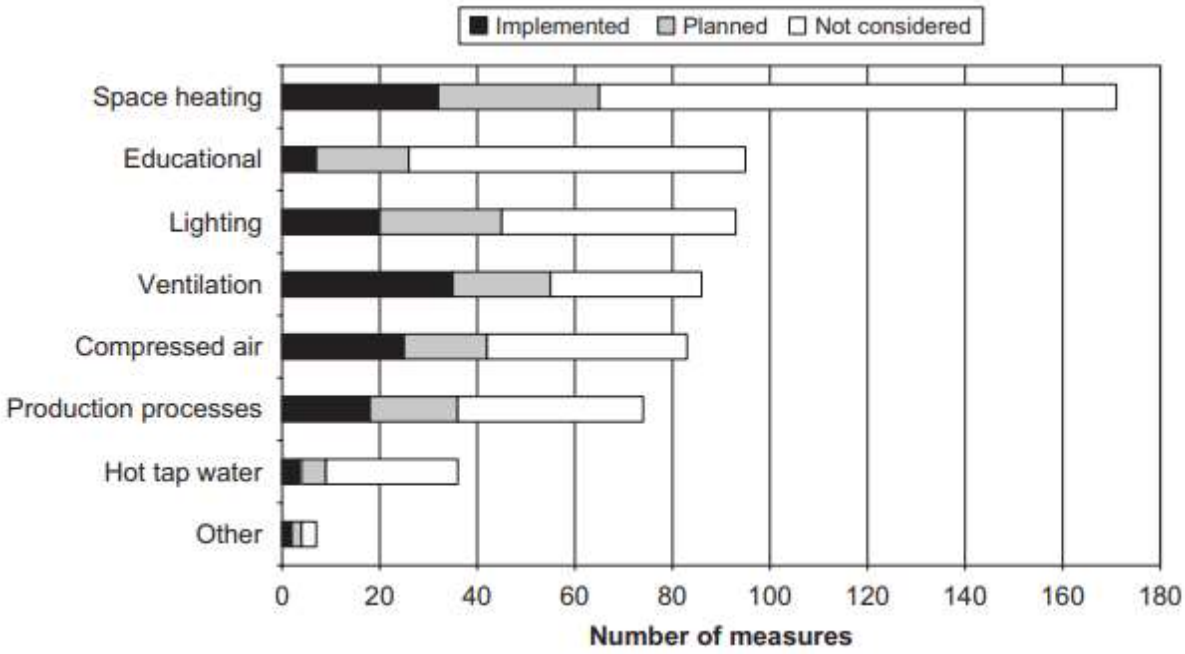


Figure 5 - Number of implemented, planned, and not considered measures for the different generic processes for the 47 evaluated firms within project Highland



The measures are usually implemented on a project basis. The limited implementation rate can be explained by the fact that often energy audits based on economic evaluation do not consider transaction costs and risks intrinsic to longer-lasting investments. Moreover, a focus on the economic perspective alone without considering behavioural aspects does not represent well the complexity of the real world[147].

[147] Paramonova, S., Thollander, P. (2016). Op. Cit.

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More details on this issue are in a study[148] published in 2002 implemented in the US that, however, we can consider meaningful also for the European SMEs today. The aforementioned adoption rate (in the US) of 50% is thus confirmed. However, the authors very correctly highlight that it is difficult to assess how many and which measures would have been implemented in the absence of an energy audit. They also point out how the adoption would be connected to the economic-financial characteristics of each measure to be adopted.

"We find that about half of the projects recommended by energy assessment teams are actually adopted by the plants receiving these recommendations, although we cannot say how many of these projects might have been adopted in the absence of the energy audit. We find that that firms respond as expected to marginal changes in the financial characteristics of projects (i.e., technology costs, energy prices, the quantity of energy saved, energy operating cost savings, and the payback period). Firms are about 40% more responsive to investment costs than to energy savings, suggesting that policies to reduce implementation costs may be somewhat more effective than various mechanisms that raise energy prices. Although the financial characteristics of projects are clearly important, there also appear to be other, unmeasured project-specific factors (e.g., individual project lifetimes, unmeasured costs and benefits, uncertainty regarding costs and benefits, or project complexity and risks) that influence the investment decision. Plant size has no measurable effect on the adoption decision among the small and medium-sized firms in our sample. We estimate that the investment threshold typically used by the plants in evaluating which energy audit recommendations to adopt was about a one to 2-year payback, which corresponds to an implicit hurdle rate of 50–100% for projects lasting 10 years or more. Finally, the reasons given by program participants for not adopting certain project recommendations suggest that most of these disregarded projects may have been economically undesirable. Many of these reasons hint at various unmeasured costs, project risks, and uncertainty that are unlikely to be reflected in estimated implementation costs and projected annual savings."

By classifying of EEMs into two groups – one requiring high managerial attention and one requiring low managerial attention – it was observed that the adoption rate is significantly lower for the former group. The adoption of EEMs seems to increase (Dutch data) with firm size, family size, solvency, modernity of machinery and when the firm owner has a successor. Uncertainty about future energy prices increases the obstacles and lowers the adoption rate (e.g., SMEs consider that it may be best to postpone irreversible investments in energy efficiency if future economic conditions are uncertain)[149].

Arguably, the ability to follow up on energy audit recommendations is more robust for larger organizations because they have better in-house knowledge and the financial resources needed to implement an audit's investment recommendations. However, the impact of this interaction between organization size and audit effectiveness appears to vary by measure. For the four cross-cutting measures considered the adoption of lighting, insulation, heating systems, and operational measures to improve heating systems no evidence have been found supporting the hypothesis that energy audits are less effective for larger organizations[150].

[148] Newell, R., Anderson, S. (2002). Information Programs for Technology Adoption: The Case of Energy-Efficiency Audits (No. dp-02-58).
[149] Fleiter, T., Schleich P., Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs - An empirical analysis based on energy audit data. *Energy Policy*, Elsevier, 51, pp.863-875. hal-00805748
[150] Schleich, J., Fleiter, T. (2017). Op. Cit.

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Apparently, the quality of the energy audits (measured by satisfaction with the audits) affects the adoption of EEMs[151]. Going more in-depth, a study based on the United States experience (but the contents can be considered reliable also for European SMEs) analyses the relations among some "quality features" of the energy audit recommendation and their adoption, taking into account 5 hypotheses[152], listed below.

- Hypothesis 1a: Recommendations which occur earlier (i.e., in the first pages) in the report drafted on the basis of the energy audit will have higher adoption rates than recommendations which occur later in a report. Partially confirmed.
- Hypothesis 1b: Recommendations which have shorter payback (or lower cost or higher saving of money) than the first recommendation in that assessment are more likely to be implemented: Confirmed.
- Hypothesis 2: Adoption rates of individual recommendations will fall as more recommendations are made in the same assessment: Not supported by empirical evidence.
- Hypothesis 3: Adoption rates are lower for recommendations that need high managerial attention: Confirmed.
- Hypothesis 4: There is evidence that adoption rates are higher for assessments done in the 1st quarters compared to the 4th quarter. This suggests that the IAC program may enhance adoption rates by trying to concentrate assessments earlier in the firm's budget year. Partially confirmed.

Finally, "higher energy prices improve the rate of return and shorten payback times for investments in energy efficiency, and thus they tend to be associated with higher adoption rates[153]".

[151] Fleiter, T., Schleich P., Ravivanpong, P. (2012). Op. Cit. A further source Kluczek, A., Olszewski, P. (2017). Energy audits in industrial processes. Journal of cleaner production, 142, 3437-3453), at this regard, states that energy auditors' competences are crucial.

[152] Muthulingam, S., Corbett, C.J., Benartzi, S., Oppenheim, B. (2011). Investment in Energy Efficiency by Small and Medium-Sized Firms: An Empirical Analysis of the Adoption of Process Improvement Recommendations. Available at: https://escholarship.org/uc/item/6545t5bf

[153] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs; *Energy efficiency investment* (No. 2019/02).EIB Working Papers.

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5.2. Internal and external barriers in the energy efficiency/management improvement process in SMEs

As we have seen, only a minority of SMEs implemented or is implementing measures for improving energy efficiency or, in a broad sense, its energy management (based on the results/recommendations of an energy audit or independently). Many factors influence this process: barriers (that hinder) and drivers and/or facilitating factors (that help). Both are multiple. This Paragraph is dedicated to the barriers and the following one to the drivers and facilitating factors.

5.2.1. What is a barrier?

According to the United Nation agency working on industrial development (UNIDO):

"A 'barrier' was defined as a mechanism that inhibits a decision or behaviour that appears both energy and economically efficient. This term is widely used within the energy efficiency literature, but there is no consensus on how barriers should be understood, how important they are in different contexts, and how (if at all) they should be addressed. This makes barriers the subject of disciplinary disputes within academia and more fundamental conflicts within the politics of climate change. There is a distinction between barriers and orthodox market failures and a recognition that some barriers may provide no grounds for policy intervention while others may prove too costly to overcome[154]".

We can add that:

"A barrier is defined as 'a postulated mechanism that inhibits investment in technologies that are both energy efficient and (apparently) economically efficient', without the necessity that one or more other barriers occur[155]".

And therefore, the barriers should be reduced to the lowest independent denominator, reaching a high level of detail, presenting elements that might occur autonomously (preventing overlapping and interactions).

Barriers are real, in the sense that there are objective factors that can be directly observed; but they can also only be perceived, in the sense that they are considered as such even if perhaps the situation is different. Both of them influence the adoption of energy efficiency

[154] Sorrell, S., Mallett, A., Nye, S. (2011). Barriers to industrial energy efficiency: A literature review. UNIDO. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846
[155] Cagno, E., Worrell, E., Trianni, A., Pugliese, G. (2013). A novel approach for barriers to industrial energy efficiency. *Renewable and Sustainable Energy Reviews*, 19, 290-308.

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measures in the firms. A simple example: the absence of tax benefits connected to specific improvements in energy efficiency can be real (in the sense that, in a given territory, actually, there are no tax benefits) or simply connected to an absence of information in this regard. The result is the same (the manager of an SME puts no effort in this matter as he/she believes that there is no such an opportunity) while the barriers are different and any solution to overcome them will be equally different. In the literature, both kinds of barriers are taken into account. However, there can be "a misalignment between perceived and real barriers in SMEs[156]".

Therefore,

"The barrier approach could benefit from, for example, in-depth studies of what energy efficiency discourse is like in a company, i.e., how employees talk about energy efficiency and how the discourse relates to environmental issues and cost allocations in regard to energy efficiency measures (how barriers are valued by the actors, and it is possible to problematize the grounds on which these barriers exist)[157]".

The distinction between real barriers and perceived barriers is made more complex when distinctions are made among the different types of barriers. For example, Cooremans identifies distinguishes the barriers identifying four levels.

"**'Base' barrier**. First-level barrier concerns information, or rather, the lack of knowledge regarding energy efficiency measures, as well as regarding their technical and financial aspects. Lack of knowledge is a general problem in firms without energy management, but it may also be a problem in firms which do manage energy where it arises from the complexity of energy-efficiency measures, at least in very large buildings, which requires multidisciplinary skills. Although this is an important barrier, it is not sufficient to explain firms' negative decisions regarding energy-efficiency investments.
'Symptom' barriers. These are designated as such because they express signs of deeper, invisible problems, or of mistaken interpretations. For instance, capital is not lacking but is allocated to other investments; risk is said to be high, when in fact it is not even assessed. Hidden costs, which are commonly said to lower energy-efficiency investments profitability, are an easy explanation, especially since they cannot, by definition, be assessed in precise figures.
'Real' barrier. The third level is the invisible problem at the source of second-level symptoms. It is the real obstacle to energy-efficiency investments: Their non low strategic character for companies, which consider energy or energy use neither as a contributor to their competitive advantage nor as a critical resource, for the risks to the security of energy supply are ignored. Indirect benefits of energy management, which can in many cases increase strategicity, are poorly understood or included in investment assessments.
'Hidden' barrier. The fourth level comprises the various cultural influences which drive organizations and their decision makers to consider energy-efficiency investments as weakly

[156] Johansson, M.T., Thollander, P. (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry-recommendations for successful in-house energy management. *Renewable and Sustainable Energy Reviews*, 82, 618-628.
[157] Palm, J., Thollander, P. (2010). An interdisciplinary perspective on industrial energy efficiency. *Applied Energy*, 87(10), 3255-3261.

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strategic, beyond possible objective reasons. It is "hidden" because it influences an organizations' behaviour and investment choices in a subconscious way[158]."

Finally, it has been noted that "literature review proves that concerning the energy savings in industrial enterprises, there is a huge gap between scientific approaches to the issue and common industrial reality[159]".

5.2.2. Which barriers? Examples, lists and classifications

Many studies on barriers to enterprises energy efficiency were implemented in the last years, as reported by Trianni et al.[160] (see Appendix).

Many studies report lists and classifications of the barriers SMEs face or may face in pursuing greater energy efficiency, in improving energy management or, more generally, in developing eco-innovations including sustainability actions.

Some of them report only a few barriers, such in the case of those mentioned by Eurochamber[161]: "Greatest obstacles to invest in energy efficiency measures: 1. Lack of financing resources; 2. Lack of time to analyse potentials; 3. Lack of information/ knowledge".

However, other studies report long lists of barriers classified based on many criteria.

One of the oldest, among these studies – that by Sorrel et al. and published in 2004 –proposes a taxonomy of barriers based on six broad categories[162].

1. Imperfect information[163], which includes transaction costs (e.g., search costs) for identifying the energy consumption of products and services.
2. Hidden costs, which include the overhead costs for management, the transaction costs associated with gathering, analyzing and applying information, the costs associated with disruptions to production, or with staff replacement and training.

[158] Cooremans, C. (2012). Investment in energy efficiency: do the characteristics of investments matter? *Energy Efficiency*, 5(4), 497-518.

[159] Máša, V., Stehlík, P., Touš, M., Vondra, M. (2018). Key pillars of successful energy saving projects in small and medium industrial enterprises. *Energy*, 158, 293-304.

[160] Trianni, A., Cagno, E., Farné, S. (2016). Barriers, drivers and decision-making process for industrial energy efficiency: A broad study among manufacturing small and medium-sized enterprises. *Applied Energy*, *162*, 1537-1551.

[161] Eurochamber (2017). National Support Schemes for Energy Audits and Energy Management Systems as required by Art. 8/2 of the Energy Efficiency Directive (2012/27/EU

2. [162] Sorrell, S., Schleich, J., O'Malley, E., Scott, S. (2004). The Economics of Energy Efficiency: Barriers to Cost-Effective Investment. Available at: https://www.researchgate.net/publication/43185108_The_Economics_of_Energy_Efficiency_Barriers_to_Cost-Effective_Investment

[163] 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 (cfr. Henriques, J., Catarino, J. (2016). Motivating towards energy efficiency in small and medium enterprises. *Journal of Cleaner Production*, 139, 42-50).

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3. Risk, which captures the technical risks of energy-efficient technologies as well as the financial risks associated with irreversible investments and the uncertainty about the returns[164] of EEMs (e.g., because future energy prices are uncertain).
4. Access to capital, which includes lack of external and internal funds for energy-efficiency investments. In the case of external funds, the costs to assess the risks associated with the investor (e.g., small EEMs) or the technology might be too high. Internal funds may be inhibited by internal capital budgeting procedures, investment appraisal rules, or the short-term incentives of energy management staff.
5. Split incentives, which imply that the investor in EEMs cannot fully appropriate the benefits (e.g., landlord-tenant or user-investor problem).
6. Bounded rationality, which means that constraints on time, attention, and the ability to process information prevent individuals from making "rational" decisions in complex decision problems. Rather than optimizing, they use heuristics and rules of thumb to decide on investments in EEMs.

As underlined by Fleiter et al., that, few years later (2012)[165], commented the taxonomy above, these categories "may overlap, co-exist and interact, and a phenomenon may fall under more than one barrier category".

A second taxonomy[166], based on broad criteria, was suggested by the CHANGE project[167] in 2010.

"Energy expertise: lacking in smaller companies. While companies of all sizes and sectors are aware of the importance and benefits of energy efficiency, small companies in particular often do not have the capacity to allocate the responsibility of energy issues to one member of staff. Thus, more information has to be targeted at SMEs and sector specific information has to be easily available.
Cost savings: main incentive for energy efficiency Companies across all sectors are taking energy efficiency measures, mainly related to staff and non-technology specific, and not requiring large up-front investment. The cost reduction potential was rated as the most important reason for energy efficiency. The financial benefits of this relatively accessible and inexpensive measure must be conveyed more effectively to businesses.
Financial factors: main obstacles to investments in energy efficiency Own resources and traditional forms of funding, such as bank loans, are the most common sources. Besides the effects of the economic climate, lack of knowledge or awareness seem to constrain the use of other forms of funding, such as energy contracting.

[164] The acceptable length of a return period vary: e.g., 3 years or less for energy efficiency investments in Sweden, which can be compared with a general pay-off period of 4.1 years in a study of German industries; Thollander, P., Ottosson, M. (2010). Energy management practices in Swedish energy-intensive industries. *Journal of Cleaner Production*, 18(12), 1125-1133
[165] Fleiter, T., Schleich P., Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs - An empirical analysis based on energy audit data. *Energy Policy*, 51, pp.863-875.hal-00805748.
[166] Change (2010). Energy Efficiency in SMEs: Success Factors and Obstacles. Available at: https://drive.google.com/drive/folders/1HUXUybF-caQ6EkpF-ylbeFu3fU1MDkWu
[167] The CHANGE project helps SMEs optimise their energy use by developing a European network of Intelligent Energy advisors at Chambers of Commerce and Industry and by kick-starting/enhancing concrete assistance to SMEs. The project builds on the traditional role of Chambers as "first port of call" for SMEs.

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More information on these options and their benefits must be provided. Though companies are implementing soft measures and investing in infrastructure or processes to become more energy efficient, further measures are needed if the EU is to reach its 2020 goal to increase energy efficiency by 20%."

Three out of four suggested categories (cost saving, financial factors, lack of information) were mentioned (with other words) also in the taxonomy developed by Sorrel et al., while the fourth one (the lack of "energy expertise" in SMEs) is not. This latter is an issue taken up by several other studies. Cagno, Trianni et al.[168], for example, which (beyond the mention of the financial aspects) develop it in detail.

"An SME does not own an internal structure able to be focused on energy consumptions, and even it does not have the chance to. In SMEs, it is quite diffused that the entrepreneur has to cover several different roles: operations, safety, administration, sales, marketing, planning, and he/she may also be employed within the factory. Briefly, energy is just one of the issues, there is not a specified focus on it.
Consequently, to point 1, the time devoted to energy efficiency activities is usually quite limited.
Compared to LEs, SMEs have limited access to the know-how of energy efficiency management and practices, easily represented by much more limited economic resources devoted to energy efficiency analyses and measures.
There is a strong financial barrier, identified in several studies: usually, pay- back-times (PBTs) of more than 2–3 years are considered, as prohibitive for SMEs, while generally LEs can afford investments for even more than 8–10 years."

A similar is proposed more recently by Baranova[169]. In this case too, funds/financial/cost issues, as well as the lack of energy expertise are mentioned. However, a further barrier is introduced, i.e., the lack of clear advice from the government and other bodies.

"The major barriers to improving energy efficiency were identified as:

- *lack of funding and finance;*
- *the initial costs of efficiency measures being too high;*
- *lack of clear advice from the Government and other bodies;*
- *lack of specialist expertise/capacity to undertake the measures and finally;*
- *perception that the Return of Investment for energy efficiency initiatives was not high enough for the key decision-makers."*

Cagno and Trianni, together with other authors, developed a few years later (2013) a much more detailed typology for what concerns both the barriers considered and the number of categories in which they are classified. This is perhaps the most detailed typology that has been found in the field of the literature review[170]. These categories are, in turn, grouped into

[168] Cagno, E., Trucco, P., Trianni, A., Sala, G. (2010). Quick-E-scan: A methodology for the energy scan of SMEs. *Energy*, 35(5), 1916-1926.
[169] Baranova, P. (2017). Environmental capability of SMEs: Capability building towards a low carbon economy.
[170] Cagno, E., Worrell, E., Trianni, A., Pugliese, G. (2013). A novel approach for barriers to industrial energy efficiency. *Renewable and Sustainable Energy Reviews*, 19, 290-308.

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two groups: the internal barriers (hindering factors that refer to the SME) and the external barriers (hinder factors that refer to the SME's environment). The list is reported below.

External (with respect to the firm) barriers

- Market
  - Energy prices distortion (Hirst and Brown): energy prices do not account for externalities, for example having variations during the day.
  - Low diffusion of technologies
  - Low diffusion of information
  - Market risks
  - Difficulty in gathering external skills

- Government/Politics
  - Lack of proper regulation: the lack of standards or classes for energy performance
  - Distortion in fiscal policies

- Technology/services suppliers
  - Lack of interest in energy efficiency
  - Technology/services suppliers not up to date
  - Scarce communication skills

- Design and manufacturers
  - Technical characteristics not adequate
  - High initial costs[171]
  - Energy suppliers
  - Scarce communication skills
  - Energy price distortion
  - Lack of interest in energy efficiency

- Capital suppliers
  - Costs to investigate debt carrying capability
  - Difficulty to identify the quality of investments

[171] In this regard, "Whereas some measures such as replacing halogen bulbs with LEDs before the end of their useful life may be justified on the basis of radically reduced energy costs, the net impact of funding for other equipment is more contentious. The energy impact of replacing motors, drives and refrigeration equipment for example, depends on the efficiency of existing machinery and the intended use of new and old units" (Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy).

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The internal (with respect to the firm) barriers:

- Economic barriers
  - Low capital availability
  - Hidden costs (pre or post intervention)
  - Intervention related risks

- Behavioural barriers
  - Lack of interest in energy efficiency
  - Other priorities
  - *Intertia*
  - Imperfect evaluation criteria
  - Lack of sharing the objectives

- Organizational barriers
  - Low status of energy efficiency
  - Split incentives
  - Complex decision chain
  - Lack of time
  - Lack of internal control

- Barriers related to competences
  - Identifying the inefficiencies
  - Identifying the opportunities
  - Implementing the interventions

- Awareness
  - Lack of awareness (or ignorance)

Mixing the internal and external barriers – aim to make the taxonomy a useful tool for the empirical research – they added two more categories:

- Technology related barriers

- Information barriers (gathering all the external barriers related to the information flow)
  - Lack of information on costs and benefits
  - Unclear information by technology suppliers
  - Trustworthiness of the information source
  - Information issues on energy contracts

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Also Špacapan[172] dwell upon a list of barriers on a SME's way to energy efficiency, including these listed below.

- The role of ownership structure.
- Loose enforcement of government regulations, and lack of government support.
- Lack of properly skilled labour.
- In some industries, energy costs typically represent a small fraction of the total cost of production, so energy costs receive relatively little attention.
- Obtaining energy consumption data and a complete overview of the entire energy system in individual companies can take up a lot of time and effort.
- Mentality – matters of energy efficiency are nor perceived as an opportunity but as a burden.
- SMEs often do not have sufficient financial or human resources to take a more active role in improving their energy efficiency.
- Small size of the company.
- Management is focused on the quality and good positioning of products on the market.
- Limited costs for energy education of employees.
- The share of energy costs is small relative to other costs.
- Focus only on production.
- No environmental awareness.
- Other investments take precedence over energy investments.

We can conclude this section considering what reported in two studies developed by two international organisations very engaged on these issues: European Commission and UNIDO.

Both mentioned a limited number of barriers "organised" in three or four large categories. The European Commission[173] considers categories already mentioned (e.g., "limited organisational capacity" and "restricted financial capacity") adding two other issues: the restricted relevance of energy demand, common to most SMEs, with the exception of course, of the "energy-intensive" ones; the fact that decision-making, in most SMEs is centred on one or few persons – and these persons can be not aware, have other priorities, etc.

"Relevance of energy demand: In general, the energy demand of an SME is lower than the demand of a large company with similar products. Even though the energy costs might be important for the overall expenditure of the SME, the absolute level of energy costs is generally lower than in the larger company. Due to this comparatively low value, the energy saving potentials both in terms of energy and money saved tend to be less important for SMEs. In turn, the attractiveness of decreasing energy demand is lower. Furthermore, economies of scale for dealing with energy efficiency are smaller as compared to large companies. For instance, a large company might need a certain level of effort to acquire knowledge on how to improve ten of its furnaces while the SME will need much the same effort to improve its single furnace.

[172] Špacapan, F. (2015). Graduation thesis: energy management and efficient use of energy in companies. Available at: http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf
[173] European Commission (2015). The EU Eco-Management and Audit Scheme (EMAS). Available at: https://ec.europa.eu/environment/emas/emas_publications/publications_studies_en.htm

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Limited organisational capacity: SMEs often do not have personnel that are focused on energy efficiency, whereas large organisations tend to employ skilled and dedicated personnel for this task. Driving energy efficiency therefore often depends on individuals with high ambition in the field. Information-related barriers are generally more prevalent in smaller organisations because SMEs tend to have less experience with energy-related matters than large companies. Thus, it becomes more difficult for them to obtain and process the information on energy-efficient technologies and saving measures, or to launch-related activities.
Restricted financial capacity: SMEs often have stronger restrictions on the availability of budget for energy-related activities or may have other investment priorities. Thus, assuring the finance for undertaking an energy audit and implementing its recommendations becomes more challenging than for large companies.
Organisational decision-making: Generally, planning processes tend to be based on less rigorous strategic approaches in smaller organisations. Due to the centralised decision-making processes, the responsibility for decision-making is often limited to a few persons or an individual, e.g., the owner of the company. Thus, improvements in energy efficiency can actually be more quickly implemented than in larger organisations, where split-incentives and more sophisticated organisational structures may slow down implementation processes. The particular challenge in SMEs is thus to convince individual decision-makers of the benefits of improving energy efficiency with credible information. It has also been observed that SMEs tend to accept longer payback times for investments than large companies. That means that economic myopia is not necessarily as strong in privately owned SMEs as in larger organisations that are mainly benchmarked by external shareholders."

UNIDO[174] underlines three categories already mentioned in other studies ("hidden costs", "imperfect information" and "access to capital/split incentives"), adding another category pertaining to the risk related to energy efficient investments. The four categories are shown in the table below, including the perspectives of "Orthodox and agency" and "Transaction costs and behavioural".

5.2.3. Barriers related to some SMEs features

By looking at SMEs size, we could appreciate substantial differences between the Small and Medium ones. According to Trianni, Cagno et al.[175] "barriers perceived by SMEs may differ significantly", underlying, more specifically, the major difficulties of the smaller SMEs.

> *"Smaller enterprises highlighted greater barriers, in particular related to the lack of personnel and expertise regarding energy efficiency issues greater awareness barriers in non-energy-intensive enterprises (they limit their focus strictly on production- related issues); smaller enterprises that highlighted major difficulties in the effective implementation of an intervention (lack of expertise and competences)[176]."*

[174] Sorrell, S., Mallett, A., Nye, S. (2011). Barriers to industrial energy efficiency: A literature review. UNIDO. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846
[175] Trianni, A., Cagno, E., Thollander, P., Backlund, S. (2013). Op. Cit.
[176] Trianni, A., Cagno, E., Farnè, S. (2014). An empirical investigation of barriers, drivers and practices for energy efficiency in primary metals manufacturing SMEs. *Energy Procedia*, 61, 1252-1255.

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Conversely, according to these same authors[177], beyond the real ones, smaller SMEs tend to have a lower perception of barriers:

> *"Medium-sized companies showed a more pronounced perception of barriers compared to smaller ones. A higher level of market innovation reduced the barriers significantly and more innovative enterprises faced fewer barriers related to technology, external risks and lack of information".*

However, this statement is not shared by everybody. According to Thollander et al.[178],

> *"barriers are perceived as higher by small enterprises, and by companies with lower production complexity and lower innovativeness".*

According to Trianni and Thollander[179], differences according to size can be important as shown in the figure below (with regard to foundries). In the figure below, without going into the details of each specific barrier, it can be seen that the histogram of small enterprises is significantly different from that of medium ones (and also that of large enterprises, which are not considered in this literature review).

[177] Trianni, A., Cagno, E., Worrell, E. (2013). Innovation and adoption of energy efficient technologies: An exploratory analysis of Italian primary metal manufacturing SMEs. *Energy Policy* 2013, 61, 430–440. In this same study, the authors highlight that "problems affecting SMEs ("operational" barriers), reveals that the barriers lack of time and lack of internal capital are more pronounced in-smaller firms (up to 100 employees) than in larger firms (100 to 250 employees. Then, they highlight the importance of considering firm-specific factors".

[178] Johansson, M.T., Thollander, P. (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry–recommendations for successful in-house energy management. *Renewable and Sustainable Energy Reviews*, 82, 618-628.

[179] Trianni, A., Cagno, E., Thollander, P., Backlund, S. (2013). Op. Cit.

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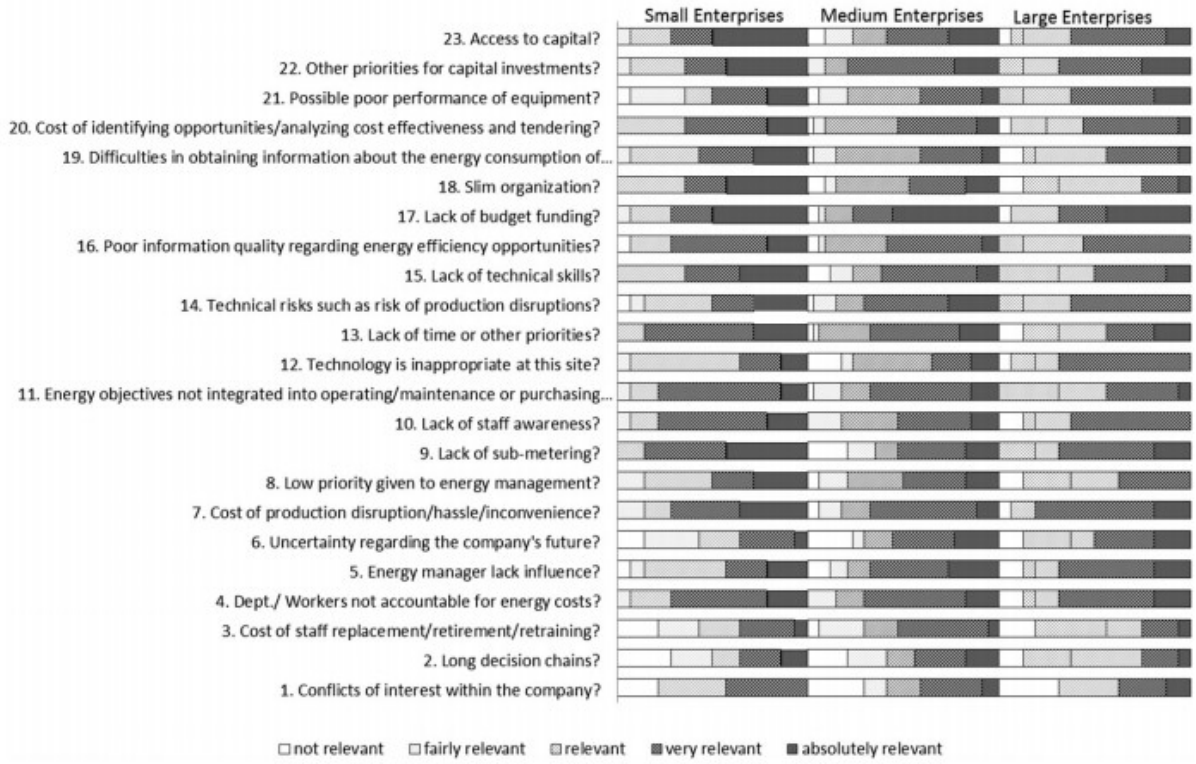
Figure 6 - Perceived barriers e by firm's size e frequency of responses



Barriers are also linked to the nature of a specific measure.

> *"Large differences were found when considering barriers to specific energy-efficient technologies. Compressed air and HVAC system (i.e., heating, ventilation, and air conditioning) measures presented higher barriers regarding investment costs, reliable information sources and hidden costs*[180]*."*

Green SMEs (i.e., SMEs that adopt green processes and/or those producing green goods using green production inputs) too (of course) meet important barriers[181]. Most of them are similar to the ones already mentioned above. Some specific barriers can be anyhow reported such as the limited green financing products across enterprise life cycles (i.e., early stage) or linked to opportunities (i.e., energy efficiency).

> *"Common barriers to SME finance (small volumes, high transaction costs, collateral issues, risk profiles) can be compounded for green SMEs:*

[180] Johansson, M.T., Thollander, P. (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry–recommendations for successful in-house energy management. Renewable and Sustainable Energy Reviews, 82, 618-628.

[181] Robins, N. (2017). Mobilizing Green Finance for SMEs in the G7. Available at: https://www.minambiente.it/sites/default/files/archivio/allegati/sviluppo_sostenibile/G7_egf_SMEs_all_presentations_venezia05042017.pdf (accessed 29 July 2019). Robins adds that "More than a quarter of EU SMEs report that they encounter difficulties in accessing financing for circular economy activities. Two key financing priorities emerging: I. Green Performers: unlocking finance for conventional SMEs to improve their sustainability performance. II. Green Innovators: allocating finance for SMEs who are focused on expanding sales of green goods and services."

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- *Data: a lack of robust data on the green financing needs of SMEs among banks and other financial institutions.*
- *Risk: incomplete integration of environmental performance into the assessment of risks facing SME funding decisions.*
- *Product: limited green financing products across enterprise life cycles (i.e., early stage), or linked to opportunities (i.e., energy efficiency).*
- *Institutional: insufficient diversity of financial institutions offering long-term patient capital for the green finance needs of SMEs.*
- *Awareness and Capacity: low awareness of cost-saving potential of green investments, lacking technical capacity and financial literacy".*

5.2.4. Some recapitulative remarks on barriers hindering SMEs

In the next sub-paragraph, we will open a specific "window" on barriers that hinder the energy efficiency/management improvement process in SMEs in the various countries documented by the literature review we have implemented.

However, before going forward, it could be useful to make a few remarks about the barriers hindering SMEs.

I – Dozens or perhaps more than a hundred barriers have been identified; in some cases, it is the same phenomenon called differently; often then, the barriers are grouped into different, partially overlapping categories.

II – The fact remains that the barriers are numerous or of many types. Rereading the lists and rankings presented in the previous paragraph, we get the impression that the barriers are connected to:

- The lack of funds and/or access to finance
- The fear of facing unnecessary costs (and the so-called "hidden costs")
- The lack of internal (in the SME) human resources or the lack of appropriate skills among the human resources present
- The difficulty of using external human resources
- The internal lack of time
- The emergence of more urgent priorities
- The plurality of interests (perhaps divergent) and points of view and, more generally the malfunctions in decision-making processes
- organizational deficiencies
- The lack of sensitivity to environmental issues
- The lack or inadequacy of technical resources
- The difficulty of planning in the medium and long term
- The lack of trust (in the market; in other interlocutors; in the announced future benefits; in the future. etc.)
- The lack of subsidies and incentives or their lack of knowledge
- Legislative and/or regulatory difficulties
- The lack of information and its imperfections.

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III – The barriers are so numerous and diverse mainly because the various and multiple contexts in which the SMEs operate are very complex (in their various aspects).

IV – It must also be considered that it is not a single barrier in itself that hinders the start or strengthening of an improvement process. Every SME, every entrepreneur, in reality, is always faced with a multiplicity of barriers, of which one barrier alone would not be decisive. What is decisive, instead, is the "accumulation" of the many barriers that, more or less at the same time, the entrepreneur is facing. This mechanism is similar to that at the basis of social exclusion which derives from the simultaneous presence, in the life of an individual, of multiple difficulties (e.g., in accessing work, credit, health services, educational and social services, transportation facilities, and so on). The small entrepreneur, because of the multifold barriers, despite being some barrier connected to one's will is almost a sort of "excluded" from the possibility of improving the management of the energy issue in his own business and therefore of achieving important economic and non-economic benefits, for himself, for his company and for the world he lives in (most of the barriers, not only the external ones but also some of the internal ones are connected to the economic, financial and social environment in which one operates).

V – Barriers might also persistent and remain also after the energy audits even when they are unequivocally convenient for the SME (for the entrepreneur) and also in the short term. Often, de facto, "the positive impact of energy audits on the implementation of energy-efficiency measures ceases to exist in the presence of financial constraints, especially for smaller firms. This indicates that not only information barriers but also financial constraints (as well as many others as seen in the previous pages) discourage firms from investing in energy-efficiency measures[182]".

VI – The barriers are so numerous also because the world of SMEs is quantitatively huge and qualitatively extremely differentiated. "Barriers are often idiosyncratic to the particular situation of the business (e.g., its staff, premises, organisational characteristics, and financial situation). It is evident that each business experiences a unique combination of barriers, even though operating in the same industry and the same geographic location[183]". Therefore, each SME has to face individual barriers. Hence, the range of barriers differs from one SME to another.

Unfortunately, however:

> *"Academic literature has treated SMEs, with respect to the barriers to energy efficiency, as a homogenous group, which is not correct. In particular, several differences can be identified in an organizational perspective, with small enterprises suffering for example a lack of specific personnel dedicated to researching energy efficiency and*

[182] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs, *Energy efficiency investment* (No. 2019/02).EIB Working Papers. This phenomenon concerns mainly SMEs in the construction sector, which consists mainly of small firms

[183] Meath, C., Linnenluecke, M., Griffiths, A., Barriers and motivators to the adoption of energy savings measures for SMEs: The case of the ClimateSmart Business Cluster Program, Journal of Cleaner Production (2015), doi: 10.1016/j.jclepro.2015.08.085

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opportunities[184]. Or, in other words, "SMEs, just for their structure – small and medium – do present a variety of situations (in terms of technologies and processes adopted) much more extended with respect to LEs[185]".

5.2.5. Barriers: Specificities per territorial areas

In this paragraph, taking inspiration from a group of studies, we will try to outline the situation of the barriers to energy efficiency in some European countries and a few non-European countries for which the literature review provided some relevant information. It is worth noticing that there are not many differences between the profiles (of barriers) across the various countries. Apart from some specific cases, the barriers faced by SMEs tend to be mostly the same everywhere.

In case specific differences are reported in a country (such as in China, Poland, Slovenia and Turkey), they will be duly highlighted.

Australia

Barriers in Australia are specified among others in a Meath et al. study[186].

Table 5 - Barriers by theme, according the interviewees

Barriers	Number of times recorded in the Final Report for each cluster	Percentage of respondents to experience barrier[1]	Theme
Cost prohibitive (even if ROI in less than 24 months)	14	33	Financial 33%
Waiting for access to funds through organisational process	2	5	Management / Organisational characteristics 49%
Lack of time / staff commitments in other areas (OH&S)	9	21	
Waiting for head office to drive and fund changes	1	2	
Intention of selling business	3	7	
General low morale of businesses, for example tough economic times	5	12	
Change in management	1	2	

[184] Trianni, A., Cagno, E., Thollander, P., Backlund, S. (2013). Barriers to industrial energy efficiency in foundries: a European comparison. *Journal of Cleaner Production*, 40, 161-176

[185] Cagno, E., Trucco, P., Trianni, A., Sala, G. (2010). Quick-E-scan: A methodology for the energy scan of SMEs. *Energy*, 35(5), 1916-1926.

[186] Meath, C., Linnenluecke, M., Griffiths, A., (2015). Barriers and motivators to the adoption of energy savings measures for SMEs: The case of the Climate Smart Business Cluster Program, *Journal of Cleaner Production*, doi: 10.1016/j.jclepro.2015.08.085

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Barriers	Number of times recorded in the Final Report for each cluster	Percentage of respondents to experience barrier[1]	Theme
Renting premises - unable to control temperature of air-conditioner (multiple retail outlets in one building)	1	2	Premises 37%
Renting premises – unable to make physical changes to premise	7	16	
Renting premises - unable to obtain information from landlords controlling electricity accounts (electricity on-sell arrangements)	6	14	
Owning or renting premises - waiting for large scale refurbishment / renovation	2	5	
Lack of "sustainability champion" / skilled staff member responsible for driving changes	1	2	Staff 35%
Lack of staff engagement or negative attitude from staff towards change	14	33	
Total	66	Does not add up to 100% as some SMEs experienced multiple barriers	

1 Out of 43 businesses which reported 66 barriers

China

(I)

"The survey data (a survey of 480 SMEs in Zhejiang province) suggest (…) that informational barriers are the core bottleneck inhibiting energy efficiency improvements in China's SME sector. Financial and organizational barriers also influence a company's energy saving activities. Three additional barriers to energy saving activities: the role of family ownership structures, lax enforcement of government regulations and the absence of government support as well as a lack of skilled labour. More than 40% of enterprises in the sample declared themselves unaware of energy saving equipment or practices in their respective business area, indicating that there are high transaction costs for SMEs to gather, assess, and apply information about energy saving potentials and relevant technologies[187]."

[187] Kostka, G., Moslener, U., Andreas, J. (2013). Barriers to increasing energy efficiency: evidence from small-and medium-sized enterprises in China. *Journal of Cleaner Production* Volume 57, 15 October 2013, Pages 59-68.

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(II)

According to another survey across 263 manufacturing firms "SMEs find it harder to receive loans from banks and face higher technology risks than larger companies" and this same source[188] mentions "11 financial key barriers, e.g., insufficient fiscal incentives, inadequate energy market trading mechanisms and low priority of energy savings".

Three peculiarities on SME's barriers in China should be noted:

- The role of family ownership structures
- Lax enforcement of government regulations and
- The absence of government support.

Germany

"Too high investment cost is the single most important reason for not adopting the recommended measures (important for more than 80% of respondents). Close to 80% mentioned 'other investments have higher priority' as an important reason. This reason however, overlaps with other barriers like financial or capacity constraints. Astonishingly, the high share of nearly 70% of respondents stated that the EEMs were not profitable, although the audits should only propose cost-effective measures with acceptable payback period. An explanation could be that firms have stricter expectations of profitability than the energy auditors do. Firms often consider measures with several years payback period as not profitable. If such high payback expectations represent, e.g., risk associated with energy price development, the non-adoption can still be justified on grounds of a rational decision; however, if the payback expectations are far more restrictive for EEMs than for other types of investments, they also classify as a barrier. Another explanation may be the existence of hidden costs (for implementation), which the auditors did not consider in their assessment and which make the EEM less attractive to the firm. The reason 'implementation too time-consuming' also indicates that for some EEM the implementation implies considerable transaction costs, which are probably not accounted for by the auditor. Also the answers 'recommendation not realistic' and 'recommendation technically impossible', which are ranked important by more than 30% of the respondents, indicate that the auditors and the firms' assessment of EEMs differ. The remaining reasons were perceived as less important. Interestingly, energy price uncertainty was mentioned by only 10% as a very important reason, whereas 30% regarded it as important and 30% as less important. This indicates that energy price uncertainty is not a primary reason, although a point of interest for most firms. Too-expensive external capital was mentioned by around 35% as an important factor … However, there are probably other factors as well. Reasons such as 'measures are not profitable', 'cancelled due to change in operation', or 'technically impossible', are typically not classified as barriers. However, the fact that firms perceive measures as technically impossible opens room for discussion, because this may be wrong and could be a result of a lack of know-how or high transaction costs. To summarize, typical barriers that persist after the audit are mostly related to financing (external capital too

[188] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, 12(7), 1338.

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expensive, too high investment costs). Other 'classical' barriers like 'implementation too time consuming' or 'insufficient know-how for implementation' only persist in a few cases, which indicate that the program helps to overcome many relevant barriers (in an older study, implemented in 1991) The most prevalent barriers for SMEs appear to be lack of capital, and for energy-intensive SMEs, also the technical risk of production interruption. In comparison, adopting EEMs in less energy-intensive SMEs is hampered in particular by lack of information and lack of staff time. These latter barriers could effectively be overcome by energy audits. High investment costs appear to impede the adoption of EEMs. Similarly, we find that lack of capital slows EEM adoption, primarily for larger investments. More specifically, the initial investment costs negatively affect the adoption rate[189]."

Italy

(I)

"Studying the non technical barriers to energy efficiency in the Italian market we found:

- ***Low priority/understanding of benefits;***
- ***Perception of lower rates of return for efficiency investments;***
- ***Poor confidence in the results of the diagnosis /feasibility studies (sometimes overestimated because of different mechanisms);***
- ***A number of factors (design, implementation, management, etc.) can influence the results of an intervention;***
- ***It is easier to assess the costs than the benefits of efficiency;***
- ***Difficulty assessing savings;***
- ***Rising energy prices and their effects are ignored;***
- ***Split incentive***
- ***Barriers inhibiting enterprises – especially in SMEs – from investing in EE include:***
- ***Lack of trust.***
- ***Energy efficiency not usually an investment priority.***
- ***Lack of suitable financing.***
- ***Lack of experience and visibility on business opportunity[190]."***

(II)

"The main brake for energy efficiency measures, recognized by as many as 2 SMEs on 3 is the excessive payback period. The second major obstacle, with a percentage of 36%, concerns the uncertainty of the regulatory framework, i.e., the difficulty in accurately implementing the obligations and incentive schemes, as well as the difficulty in implementing the discontinuity of the laws over the years. Other barriers but at a lower percentage concern the critical interaction with the production process and / or the purchasing process and the difficulty of access to capital, one's own and those of third parties[191]."

[189] Fleiter, T., Schleich P., Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs - An empirical analysis based on energy audit data. *Energy Policy*, Elsevier, 51, pp.863-875.hal-00805748.

[190] Forni, D. (2019). Stimulate energy efficiency in SMEs. Available at: http://blog.fire-italia.org/wp-content/uploads/2019/06/2019-06-EfficiencySMEs.rev1_.key.pdf

[191] Chiaroni, D., Salvio, M., Bazzocchi, F. (2016). Diagnosi energetica, primo passo verso un'industria 4.0 (Energy audit, a first step towards Industria 4.0), Energia Media Efficienza Energetica, paper 10/2016.

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(III)

"A survey among SMEs in the Italian manufacturing sector during an energy audit revealed a lack of capital as the single most important barrier as perceived by the respondents. This barrier is likely to be amplified by the current financial crisis… Lack of information about energy consumption and EEMs is ranked as the second most relevant barrier[192]."

Pakistan

"Barriers are the same (than in Europe ed.) but are exacerbated (e.g., disruption of the supply of electricity and natural gas and the necessity of use alternative source of energy like diesel generators that increase the product price)[193]."

Poland

(I)

"1. low investment opportunities, other priorities in the budget limits the expenditure possibilities of enterprises,
2. unwillingness to changes,
3. lack of technical skills,
4. lack of information on the benefits of energy efficiency,
5. low awareness of the staff,
6. fear of the hidden costs not included in investment plans,
7. lack of information on the energy efficiency of specific technologies,
8. lack of information on the possibility of improving energy efficiency[194]."

(II)

According to another source[195], focalized on barriers to pro-ecological activity in SMEs and based on a study implemented in 2015 (percentages are the SMEs affected):

- Limited access to external capital (including high costs of raising such capital) – 42 enterprises (76%)
- Financial risk, resulting from an increase in the costs of the core business – 38 enterprises (69%)
- Insufficient detailed knowledge of environmental investments (e.g., scale, technological solutions, rate of return and time of return) – 35 (63%)
- The inability to invest in rented properties (7%)

[192] Trianni, A., Cagno, E. (2012). Dealing with barriers to energy efficiency and SMEs: some empirical evidences. *Energy*, 37(1), 494-504 (quoted by Fleiter, T., Schleich P., Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs - An empirical analysis based on energy audit data. *Energy Policy*, Elsevier, 51, pp.863-875.hal-00805748.)

[193] Hassan, M.T., Burek, S., Asif, M. (2017). Barriers to industrial energy efficiency improvement–manufacturing SMEs of Pakistan. *Energy Procedia*, 113, 135-142.

[194] Leszczyńska, A., Curie-Skłodowska, M. (2016). Sources and barriers to the energy efficiency of Polish enterprises. *Annales Universitatis Mariae Curie-Skłodowska*, section H – Oeconomia, Vol 50, No 3.

[195] Kucęba, R., Koszarek-Cyra, A. (2015). Directions, barriers, factors energy management in SMEs organisations". Scientific notebooks of the Silesian University of Technology, Series: Organization and management no. 83.

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- Fears and expected disruptions to the company's core business during the implementation of pro-ecological investments (13%)
- Lack of qualified personnel/lack of competences (7%).

(III)

"Internal barriers:

1. *Low awareness of entrepreneurs about: energy efficiency, feasible measures which can improve it and potential scale for energy cost savings.*
2. *Energy efficiency in companies is an issue of low importance, supported by the general belief that the company is already energy-efficient.*
3. *SMEs usually do not have an employee responsible for energy issues and having a thorough knowledge of company's energy consumption.*
4. *On the market there are offered sometimes schematic energy audits, not always adapted to the needs and awareness of the final recipient.*
5. *SMEs reported lack of time for preparatory efforts for the audit, and difficulties with answering many preliminary questions, gathering and sending invoices for energy, etc..*
6. *Lack of time to implement the audit recommendations.*
7. *Lack of funds to implement the audit recommendations.*

External barriers:

1. *Low activity of companies offering energy audits for SME sector, poorly developed activities related to reaching companies and persuading them to take actions aimed at improving energy efficiency. It is related with the necessity to involve not only auditors, but also marketing and advertising specialists (additional costs which should be included in the audit's price).*
2. *Lack of an appropriate offer on the market. Cost of the audits perceived as too high, entrepreneurs are not willing to pay the full cost of the audit.*
3. *Lack of possibility to choose the scope of the audit – less analysis, lower audit cost.*
4. *Energy audits do not indicate adequate co-financing programs for recommended measures.*
5. *Lack of ongoing and predictable support programs connected with activities recommended in audits. Identified programs typically are organized with short time-frame window for application, what reserves not enough time to prepare properly the investment.*
6. *Lack of proper communication from the company providing audits during the first meeting / conversation with the entrepreneur.*
7. *Too long audit reports described in a very technical language, difficult to understand by companies*[196]*."*

This last study contains some novelties that should be emphasized. We refer, in particular, to some external barriers, such as those numbered from 8 to 11 and from 13 to 14 which concern all issues related to the inadequacy of energy audits.

Portugal

[196] Korczak, K. (2015). Master Thesis - Energy efficiency improvement in small and medium-sized enterprises. University of Technology, Faculty of Power and Aeronautical Engineering, Division of Rational Use of Energy.

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"In Portugal, 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. In Portuguese companies the major behavioural barriers appear to be limited time, information, and cognitive capacity to process complicated and unfamiliar choice. 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[197]."

Slovenia

(I)

"Although there are considerable differences between individual SMEs in the organization of energy and the state of energy systems, the barriers that make it difficult to improve the existing energy situation in companies can be divided into three main ones. These are:
- There are no energy experts employed in Slovenian SMEs.
- Slovenian SMEs are narrowly focused on their own production.
- In Slovenian SMEs, energy costs have a relatively small share in the total annual costs. Slovenian SMEs face the same difficulties in implementing energy efficiency programs when implementing energy efficiency measures as SMEs in the world. Each of these obstacles is important, but probably the most critical obstacles are the narrow orientation of SMEs to their own production, as these are largely the cause of all other problems related to energy supply and its use in companies[198]."

(II)

According to a second source[199], based on a survey in 848 Slovenian manufacturing firms, energy costs, market share and export orientation are among the factors impacting the decision to invest in energy-efficient and clean technologies. It was also seen that the economic crisis reduced the likelihood to invest in clean technologies but had no impact on investments in energy-efficient technologies.

The economic crisis, that, of course, does not characterize only Slovenia, is mentioned for the first time in this document. It is possible that the other sources overlooked or simply forgot these aspects. More probably, they considered this factor as "incorporated" in the many economic and financial barriers already mentioned (some of which are aggravated in the crisis).

[197] Henriques, J., Catarino, J. (2016). Motivating towards energy efficiency in small and medium enterprises. *Journal of Cleaner Production*, 139, 42-50.
[198] Špacapan, F. (2015). Graduation thesis: energy management and efficient use of energy in companies. Available at: http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf
[199] Hrovatin, N., Dolsak, N., Zoric, J. (2015). Factors impacting investments in energy efficiency and clean technologies: Empirical evidence from Slovenian manufacturing firms. J. Clean. Prod. 2015, 127.

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Another barrier which is not mentioned in other sources is "Slovenian SMEs are narrowly focused on their own production". This barrier is reported in most SMEs and certainly is not peculiar to the Slovenian ones. However, it is mentioned here for the first time as, probably, the other sources do not consider it as a real barrier to energy transition.

Spain

"94% of SMEs do not have an energy management system, 88% do not have any quality, energy or environmental management system, 90% have not participated in any program or subsidy for energy efficiency, 94% have not contracted any energy audit in the last 3 years… the top barriers to investment are: 1. Lack of technical expertise to evaluate or execute projects (40%). This number is quite impressive compared with the global rate (28%); 2. Lack of funding to pay for improvements (22%); 3.Uncertainty regarding savings and performance (15%)[200]."

Sweden

(I)
"The major barriers to energy efficiency were found to be: lack of time or other priorities/other priorities for capital investments, lack of access to capital/lack of budget funding, cost of production disruption/hassle/inconvenience, technical risk such as risk of production disruptions, difficulty/cost of obtaining information on the energy use of purchased equipment[201]."

(II)
A study among 60 micro and small companies in Sweden[202] revealed that the major barriers to energy efficiency were lack of time, other priorities, slim organisation and lack of technical skills

Turkey

"Market barriers still exist for scaling up financing to energy efficiency investments, especially in SMEs. These include; (a) Lack of knowledge among banks and SMEs about energy efficiency opportunities, project performance and risks; (b) High transaction costs for small SME energy efficiency investments; (c) Financing constraints due to high collateral requirements; (d) Limited institutional capacity in market to identify, prepare

[200] Johnson Controls (2018). 2018 Energy Efficiency Indicator Survey – Spain. Available at: https://www.johnsoncontrols.com/media-center/news/press-releases/2018/11/15/~/link.aspx?_id=4B3426E1445A4F4FB85C6D504D000D2F&_z=z

[201] Thollander, P., Ottosson, M. (2010). Energy management practices in Swedish energy-intensive industries. *Journal of Cleaner Production*, 18(12), 1125-1133.

[202] Backman, F. (2017). Barriers to Energy Efficiency in Swedish Non-Energy-Intensive Micro- and Small-Sized Enterprises - A Case Study of a Local Energy Program. *Energies,* 2017, 10, 100.

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bankable energy efficiency projects. The ESCO[203] model has also been unable to gain traction within the Turkish market to date."

This last barrier (the non-appropriateness of the ESCO model) appears typical of the Turkish context.

UK

"'Lack of managerial awareness' was their least significant barrier, compared to access to capital or information on investment payback times relating to energy efficient technologies. It seems unlikely that owners and managers would identify their own lack of awareness as a significant barrier, as it is difficult to have insight into personal unawareness. Environmental issues were factored into investment decisions less frequently for SMEs compared to larger organisations where decision making is comparatively more structured and procedural. The 'split-incentive' is a significant barrier to energy efficiency investments for SMEs occupying non-domestic premises[204]."

Zimbabwe

In a review[205] of the challenges for energy efficiency in industrial SMEs in Zimbabwe, the main barriers found were related to financial and technical capacity, awareness and cultural issues in the organisation.

Developing countries (in general)

"Barriers to energy efficiency in developing countries are similar to those in developed countries, but more pronounced. Problems of lack of information and skills are widespread in developing countries and inadequately addressed through public policy, while difficulties in accessing capital are very common, especially for smaller firms. What this is partly a consequence of hidden costs (e.g., the cost to the lender in establishing credit worthiness), it tends to be exacerbated by the deficiencies of the financial sector in many developing countries, including more limited knowledge of technical risks and opportunities combined with trade and investment policies that restrict access to foreign capital. These problems should be a priority for reform, alongside the removal of energy subsidies which undermine economic case for improved energy efficiency[206]."

[203] World Bank (2013). PROJECT INFORMATION DOCUMENT (PID) - Small and Medium Enterprises Energy Efficiency Project for Turkey. Available at: http://projects.worldbank.org/P122178/turkey-sme-energy-efficiency?lang=en

[204] Hampton, S., Fawcett, T. (2017, June). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.

[205] Muzamwese, T.C. (2016). Challenges and opportunities for mainstreaming industrial energy efficiency in small-to-medium-sized industries in Zimbabwe. *Wiley Interdisciplinary Review Energy and Environment*, 2016, 5, 510–518.

[206] Sorrell, S., Mallett, A., Nye, S. (2011). Barriers to industrial energy efficiency: A literature review. UNIDO. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846

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5.3. Facilitating factors and drivers/motivations in the energy efficiency/management improvement process in SMEs

5.3.1. Which facilitating factors/motivations drivers?

According to Meath et al.[207]:

> *"While much of the extant literature generally supports the argument that SMEs encounter significant barriers to successfully implementing energy efficiency or sustainability measures, new insights gained from our case study analysis reveal the importance of motivating (and facilitating) factors, which to date have been underrepresented in the literature. The large number of motivators suggests that SME owners are considering the positive outcomes and not just limiting factors. Some SMEs potentially have an idealistic desire to change their business operations by implementing (EEMs)".*

It is in this perspective that, in this chapter, after an analysis of the barriers, we will dwell on the "positive" or facilitating factors (whatever be the term used) that influence the involvement of SMEs in promoting energy efficiency and, in a broader sense, the energy transition.

Many facilitating factors helping SMEs promote the implementation of EEMs are reported in the literature. To some extent, they represent "counterweights" to many of the barriers previously reported. Therefore, many of the categories in which these factors are classified are the same as those already used in the analysis of the barriers.

- **Level of information**

> *"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 hotlines, energy efficiency standards for equipment, and clear marking of efficiency levels on equipment may help small and medium sized enterprises to improve energy efficiency*[208]*. More specifically, Better information about technology options and related*

[207] Meath, C., Linnenluecke, M., Griffiths, A., (2015). Barriers and motivators to the adoption of energy savings measures for SMEs: The case of the Climate Smart Business Cluster Program, Journal of Cleaner Production. In this paper, based on a study implemented in Australia on 2020 SMEs, motivating factors resulted more important than barriers (Nearly twice as many motivators (134) were identified as barriers (66)).

[208] Henriques, J., Catarino, J. (2016). Motivating towards energy efficiency in small and medium enterprises. *Journal of Cleaner Production*, 139, 42-50.

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energy cost savings is expected to accelerate the adoption of energy efficiency measures[209]*."*

"Information campaigns appear to be useful instruments in incentivising energy audits, promoting investment in energy efficiency[210]*."*

- **Financial aspect**

Financial measures are also crucial: loan interest rate discounts, and establishment of financial institutes to promote energy efficiency in SMEs[211].

"An important aspect of the incentive system for energy efficiency in Italy is connected to the so called "White Certificates" (a certificate of achievement of energy efficiency that gives the right to an economic recognition, an incentive; such certificates could be sold by the companies who have them in excess compared to what is established by the official authority for energy)[212]*."*

- **Aspect of bureaucracy and regulations**

"SMEs need by governmental institutions to extensively simplify the bureaucratic process behind an investment in energy efficiency (…) 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[213]*."*

"Those entrepreneurs who consider existing regulations[214] *crucial are more prone to do environmental organizational innovation, although giving importance to expected future regulations and access to existing subsidies and fiscal incentives has no significant effect on the decision to environmental organizational innovations. Management capabilities and research infrastructure become very important drivers for environmental organizational innovations. On the demand side, attributing importance*

[209] Schleich, J., Fleiter, T. (2017). Effectiveness of energy audits in small business organizations. Resource and Energy Economics. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846

[210] Kalantzis, F., Revoltella, D. (2019). How energy audits promote SMEs' energy efficiency investment (No. 2019/02). EIB Working Papers

[211] Johansson, M.T., Thollander, P. (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry–recommendations for successful in-house energy management. *Renewable and Sustainable Energy Reviews*, 82, 618-628.

[212] Vascellaro, D. (2018). L'efficienza energetica è un'opportunità per le PMI (Energy efficiency is an opportunity for SMEs), in *Il giornale delle PMI*, interview to Patrizia Malferrari, availble at: https://www.giornaledellepmi.it/lefficienza-energetica-e-unopportunita-per-le-pmi/

[213] Trianni, A., Cagno, E., Farnè, S. (2014). An empirical investigation of barriers, drivers and practices for energy efficiency in primary metals manufacturing SMEs. *Energy Procedia*, 61, 1252-1255.

[214] At this regard: "The law enforcement in Japan through the Energy Conservation Law reveals that this could be a means to be more strongly emphasized also in the Swedish policy mix, as well as for any country aiming to improve energy efficiency in the industrial sector. Results for Japan showed that in particular towards medium-sized companies, the law is a strong policy" (Thollander, P., Backlund, S., Trianni, A., Cagno E. (2013). Beyond barriers – A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden. Applied Energy, Volume 111, November 2013, Pages 636-643).

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to increased market demand for green products and market share impact are also decisive to environmental organizational innovation[215]*."*

- **Internal motivations**

"higher level of collaborators' motivation[216]*"; this is also for monitoring of the energy use and costs*[217]*."*

Beyond specific statements (such as the ones above), various classifications of facilitating or motivational factors as well as for barriers were also developed.

A list is proposed, for example, by a recent study (2016) from Leszczyńska et al.[218].

"Factors that motivate entrepreneurs and employees to introduce energy-efficient activities:

1. ***possible improvement of working conditions,***
2. ***PR and marketing benefits,***
3. ***volatility of energy prices – the need to reduce energy consumption in order to protect against price fluctuations,***
4. ***the possibility of cost reduction – improvement of short-term and long-term results,***
5. ***external subsidies,***
6. ***involvement of management staff,***
7. ***legal obligation to report the energy efficiency."***

Some among these factors (1, 2 and 6) look like the NEBs (Non-Economic Benefits) of the EEMs (see Paragraph 1 in this Chapter). The others represent "another face" of few among the barriers mentioned in the previous paragraph.

A second classification can be mentioned, referring to Australia, a context somewhat different from Europe in terms of facilitating factors. We talk about it here as it includes a category which is not mentioned elsewhere – the attention to "compliance" to certain standards – that deserves to be highlighted.

[215] Triguero, A., Moreno-Mondéjar, L., Davia, M.A. (2011). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, August 2013, Volume 92, Pages 25-33.
[216] Catarino, J., Henriques, J., Egreja, F. (2015). Portuguese SME toward energy efficiency improvement. *Energy Efficiency*, 8(5), 995-1013.
[217] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, 12(7), 1338. Attitudes to monitoring also varied, from those who saw it as having a role in the efficient running of the business and therefore being, in itself, an efficiency measure: "We are just installing some more electricity meters and we can monitor different sections a bit better because we haven't really got full visibility on where all the power usage is in the factory"; to those who felt it was a drain on their resources: "Given that I've only just spent twenty grand on getting the electricity circuit boards up to code… Having to spend another five grand to do a monitoring and targeting is not number one or not even number ten on my list at the minute" (Brown, P., Sherriff, G. A. (2014). Research to assess the barriers and drivers to energy efficiency in small and medium sized enterprises).
[218] Leszczyńska, A., Curie-Skłodowska, M. (2016). Sources and barriers to the energy efficiency of Polish enterprises. *Annales Universitatis Mariae Curie-Skłodowska*, section H – Oeconomia, Vol 50, No 3.

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"Motivating factors to engage in energy savings measures across 3 categories. Financial factors include the desire to save money, environmental factors include the desire to become more sustainable or carbon neutral, and compliance factors include the desire to achieve a NABERS rating (The National Australian Built Environment Rating System measures the environmental performance of a premise). It is important to note that different businesses experienced different motivators and also different combinations of motivators[219]."

Another important category is environmental sustainability. This aspect is deepened in a study by Kerr et al.[220].

"SMEs need supportive measures as • creation of a framework of legislation and regulation that encourages environmentally and socially sustainable operation, • support for the development of environmentally sound products and services and • development and promotion of environmental information and advice, especially in the areas of environmental research and development, technology, marketing, educational training and basic environmental financial management."

The concept of 'drivers' is commonly found in discussions on energy efficiency and is used as a term for 'what is driving' activity and is commonly used interchangeably with other terms such as motivation and rationale[221]. The term driver is still the most utilized. Just as for barriers, it is to mention that the case of drivers, an important distinction is that between internal drivers (e.g., staff with real ambitions, information about real costs, cost reduction from lower energy) and external drivers (e.g., technical support, clarity and trustworthiness of information). External drivers play a more important role at the beginning (in particular the regulatory ones) and in the middle step (e.g., concerning external assistance) of the decision-making process for energy management enhancement, whereas in the final steps internal drivers seem to be of more relevance[222].

A taxonomy of drivers (useful for empirical investigation) was elaborated by Trianni, Cagno and Farné, which is shown in the table below[223].

[219] Meath, C., Linnenluecke, M., Griffiths, A. (2015). Barriers and motivators to the adoption of energy savings measures for SMEs: The case of the ClimateSmart Business Cluster Program, *Journal of Cleaner Production*, doi: 10.1016/j.jclepro.2015.08.085.

[220] Kerr, I.R. (2006). Leadership strategies for sustainable SME operation. *Business Strategy and the Environment*, 15(1), 30-39.

[221] Sherriff, G. (2013). Drivers of and barriers to urban energy in the UK: a Delphi survey, Local Environment 19(5) 497–519.

[222] Johansson, I., Mardan, N., Cornelis, E., Kimura, O., Thollander, P. (2019). Designing Policies and Programmes for Improved Energy Efficiency in Industrial SMEs. *Energies*, 12(7), 1338.

[223] Trianni, A., Cagno, E., Farné, S. (2016). Barriers, drivers and decision-making process for industrial energy efficiency: A broad study among manufacturing small and medium-sized enterprises. *Applied Energy*, 162, 1537-1551

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Table 6 - Taxonomy of drivers for empirical investigation

Categories	Drivers
Regulatory Internal	Long-term energy strategy Willingness to compete Green image Voluntary agreements
Regulatory External	Clarity of information External energy audit/submetering Increasing energy tariffs Efficiency due to legal restrictions Technological appeal Trustworthiness of information
Economic Internal	Cost reduction from lower energy use Information about real costs
Economic External	Management support Public investment subsidies Private financing
Informative Internal	Management with ambitions Staff with real ambitions Knowledge of non-energy benefits
Informative External	External cooperation Availability of information Awareness
Vocational training Internal Vocational training External	Programs of education and training Technical support

Besides the drivers, the presence of a culture concerning energy efficiency is reported to be an influencing driving factor. Analysis suggests a slight correlation between those reporting the presence of such a culture in the companies and higher implementation rates of EEMs[224].

Cagno and Trianni conducted semi-structured interviews with 71 companies in the Lombardy region in Italy to analyse energy efficiency drivers. The companies had been part of a regional energy program performing energy audits at SMEs as a means to increase the adoption of energy-efficient technology. The result of the analysis taking the whole samples into account emphasizes the importance of allowances or public financing which are ranked by the respondents as the major driver. External pressures, such as increased energy prices or the reduction of fees and taxes or some exemptions were also highly ranked drivers whereas the increase of internal competencies was ranked as the lowest driver. However, the perception of drivers varied with different variables like enterprise size, sector and supply chain complexity. In order to quantify barriers to energy efficiency[225] Cagno et al. implemented a case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden (65 companies of which 30 small-sized and 15 medium-sized enterprises; SMEs are representing 77% of the investigated

[224] Brown, P., Sherriff, G.A. (2014). Research to assess the barriers and drivers to energy efficiency in small and medium sized enterprises.

[225] Cagno, E., Trianni, A. (2013). Exploring drivers for energy efficiency within small- and medium-sized enterprises: First evidences from Italian manufacturing enterprises. *Applied Energy* 2013, 104, 276–285.

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sample)[226]. The two tables below give information of organizing and ranking several drivers. The first shows the driving forces considered in the study. The second shows the average value attached to them by the respondents according to their importance, going from 1 (no impact) to 5 (major impact).

Table 7 - Driving forces for increased energy efficiency implementation

Financial driving forces	Energy taxes including taxes on sulphur, No_x and CO_2
	Threat of rising energy prices
	Cost reductions from lowered energy use
	Beneficial loans for energy efficiency investments
	Investment subsidies for energy efficiency technologies
Informational driving forces	Local public energy consultants
	Public sector as a role model
	Voluntary agreements
	Energy advice through journal/booklets
	Energy advice through seminars
	Information and support through sector organization
Organizational driving forces	Commitment from top management
	Network within the company
	Improve working conditions
	Company's environmental profile
	Environmental management system
	Long-term energy strategy
	People with real ambition
External driving forces	Demand from customers
	Demand from owner
	Annual environmental report to public administrations
	Pressure from environmental NGOs
	Network within the sector
	Your municipality being part of a climate/energy efficiency programme
	National requirements for energy efficiency
	International competition
	ESCOs responsible for operation and maintenance of the buildings

[226] Thollander, P., Backlund, S., Trianni, A., Cagno E. (2013). Beyond barriers – A case study on driving forces for improved energy efficiency in the foundry industries in Finland, France, Germany, Italy, Poland, Spain, and Sweden. *Applied Energy*, Volume 111, November 2013, Pages 636-643.

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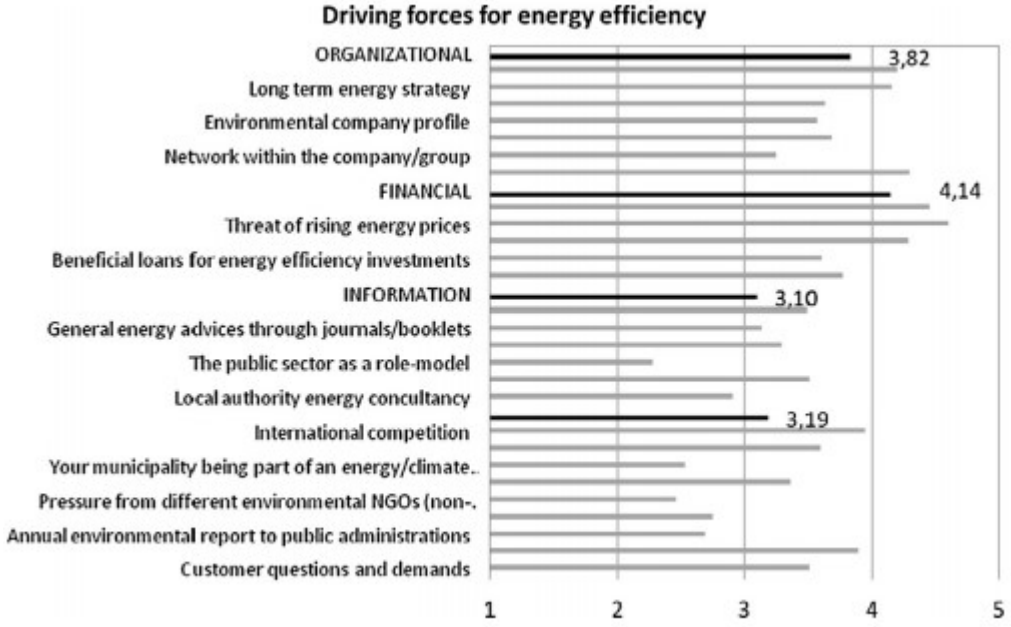
Figure 7 - Total ranking of driving forces among the studied foundries evaluated through a Likert scale from 1 ‘‘no impact’’ to 5 ‘‘major impact’’



An analysis by categories shows that the most relevant driving forces perceived by the respondents are related to financial and organizational issues. Indeed, those recognized as the most relevant among them (cost reductions, the threat of a rise in energy prices and energy taxes) are related to the financial domain. Right below them, in terms of relevance, we find the organizational drivers (i.e., commitment from top management, people with real ambition). Moreover, we can observe also the presence of external driving forces, in particular, connected to the international growing competition. Among them, besides the already well-known and somehow expected external drivers (i.e., customer demand, demand from owner and obligations), it is worth noticing how the network within the sector is perceived as having some impact. Finally, we can note that information-related driving forces are not perceived as particularly relevant, as in the lowest positions we find drivers such as “public sector as a role model”, “your municipality being part of an energy/climate efficiency program” and “pressure from different environmental NGOs”.

As for the relations between driving forces and the size of the company, we can note some interesting results that are worth commenting on. Firstly, the presence of a network within the sector as well as the information and support through sector organization are perceived as driving forces having much greater importance by smaller enterprises than larger ones. In fact, about eight out of ten smaller enterprises have the opinion, that these are the most relevant driving forces, some with major impact. When larger firms are considered, those drivers seem to have less importance (in medium enterprises about five out of ten, and one out of three in larger ones). Secondly, small enterprises seem to perceive investment subsidies for energy efficiency technologies as having greater importance than medium and large enterprises.

No relevant differences of driving forces are found between different countries. However, some exceptions can be observed. Limiting our focus on the countries with the largest number of enterprises involved in the research, i.e., Sweden (20 enterprises) and Germany (16

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enterprises), some interesting results can nonetheless be observed. Indeed, we can note that the municipality being part of an energy or climate efficiency program is perceived as a relevant driver by 11 out of 20 firms investigated, while one out of four in the total sample considered it as having some or major impact. Moreover, in Swedish cases, 17 out of 20 companies consider the network within the sector as a relevant driver, compared with about 55% for the overall enterprises studied. Swedish firms seem to have a different perception with respect to German ones, in which only one out of four companies believe the network within the sector to be a relevant driver. Looking at German enterprises, two comments appear relevant.

1. For beneficial loans for energy efficiency investments as well as for investment subsidies for energy efficiency, which are the used technologies is perceived as much less relevant compared to the survey in Sweden. At first glance, this difference can be attributed to the competitiveness of the German enterprises, and more generally, of the German economy in comparison to the rest of Europe.
2. Firms that have conducted an energy audit rank all the listed driving forces (by categories) higher than firms that have not conducted an energy audit. This can be particularly observed for information-related and organizational driving forces, presenting a difference of about half a point from each other. The results seem to suggest that, besides external and financial issues that should be promoted, the implementation of an energy audit allows the companies to shed light on existing difficulties in implementing the actions necessary to improve energy efficiency.

Finally, we can look now at two very recent country studies.

The first was implemented in Spain in 2018[227]. It identifies 5 drivers underlying the role played by external and internal actors as well as other well-known factors (e.g., factors 1 and 5):

1. Energy cost savings
2. Attracting/ retaining employees
3. Customer attraction and retention
4. Investor reporting demands
5. Greenhouse gas footprint reduction.

The second study[228] was implemented in Switzerland and published in 2019. It focused on 302 enterprises (of which 197 SMEs). The study identifies the following driving factors (all, albeit with other words, were mentioned already before):

- Cost reductions resulting from lower energy use (260 of 296 respondents)
- Enhancing the positive image and reputation (184 of 298 respondents)
- Enhanced competitiveness (183 of 295 respondents)
- Lower production risks (153 of 294 respondents)
- Other non-energy costs reductions (135 of 264 respondents)

[227] Johnson Controls (2018). 2018 Energy Efficiency Indicator Survey (Spain). Available at: https://www.johnsoncontrols.com/media-center/news/press-releases/2018/11/15/~/link.aspx?_id=4B3426E1445A4F4FB85C6D504D000D2F&_z=z

[228] Cooremans, C., Schönenberger, A. (2019). Energy management: A key driver of energy-efficiency investment? *Journal of Cleaner Production*, *230*, 264-275.

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- Higher quality/reliability of products and/or production process (135 of 293 respondents).

5.3.2. Some remarks on facilitating factors/motivations/drivers

As well as barriers, dozens of motivations, driving forces, facilitating factors (and other factors, however, they are called) that have the potential to support the energy efficiency/management improvement process in SMEs were identified in our literature review.

Just like the barriers, these factors are not only numerous but also of many types. As we did previously for the barriers, let us try to summarize them:

- Information measures (and trustworthiness of information)
- Simplification in the bureaucratic processes and regulations
- SME internal motivations (e.g., possible perception of improved working conditions)
- The ambition to become more sustainable or carbon neutral/to get a "green image" (also linked to pro-environmental values/"energy culture" of some managers and/or employees and their commitment)
- Other non-energy benefits (e.g., improved product quality and increased productivity, raw material savings, extended equipment life and reduced maintenance requirements)
- Financial measures (e.g., external subsidies and/or availability of private financing)
- Possible economic improvements (e.g., cost reductions)
- Other economic factors (e.g., the need to reduce energy consumption to protect itself against energy price fluctuations) also for enhancing competitiveness
- Identification of new market niches (e.g., the development of environmentally sound products and services)
- Demand/pressure from customers and/or from environmental NGOs/movements and/or from local authorities (and possible specific projects).

As in the case of the barriers, also in this case the factors are numerous and diverse, also because the various and multiple contexts in which the SMEs operate are very complex.

Are we repeating in a "mirrored" way what has already been written in Paragraph 2.4. of this chapter (e.g., the thesis on the "accumulation" of barriers on an SME/on an entrepreneur that represent the main difficulty to be overcome)? No, because, the analogy between barriers and drivers ends here.

While every entrepreneur faced with a multiplicity of barriers whose accumulation represents an obstacle considered insurmountable, the "helping" factors do not produce a similar accumulation effect (e.g., a very favourable context). This occurs for many reasons including those mentioned below:

- Some factors are present in some territorial areas, less or not at all in others
- In many cases, driving factors can be even present but are little impactful because of rules or obstacles of various kind (e.g., financial, administrative)

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- Some factors can be volatile (sometimes they have a real effect today and but they lose tomorrow, perhaps due to the change of a minor rule or to the change of a manager in a bank or a public body)
- Many factors are known by some entrepreneurs and not by others
- Some factors are well understood by some entrepreneurs, less or not by others
- There could be internal "conflicts" in some SMEs regarding some factors (e.g., internal motivations, ambition towards a green image, usefulness of subsidies).

Therefore, most of the "helping" factors, even when they are persistent over time, do not affect or affect so much the life of an SME and its managers. For such a reason they are not able to play as a counterweight (or at least a sufficiently strong counterweight) to the accumulation of barriers. That is why strong/structured forms of external assistance (which, some sources include among the "external drivers"), even within the world of SMEs become indispensable. This is what we will deal with in the next paragraph.

5.4. SMEs external support

Besides the importance of the drivers and other facilitating factors highlighted in the previous paragraphs, external support is considered necessary for assisting/helping SMEs to adopt an energy-efficiency (or, better an eco-sustainable) approach, as clearly underlined by the European Commission[229] (see the following box).

How have Member States engaged with organisations representing SMEs to demonstrate how energy management systems could help their businesses?
There is no general approach that is used across the Member States as the institutional structures differ between countries. However, many Member States try to maintain close contact with industrial associations and representatives, e.g., trade *organizations* or chambers of commerce, setting up or organising joint events on energy-related matters.

What specifically has been done to raise awareness and expertise among SMEs?
The use of formalised and structured information exchange mechanisms is limited to comparatively few Member States. Many Member States rely on less formal systems for information exchange both between companies and the government. These approaches include discussion platforms, websites and portals, information events (e.g., conferences, seminars, presentations and workshops), awards, help lines or desks, printed and online resources, the provision of local contacts/offices.

What types of organisations that represent SMEs can contribute to the exchange of information?
The analysis of the implementation of exchange mechanisms in the Member States suggests that support by key institutions from industry and the government (e.g., trade associations, chambers of commerce, service providers, energy utilities) can effectively facilitate the

[229] European Commission (2015). The EU Eco-Management and Audit Scheme (EMAS). Available at: https://ec.europa.eu/environment/emas/emas_publications/publications_studies_en.htm

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exchange of information as these institutions often have more direct access to SMEs as they often are their first contact point.

How has the European Commission assisted the Member States by supporting the exchange of good practices?
Generally, the provision of the guidance note, as well as the activity of the Concerted Action working group, have been perceived as the main support mechanisms provided by the European Commission so far. While both approaches are generally considered as helpful by the Member States, it has been pointed out that a faster provision of the guidance note, as well as a more intensive exchange on different issues related to the implementation of the EED, e.g., on the definition of companies, issues related to transport or on the identification of multi-national companies, would have been welcome to facilitate and accelerate the implementation process.

What support schemes for SMEs that cover costs of an energy audit and of the implementation of highly cost-effective recommendations from the energy audits are provided by the Member States?
Support schemes that are in place address partial funding of energy audits or financial support for implementing energy-efficient technologies; they also include low-cost loans for companies. With regard to audit costs, both the covered share of the audit costs as well as the upper absolute ceiling vary and may be up to 80% of the audit costs.

What incentives or support schemes have the Member States introduced to implement energy or environmental management systems in SME?
With regard to specific instruments dedicated to energy management systems, fewer countries tend to address this area as compared to funding for energy audits. Most of the existing instruments concerning energy management are financial instruments while there are also regulatory approaches, voluntary agreements and information-based approaches in some countries.

We will start this paragraph dealing with an important issue related to the external assistance: the need of a customised approach, able to take into account the wide heterogeneity of the SMEs and of the contexts they work in. Then, some among the main existing programs for assisting SMEs in relation to energy efficiency/eco-sustainability issues will be presented. Finally, the networks mixing external-internal assistance will be dealt with.

5.4.1. Targeted approaches

As stated above, each SME (or each "cluster" of SMEs) can encounter a specific set of barriers. Therefore, the support should be, as far as possible, "personalized"[230]:

> *"Targeted approaches are essential as noted previously, there are significant differences between industries and even individual organisations. Overcoming barriers requires development and deployment of different initiatives based on careful segmentation of energy users considering management style, significance of the energy use and efficiency opportunities*

[230] Thollander, P., Danestig, M., Rohdin, P. (2007). Energy policies for increased industrial energy efficiency: Evaluation of a local energy programme for manufacturing SMEs. *Energy policy*, 35(11), 5774-5783

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and the energy using equipment or processes in the organisation. Targeting the right kind of interventions, to the right personalities in the right industries, at the right time is key to achieving the most cost effective energy efficiency impact. While energy use and energy using equipment and processes are relatively straight forward to identify, management style is much more subjective and open to change over time. Those with a more optimising style are likely to make themselves known when presented with an opportunity for business improvement, while those with a satisficting style will be harder to engage and more suited for approaches that require only limited new understanding or participation. Yet it is also important that there are avenues for 'satisficers' to seek out support should their mindset change, most likely during a time of disruption. There is no single initiative that can deliver the scale and range of necessary interventions across the SME (sector)[231]."

In this regard, the energy service companies (ESCOs) have proven, in many countries, to be an effective way of facilitating EE investments, including in emerging sectors and new technologies. ESCOs can provide a "one-stop shop" solution to project owners, allowing them to effectively outsource the project from energy audit and development through implementation and monitoring. In some cases, the ESCOs are also able to arrange or facilitate financing for the project[232]. In line with the "targeting" and/or the "personalization", we can report also "the concept of local energy programmes seems to be an effective energy policy option[233]".

Of course, "personalized"/"target" support should be aside from a suite of foundational initiatives that will ensure opportunities for all to improve their energy efficiency (i.e., "universal policies").

"Three categories of options available to policymakers are described: (1) designing 'universal' policy (2) developing organisational policy designed with minimum obligation thresholds, and (3) deploying measures specifically targeted at SMEs. We argue that the focal unit of policy design is the crucial factor influencing whether SMEs are likely to be included in scope. Where the organisation is the primary focus, SMEs are more likely to be exempted, whereas universal policy such as those focused on products, buildings or technologies may hold potential for extending the benefits of energy efficiency to SMEs. Targeted SME policies largely consist of incentives and information provision, and are typically delivered by business support organisations with primary aims to support economic growth. We argue that while there are benefits from utilising existing support networks for delivering energy efficiency programmes, SMEs with stable business plans are deprioritised, and contradictory effects may arise[234]."

But what is the point of view of the entrepreneurs in this regard? What assistance do they want? Some results, in this regard, are reported in a 2017 Baranova paper.

[231] Energy Efficiency Council (2017). SME and community organizations – enabling best practice energy efficiency. Available at: http://www.eec.org.au/uploads/Projects/EEC2017_SMENFP_enabling_best_practice_energy_efficiency.pdf

[232] World Bank (2013). PROJECT INFORMATION DOCUMENT (PID) - Small and Medium Enterprises Energy Efficiency Project for Turkey. Available at: http://projects.worldbank.org/P122178/turkey-sme-energy-efficiency?lang=en

[233] Thollander, P., Danestig, M., Rohdin, P. (2007). Op. Cit.

[234] Hampton, S., Fawcett, T. (2017). Challenges of designing and delivering effective SME energy policy. European Council for an Energy Efficient Economy.

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"Many SMEs still require support in developing the 'business case' for low-carbon interventions, including help with investment options, return on investment and value added options. Assistance in attracting external funding as well as project management expertise could, therefore, have a significant impact on SMEs' confidence towards low carbon, eco-innovation and energy-efficiency projects. The capability associated with 'accessing funding and finance' attracted the highest interest (49%), closely followed by 'energy and materials efficiency' (47%) and 'waste management' (44%). 'Design for low carbon product and services' category attracted substantial attention (24%); 'leadership for sustainability' (18%) with 'environmental management' and procurement and purchasing both attracting the same interest with 16%, with 'strategic planning' (13%) and 'accessing and building the right networks' (12%) not far behind. This suggests that other, more costly policies targeted at increasing the financial attractiveness of these projects (e.g., energy/carbon taxes, or tax breaks/subsidies for implementation) may be needed to further promote energy efficiency in these sectors. Furthermore, it would seem that policies that could lengthen the short paybacks that firms routinely demand from all types of projects (not just those for energy efficiency) would have implications that extend well beyond the realm of energy and climate policy[235]*."*

5.4.2. Programmes designed to support SMEs

In more practical terms, let us now illustrate some programs and other initiatives through which external support for SMEs has recently been implemented (or is implementing at present). Most often, public policies and programmes designed to support SMEs to pursue energy efficiency work are in the form of various types of energy audit programmes[236], as well explained below[237].

Overall view

An overall view of the kinds of programs to support SMEs to undertake energy audits and, more broadly, to implement EEMs was drafted by Price et al. in 2011. Some of these programs are still active today. Regardless of this, the framework below allows for an overview of the type of support programs for SMEs that have been conceived, which, as can be easily seen, are sometimes entirely focused on energy audits ("stand-alone energy auditing program") and, possibly, on their follow-up ("post-audits follow-up"). Sometimes, these programs cover a broad set on EEMs, combining energy audits with other measures as "energy audit integrated program" and "integrated policy programs".

"A number of government programs have been established around the world to encourage, facilitate, or mandate industrial facilities to undertake energy audits. This paper presents information from a survey of 22 industrial energy auditing programs in 15 countries and one region: Australia, Canada, Denmark, Finland, France, India, Ireland, Japan, Netherlands, Norway, Portugal, Sweden, Switzerland, the United Kingdom, the United States, and the European Union (…) There is some overlapping between the two approaches.

[235] Baranova, P. (2017). Environmental capability of SMEs: Capability building towards a low carbon economy.
[236] Paramonova, S., Thollander, P. (2016). Op. Cit.
[237] Price, L., Lu, H. (2011). Industrial energy auditing and assessments: A survey of programs around the world. In Proceedings of the ECEEE.

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Stand-alone energy auditing program largely focuses on the energy audit itself and asks participants to perform energy audits (usually in exchange for support or meeting requirements). Stand-alone energy auditing programs typically focus on SMEs and are offered free or costs are shared between the industry and government. Stand-alone energy auditing programs often emphasize how to build an effective, standardized, and practical system and are designed to ensure that industrial participants can implement the proposed cost-effective measures, that energy audits are conducted comparably and coherently, and that the results are measurable, verifiable and useful to other manufacturers. Subsidies for energy audits, training and certification of energy auditors, standardized tools and guidebooks, energy audit databases, post-audit follow-ups and dissemination of case studies are critical to a robust stand-alone energy auditing program. A mature industrial energy auditing program not only institutionalizes energy audits in the long-run, tracks the performance of energy auditors, monitors the implementation of recommendations, but also provides feedback to industry participants, and provides insightful policy recommendations based on analysis of aggregated energy auditing reports for industrial sectors and energy-use systems. In the table below, some of the typical components of Stand-alone Energy Auditing programs are presented.

Post-Audit Follow-Ups and Case Studies are considered a part of Stand-alone Energy Audit programs. Post-audit follow-ups are important for understanding how the recommended energy-saving measures are implemented after energy audits. Only after the assessment of why plants have difficulties adopting measures can more targeted services be provided to facilities. In the reviewed stand-alone energy auditing programs, several programs surveyed the audited plants after the energy audits were conducted.

Energy audit integrated program, combines energy audits with other policy measures to better motivate participants, to help decision makers to set a reasonable yet ambitious energy-saving target, and to achieve the broader goals of the program. In the integrated policy programs with energy audits, energy audits are either integrated into voluntary agreement schemes or required by governmental mandate. If it is not feasible to have mandatory energy audits in designated facilities by law, energy audit program developers may consider integrating energy audits with other policy measures under a voluntary agreement scheme. Common complimentary policy measures identified include subsidies for energy audits, certified energy management systems, use of energy or CO2 tax (or tax exemptions), financing support for energy-efficiency investments, and target setting and required energy-efficiency improvement.

The integrated policy programs include voluntary agreement[238] schemes and mandatory regulations. Voluntary agreements (agreements signed between industry and the government), have been widely used (Price, 2005) and in many cases require energy audits for participants. Mandatory requirements are regulations or legal mandates established by national governments, which often require facilities to conduct energy audits, or meet energy-efficiency improving targets, or establish a certified energy/environmental management system. Often, energy audits have been utilized as one of the effective tools to achieve broader goals of the national regulations."

[238] Voluntary agreements (VAs) are another form of external assistance. VAs "interpreted as basically voluntary contracts between two parties – e.g., either between companies and governments or between a business association and the government. These agreements are signed with the aim of achieving energy-related objectives or improving energy efficiency beyond compliance to regulation. VAs are sometimes on the cusp of a regulatory instrument as these are not entirely voluntary and non-compliance may result in fines or the loss of rewards. VAs are occasionally also combined with financial incentives to motivate companies for participation" (Cfr. Nabitz, L., Hirzel, S., Rohde, C., Wohlfarth, K., Behling, I., Turner, R. (2016). How can energy audits and energy management be promoted amongst SMEs? A review of policy instruments in the EU-28 and beyond. Proceedings of the ECEEE Industrial Summer Study, 401-415).

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We can now dwell upon in details some programs in some European countries[239].

Germany

As for the Germany[240], energy audits aim a better cost-efficiency in these organizations and focus on insulation measures and measures optimizing heating system operations (the adoption of lighting, insulation, heating systems, and operational measures to improve heating systems). Findings of a study implemented by Schleich and Fleiter[241] in 2017 for SMEs with up to 50 employees suggest that energy audits are most effective for lighting and insulation measures and for measures optimizing heating systems in the case of larger organizations.

Spain

Spain possesses the "Estrategia PYME"[242] (PYME = SMEs), which objectives are to increase the competitiveness and growth of SMEs. In this perspective, this strategy allocates more than 400 million Euros, as well as loans with favourable conditions to improve the situation of SMEs. The Strategy has also allocated 307.6 million Euros to improve energy efficiency and reduce final energy consumption in the industrial sector (in SMEs, but also in large enterprises). These subsidies can support many measures, such as technology innovation in industrial equipment and processes and the improvement of energy management systems. Autonomous communities will manage and address the grant to SME and large companies from the industrial sector and ESCOs.

Italy

In Italy, some programs exist at the regional level and assist many SMEs (e.g., 30% of the manufacturing SMEs located within the Pavia province[243]). Moreover, since 2015, through the Regions, the Ministry for Economic Development (MSE) supports the implementation of energy audits in SMEs or the adoption, in the SMEs, of energy management systems compliant with the ISO 50001 standards. Since November 2017[244], MSE can finance energy audits up to a maximum of 35% of the eligible expenses and € 8,000, net of VAT; and the adoption of energy management system compliant with the ISO 50001 standard up to a maximum of 35% of eligible expenses, and € 16,000, net of VAT. Italian Regions, in addition to the resources of the MES, can also benefit from those of the European Regional Development Fund (through

[239] However, the world's largest energy audit program is the American IAC (Industrial Assessment Centers – mentioned also in the table above). It offers industrial SMEs energy audits free of charge without any agreements
[240] Schleich, J., Fleiter, T. (2017). Effectiveness of energy audits in small business organizations. Resource and Energy Economics. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846
[241] Ibid.
[242] La Moncloa-Spanish Government (2019). "Estrategia PYME". Available at: https://www.lamoncloa.gob.es/consejodeministros/resumenes/Paginas/2019/120419-consejo-ministros.aspx
[243] Trianni, A., Cagno, E., Farnè, S. (2014). Op. Cit.
[244] Public notice (7 November 2017) for the co-financing of programs presented by the Regions and aimed at supporting the implementation of energy audits in small and medium-sized enterprises (SMEs) or the adoption, in the same, of energy management systems compliant with ISO 50001, pursuant to of article 8, paragraph 9 of the legislative decree 4 July 2014, n. 102. Available at: https://www.mise.gov.it/index.php/it/normativa/decreti-interministeriali/2037332-decreto-interministeriale-8-novembre-2017-bando-2017-per-il-cofinanziamento-delle-diagnosi-energetiche-nelle-pmi

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respective Regional Operational Plans). Then usually, 50% of eligible expenses can be funded. Regions should issue specific Calls addressed to the SMEs; and this was done only by some Regions (over half).

Slovenia

Slovenia[245] possesses a voluntary program called "Community Eco-Label"(Eco-Label is the symbol of environmental quality – flower), as well as the "Eco Management and Audit Scheme" (EMAS). The eco-label is awarded to products and services, provided they meet a range of environmental performance criteria, taking into account the entire life cycle of the product (17 eco labels were appointed in Slovenia).

Poland

In Poland[246], we have found the Polish Agency for Enterprise Development's (PARP) program realized in the period September 2013 - October 2014 by ten entities in Poland. The project consisted of testing of the developed energy efficiency audit's standard in more than 480 micro and small enterprise.

UK

In the UK[247], the European Regional Development Fund (ERDF) represented, before BREXIT, the single largest source of funds for SMEs[248]. Between 2014 and 2020 in England, 792 millions Euros have been allocated to supporting the 'shift towards a low-carbon economy', with a further 1.400 millions of Euro to support SMEs competitiveness. Local Enterprise Partnerships (LEPs) are responsible for distributing these funds through energy efficiency programs, which are designed and delivered according to the priorities set out by LEPs' strategic economic plans. Many schemes (such as ECA in the UK) assume, but do not require, the disposal of older equipment, meaning that energy consumption may increase overall.

Sweden

A clear description of the Swedish program Highland was done in 2010 by Thollander and Dotzauer[249]. This program includes the following elements:

> *"… that the company reports the results from the energy audit, including the annual energy use; that the company presents the potential energy efficiency measures spotted in the energy audits, including an overall energy efficiency potential; that the company presents a simple energy plan over which measures they plan to conduct, including when, in time, this is supposed to take place;*

[245] Špacapan, F. (2015). Graduation thesis: energy management and efficient use of energy in companies. Available at: http://www.ediplome.fm-kp.si/Spacapan_Franko_20160215.pdf
[246] Korczak, K. (2015). Master Thesis - Energy efficiency improvement in small and medium-sized enterprises. University of Technology, Faculty of Power and Aeronautical Engineering, Division of Rational Use of Energy.
[247] Hampton, S., Fawcett, T. (2017). Op. Cit.
[248] For the future, there is a clear need for the improved evaluation and monitoring of local energy efficiency programmes. Reliable, quantitative data, aggregated at a national scale would help to formalize the SME contribution towards energy efficiency.
[249] Thollander, P., Dotzauer, E. (2010). An energy efficiency program for Swedish industrial small-and medium-sized enterprises. *Journal of Cleaner Production*, 18(13), 1339-1346.

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mandatory requirements to implement the measures, however, were not included; and, after receiving the subsidy, the company should annually, for a period of three years, present which measures; that were implemented, alternatively, that no measures were implemented.
This proposed energy program aims towards industrial SMEs with an annual energy use of more than 500 MWh (...) The program is estimated to result in saving of 700-1 400 GWh annually, offering half of the audit cost, at the very lowest 1000 Euro, with an upper limit of 3000 Euro.
This Swedish energy audit program is a result of Sweden's obligations to fulfil the European Energy End-Use Efficiency and Energy Services Directive. The program is planned to last for five years up until 2014".

Finland and Norway

Finally, the cases of Finland and Norway[250]:

- The Finnish program offers a subsidy of 40% of the costs of the energy audits
- The Norwegian program energy audits free of charge, with some requirements to be met as regards energy management practices.

5.4.3. Some remarks on external assistance

The initiatives activated in the different countries (some of them presented above), although important and often promising, cannot be considered sufficient for promoting a widespread development of energy-efficient solutions among the SMEs.

As it emerges in a survey implemented in 2017 by Eurochamber[251], in many EU Member States "existing support schemes have severe shortcomings, making them unattractive for SMEs. These include too low co-financing rates and too high minimum thresholds for investments. In other cases, grants are limited to certain energy-intensive sectors, excluding a large part of the economy". Therefore, Eurochamber identifies the following key recommendations.

- "The European Commission should pressure and support Member States in fulfilling their obligations to swiftly set up support schemes, providing appropriate incentives to undergo energy audits or establish energy management systems.
- Member States must 'think small first' and provide more SME-customised cross-sector support programmes, including for smaller investments and featuring higher co-funding rates.
- Public authorities should collaborate more effectively with trusted and experienced facilitators, such as Chambers of Commerce and Industry, to ensure the promotion of energy audits and energy management systems to SMEs".

[250] Johansson, M. T., Thollander, P. (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry–recommendations for successful in-house energy management. *Renewable and Sustainable Energy Reviews*, 82, 618-628.
[251] Eurochamber (2017). National Support Schemes for Energy Audits and Energy Management Systems as required by Art. 8/2 of the Energy Efficiency Directive (2012/27/EU)

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Moreover, to understand why opportunities are seized or not by SMEs in particular contexts, there is a need to better understand the learning dynamics and competing pressures involved when firms seek to incorporate environmental concerns into their general business strategy.

> *"Studies draw particular attention to the importance of appropriate incentives and an institutional context that is supportive of the greening of SMEs. Studies show that the more consistent application and extension of whole life costing (i.e., including the full environmental costs/benefits of products/services) in the public sector is particularly crucial. Government has a key role to play in relation to supporting innovation and R&D, with a number of studies pointing to the need to increase both business and government expenditure on low carbon technology (…) Some recent contributions have warned against the danger of over-emphasising new technology as a solution to climate change, drawing attention to the need to speed up the deployment of existing technologies and also the need for behavioural change on the part of both businesses and consumers. The technologies and business models seen as contributing most to the achievement of a low carbon economy and therefore most in need of support are essentially „disruptive", involving step changes in both business practice and consumer behavior[252]."*

Also improving cooperation with research institutions is crucial.

> *"A favourable opinion towards collaboration with research institutes, agencies and universities as innovation drivers significantly favours eco-innovation[253]."*

Several incentives have been mentioned in this paragraph. However, attention must be given to their extent and possible counterproductive effects.

> *"Where efforts are made to plug the gap created by regulatory exemptions, these are led by 'carrots' such as incentive schemes, advice and information provision; while 'carrot' approaches are crucial for reducing emissions from SMEs, these are not sufficient to achieve the scale of carbon reductions required to meet the EU's emissions reductions targets. Questions remain over the ways in which these are delivered by business support organisations, which primarily exist to promote economic growth and job creation. We argue that low carbon initiatives and energy efficiency programmes are 'bolted-on' to these priorities, meaning that SMEs with stable business plans are deprioritised, and 'contradictory' effects may arise[254]."*

5.4.4. Networks

SMEs networks represent a very positive experience, described, among others by Thollander, Paranova and Johansson[255].

[252] Vickers, I., Vaze, P., Corr, L., Kasparova, E., Lyon, F. (2009). SMEs in a low carbon economy: final report for BERR enterprise directorate.
[253] Triguero, A., Moreno-Mondéjar, L., Davia, M.A. (2011). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics*, August 2013, Volume 92, Pages 25-33.
[254] Hampton, S., Fawcett, T. (2017). Op. Cit.
[255] Paramonova, S., Thollander, P. (2016). Energy-efficiency networks for SMEs: Learning from the Swedish experience. *Renewable and Sustainable Energy Reviews*, 65, 295-307; Johansson, M.T., Thollander, P. (2018). A review of barriers to and driving forces for improved energy efficiency in Swedish industry–recommendations for successful in-house energy management. *Renewable and Sustainable Energy Reviews*, 82, 618-628.

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SMEs can supplement their efforts to improve energy efficiency by participating in industrial energy-efficiency networks (IEENs). This approach has been widely used in the countries listed below.

- Switzerland: currently, around 70 energy-efficiency networks financed by around 2,000 participating companies exist in this country; the annual average reduction in energy cost achieved by each company is €110,000.
- Germany: the German networking model is referred to as the Learning Energy-Efficiency Network or LEEN; currently, more than 50 networks operate).
- Denmark: several energy networks have been established in 100 Danish municipalities), and it has resulted in improved electrical efficiency and increased investment in energy-efficiency measures[256].

In other countries (e.g., Sweden), however, this concept has not been used as widely.

Smaller manufacturers require more guidance, individual support, and implementation assistance. Collaborative activities across companies can help SMEs to implement EEMs. Thus, public support in the form of audits should be complemented by programmes oriented towards energy management issues and collaboration. Networking across SMEs can be a good platform for energy management and collaborative activities.

Thollander, Paranova and Johansson[257] describe how the energy efficiency network works.

> *"In an energy-efficiency network, companies form a group (a constellation of 10 – 15 companies who share their experiences in energy efficiency activities in moderated meetings) coordinated by an external actor on a continual basis to exchange knowledge and share experiences about energy efficiency. The coordinator handles administrative functions and leads the work. The companies obtain consultancy from external specialists to gain knowledge about a particular topic (energy efficiency in cross-cutting technologies, motor efficiency, and so on). Thereafter, a mutual goal is defined, and the companies work cooperatively to achieve it. Performance on the network and company levels is monitored constantly. This type of collaboration can help reduce transaction costs, minimize risks, and increase awareness about energy efficiency. Some network constituents are well-researched, nationally and internationally, with rather developed methods, tools and standards. These include energy audits and energy management practices (…)."*

Most networks for SMEs are funded by public organizations (e.g., The Swedish Energy Agency in Sweden, as well as regional councils), but also by industrial associations, and the companies themselves.

[256] There was also previous experiences in Australia: "Important forces at play in motivating SMEs to operate sustainably are compliance with regulations as a principal driver and pressure from the supply chains. Moreover, regional environmental management systems may be helpful for SMEs to engage in useful networking in the field and to enjoy the synergistic effects of applying environmental management policies to all sectors of activity. This has been explored by the Victoria Environmental Protection Authority" (Kerr, I.R. (2006). Leadership strategies for sustainable SME operation. Business Strategy and the Environment, 15(1), 30-39).
[257] Ibid.

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Knowledge and experience exchange takes place via meetings. Overall, common energy network activities such as meetings, courses, and study visits take place but not regularly. Lectures and seminars are often given 'as needed'. However, competition can limit the information shared. Companies located in the same area may not have much in common. Internal knowledge varies greatly depending on the participating companies' size and the person involved from the companies. External knowledge is delivered by consultants, who educate participants on particular topics. Energy audits are not a common practice in every network.

The most common reason for joining a network is to decrease energy costs. Another reason is interest in energy questions from the top management (using good practices from others). One more reason for joining a network was to establish energy efficiency work in organizations. Networking helped the companies to plan how to decrease their energy use (and to implement it, also thanks of other participants' feedback on the work performed; and an increase of energy awareness among staff, e.g., to introduce energy-related aspects in weekly meeting agendas). Many companies mentioned that they did not have enough time and staff resources to work continuously, even though individuals could be very ambitious. Moreover, networking took too much time and did not give them anything in return (considering the expectations).

There are many ways to improve the existing networks according to the companies. First, it is very important to set goals, mutual and individual, to follow the performance of the companies and motivate them. Initially, profitable energy efficiency measures are identified at each company and targets for improved energy efficiency and CO_2 emission reductions are jointly set. Energy performance is then monitored and evaluated annually. Moreover, make the network meetings less theoretical and more adapted to the respective participants' needs. Concrete technical and practical questions are more interesting to discuss according to the participants. A network must have a driving force in the form of a coordinating organization. Continuity plays a key role because the network's work follows the definite cycle of mapping, planning, follow-up, and new measures as well as agreed goals checked later.

During the meetings, participating companies exchange experiences and new energy efficiency measures are presented by experts.

The process requires commitment and continuous work. Thus, to achieve significant energy savings in SMEs, there is a need to step aside from project-based energy-related activities and introduce energy work into the day-to-day activities of SMEs. With this in mind, energy-efficiency networks can embed energy efficiency in corporate culture and make energy efficiency a strategic organizational issue that plays an important role in the corporate decision-making process. Network participants can get information about available solutions from their peers and eliminate many risks related to technology implementation. Moreover, participating in energy-efficiency networks can shift companies' attention from techno-economic aspects of energy efficiency to behavioural aspects.

In order to facilitate the management of EEN, network management systems have been developed. An example is the Learning Energy Efficiency Network (LEEN) developed in Switzerland back in the 1990s (since then, the approach has been successfully transferred to

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Germany, France and Austria)[258]. LEEN consists of a manual with contract templates, checklists, technical manuals and presentation of energy efficient solutions, about 25 software-based techno-economic calculation tools, and other components. EEN can be seen as a way to conduct energy management with or without a standardized energy management system, where the EEN coordinator partly takes the role as in-sourced energy manager.

A recent report from the International Partnership for Energy Efficiency Cooperation (IPEEC) examines existing EENs and highlights their best practices and success factors in OECD countries. A summary of findings is provided below[259].

> *"EENs have been established in various forms and with various functions to address the many barriers to energy efficiency. In most cases, networks focus both on identifying energy saving potential and supporting the process of implementing an appropriate savings program. Some aim to share expertise in a given sector. There are also networks that focus on the training and certification of energy managers and consultants, or that are established to play an advocacy role and liaise with government institutions towards improved energy efficiency policy design. EENs generally consist of 10–15 medium-sized companies located in a close proximity and often not in the same sector. They serve a number of functions including knowledge sharing, capacity-building, consultation with experts, as well as uniting companies with a common interest. Coordinators are generally external to the network participant and based in energy or environmental agencies or private energy service companies. In their early phases EEN are financed by the initiating organisation but transitioning to participant financed.*
>
> *There are quite specific criteria for establishing and operating successful EEN that can be summarised as follows:*
> - *Participant company/site with annual energy costs of about €1 million to €2 million with annual expenditures material to the business operational costs.*
> - *The EEN includes a variety of different sized companies. • EEN participants do not have the same customers.*
> - *Participants should not be situated far from each other to ensure a good meeting frequency.*
> - *EEN representatives participate in an active and constructive way – they must be sufficiently informed and with authority to make commitments and facilitate action.*
> - *Top management of the participants are included in the flow of essential information and participate in the network once a year.*
> - *The initiating institution has the trust and confidence of EEN participants.*
> - *A network manager/coordinator is a driving force – they have to be educated to be capable to run the network activities and operate in a very professional manner.*
> - *Supporting policy conditions, such as the Swiss CO2 law (The Swiss CO2 law allows companies achieving results through EENs to be exempted from the payment of a CO2 surcharge), are in place to incentivize participation.*
> - *The EEN is able to access well-qualified energy consultants and external experts.*
> - *A common target is established to create a social coherence between the companies, supporting their exchange of information and experience.*
> - *Participation in EEN brings a profit."*

[258] Rhode, C., Mielicke, U. (2015). Learning Energy Efficiency Networks -Evidence based experiences from Germany. Available at: https://www.researchgate.net/publication/281818276_Learning_Energy_Efficiency_Networks_-Evidence_based_experiences_from_Germany

[259] Energy Efficiency Council (2017). SME and community organizations – enabling best practice energy efficiency. Available at: http://www.eec.org.au/uploads/Projects/EEC2017_SMENFP_enabling_best_practice_energy_efficiency.pdf

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5.5. How to overcome barriers?

5.5.1. The centrality of energy audits

Energy audits represent an important milestone to overcome barriers hindering the wide application of energy efficiency actions in SMEs. Spreading the concept and operation of energy audits in this target group is the aim of INNOVES. As highlighted by Fleiter, Gruber, Eichhammer and Worrel[260],

> *"(…) the energy audit helped to overcome information related barriers through a detailed analysis of energy demand (86%) and potential EEMs (80%). (...) Obviously, the energy audit did not contribute significantly to overcoming the two barriers related to risk of production disruption and product quality losses. However, this could also result from the types of EEMs recommended. The cross-cutting technologies mainly recommended in the audits (building insulation, heating system, lighting, etc.) mostly do not affect the core production process or product quality".*

But this is certainly not a sufficient condition as underlined in a document of the European Commission[261]. To implement an energy audit is only a side-objective. It is a tool for reaching the real goal that is better energy efficiency (e.g., "energy savings", as in the text below):

> *"After completing an energy audit, mandatory or otherwise, implementation of the recommendations is necessary to actually realise energy savings (...). It is good practice not to limit financial support to the audit alone, but to also cover part of the implementation. Otherwise there is a risk that the recommendations of the audit report are not realised by a company. This is especially important for SMEs as they do not have the same organisational capacity as larger enterprises to take audit recommendations forward. Some countries, like Germany for example, provide implementation support beyond the actual execution of an audit".*

5.5.2. A targeted policy mix

To overcome barriers, a targeted policy mix is required, as suggested, since 2011 by Sorrell et al.[262] including, in a synergetic frame many initiatives including financial measures, training, demonstration projects and labelling schemes.

> *"Barriers to energy efficiency are multi-faceted, diverse and often specific to individual technologies and sectors. This implies that effective policy solutions will need to address the*

[260] Fleiter, T., Gruber, E., Eichhammer, W., Worrell, E. (2012). The German energy audit program for firms - a cost-effective way to improve energy efficiency? *Energy Efficiency*, 5(4), 447-46

[261] European Commission (2015). The EU Eco-Management and Audit Scheme (EMAS). Available at: https://ec.europa.eu/environment/emas/emas_publications/publications_studies_en.htm. Moreover, as noted in the first part of this chapter, it is not even a necessary condition, given that some SMEs progress in the energy transition (e.g., adopt EEMs) without having ever implemented an energy audit.

[262] Sorrell, S., Mallett, A., Nye, S. (2011). Barriers to industrial energy efficiency: A literature review. UNIDO. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0928765516302846

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particular features of individual energy service markets, the circumstances of different types of energy-using organization, and the multiple barriers to energy efficiency within each. As a result, it is likely that a policy mix will be required, in which several different initiatives work together in synergy. For example, while carbon taxes may create price incentives to improve energy efficiency, the response will be muted in many sectors unless steps are taken to lower transaction costs. Conversely, if such steps are not taken, carbon pricing may need to be unacceptably high to have a significant impact on energy demand. The basic elements of this mix are well established in developed countries and include best practice schemes, demonstration projects, training initiatives, market-based instruments, labelling schemes and minimum standards for the energy efficiency of equipment. The costs and benefits of these individual instruments will require careful analysis, as will the overall coherence the policy mix. To date researchers have paid too much attention to modelling what could be achieved and too little attention to evaluating what policy has (or has not) achieved – and why."

How this targeted policy mix can be designed and implemented? The "recipes" are many.

A detailed approach is proposed by Robin[263] in 2017, based on a "core" role of green SMEs, i.e., SMEs that play an active role in the energy transition. This proposal includes a road map from the assessment of needs to the share of examples and the evaluation of the impact of implemented actions.

"1. Assessing needs: A foundational first step towards effective market and policy action would be to assess green finance needs of SMEs in a given market.
2. Measuring flows: Improving data and analytics on flows of green finance to SMEs to inform interventions (for example, through 'green tagging' of loans).
3. Evaluating impact: Relatively new practice has yet to be fully assessed; important lessons could be learned and experience shared across G7 countries.
4. Setting strategy: financial institutions could be encouraged to develop green finance strategies for SMEs (leveraging existing frameworks).
5. Scaling up success: countries could support the broader use of successful instruments, including bond markets to transfer green SME loans to institutional investors.
6. Focusing on resilience: More work is needed to improve SME resilience to environmental shocks, including through preventive investment and insurance.
7. Public-private leverage: Further work could be done to identify where public capital can best be deployed to crowd in private funds for green finance.

Going more in details on scaling up:
- There is a growing array of practical measures to improve access to green finance for SMEs
- This will require a sophisticated process to develop trusted market definitions and standards for green finance, which can be supported by policy measures (eg labels, incentives)
- Looking ahead, green finance could provide a strategic catalyst for reconnecting finance with the underlying purpose of the financial system and provide attractive risk: returns.
- The task is how to best to scale up this experience and spread best practice to drive solutions to sustainability challenges and reduce environmental risks in the financial system.

Elements for a roadmap could be as follow:

[263] Robins, N. (2017). Mobilizing Green Finance for SMEs in the G7. Available at: https://www.minambiente.it/sites/default/files/archivio/allegati/sviluppo_sostenibile/G7_egf_SMEs_all_presentations_venezia05042017.pdf

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Assessing
1. Understanding the role of SME finance in delivering the sustainability transition
2. Evaluating SME needs for different types of green finance
3. Measuring flows of green finance for SMEs

Connecting
4. Driving a two-way integration of the SME financing dimension in sustainability policies – and a sustainability dimension in SME financing policies.
5. Sharing examples and experience across countries (e.g., private, public; debt, equity; capital markets; fintech).
6. Exploring the value of developing networks of local exchanges and partnerships across international markets

Promoting
7. Improving financial architecture to facilitate green finance (e.g., principles, standards, regulation, reporting, standardized contracts, legal frameworks for capital structures)
8. Providing catalytic financial support for individual SMEs & accelerators including fiscally neutral incentives, guarantees, loans, equity, advisory services & warehousing facilities
9. Raising awareness; commitment by private financial institutions to integrate sustainability opportunities and environmental risk analysis into mainstream SME finance."

It is likely that, for the great majority of SMEs, what suggested by Robin is too complex. However, this road map could be useful for understanding which is the kind of actions to be taken for overcoming barriers that hinder SMEs to reach a better energy efficiency level.

Henriques and Catarino[264] do not build an overall approach to overcome barriers, limiting themselves to provide some guidance. Their fundamental concern is being aware of the complexity of the world of SMEs on the one hand (e.g., "heterogeneity of enterprises") their limits (e.g., "limited resources") and the need of integration of different kinds of measures on the other hand.

- *"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[265]).*
- *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.*
- *Measure to overcome barriers and implement energy management and energy efficiency technologies may be considering energy services that through contractual arrangements can*

[264] Henriques, J., Catarino, J. (2016). Motivating towards energy efficiency in small and medium enterprises. *Journal of Cleaner Production*, 139, 42-50.
[265] Not only involved. Also engaged. "In order to successfully champion energy-efficiency investments, all energy-efficiency actors—scholars, practitioners, and public programmers—need to highlight, as much as possible, the strategic character of energy-efficiency investments. In other words, they need to highlight, whenever it is possible, the impact of energy-efficiency investments on firms' competitive advantage in performing their core business." (Cooremans, C. (2012). Investment in energy efficiency: do the characteristics of investments matter? Energy Efficiency, 5(4), 497-518).

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offer financial support in investments in new technologies, support in managing the intervention within the plant and provide information about existing opportunities

- *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.*
- *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.*
- *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."*

Finally, a more radical approach, based on a socio-technical perspective (e.g., the co-evolution of technologies, institutions, skills, knowledge and behaviours), was also found in the literature review, proposed by Geels and colleagues[266]. According to these authors, change is a difficult process that requires a complex approach.

"A socio-technical transitions perspective is more appropriate for two reasons. First, energy services such as heating and mobility are provided through large-scale, capital intensive and long-lived infrastructures that co-evolve with associated technologies, institutions, skills, knowledge and behaviours to create broader 'socio-technical systems' These systems are termed 'socio-technical' since they involve multiple, interlinked social and technical elements, such as technologies, markets, industries, policies, infrastructures, user practices and societal discourses. Second, a transitions perspective acknowledges specificities of the kinds of change processes involved. Socio-technical systems have considerable inertia, making it difficult for radically different (and more sustainable) technologies and behaviours to become established – such as electric mobility or mass transit schemes. Hence, reducing energy demand involves more than improving individual technologies or changing individual behaviours, but instead requires interlinked and potentially far-reaching changes in the systems themselves – or 'socio-technical transitions'.

The emergence of low carbon innovation has three core processes:

- *Articulation of expectations and visions*
- *Building of social networks*
- *Learning processes along multiple dimensions*

Niches [of innovation] can be said to gain momentum if: first, visions and expectations become more precise and more broadly accepted; second, the alignment of various learning processes results in shared expectations and a 'dominant design'; and third, networks increase in size, including the participation of powerful actors that add legitimacy and expand resources."

[266] Geels, F.W., Schwanen, T., Sorrell, S., Jenkins, K., Sovacool, B.K. (2018). Reducing energy demand through low carbon innovation: A socio-technical transitions perspective and thirteen research debates. Energy research & social science, 40, 23-35.

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6. Chapter Five Going ahead

6.1. Next steps

In the previous chapter we drew the portrait (better: the various portraits) of European SMEs in the framework of the energy transition, showing, among other things, the recent and on-going improvements in the management of energy (energy efficiency enhancement, eco-innovation, etc.), how this process happens and through which measures. Moreover, we identified the barriers that hinder (in the various contexts characterizing SMEs) energy management improvements as well as drivers, motivations and other facilitating factors (e.g., rules, subsidies, networks, external supports) that have the potential to support these improvements to occur and allow to overcome the existing barriers.

One specific measure that can allow energy management improvements in SMEs is represented by energy audits. In the previous chapter, we already put in evidence that energy audits, inter alia:

- Can follow dozens of schemes/procedures
- Can be more or less "personalized" on a single (or on a group of similar) SMEs
- Are not always necessary to adopt energy-efficient solutions (many SMEs adopted them without implementing and energy audit)
- Are useful for identifying measures/actions for energy enhancement, even though the adoption rate is usually low or very low, especially because of all the presence of many hindering factors or the lack of motivational/facilitation factors discussed above.

Energy audits and SMEs are put in focus of INNOVEAS project. Therefore, after the completion of this first part of this study which has been broad in scope (energy culture and energy management improvements in SMEs, that is the "object" of this deliverable), we will focus our attention on the existing non-technical barriers that hinder the use of energy audit to uptake energy-saving measures. At the same time, we will enlarge our information basis, coupling the literature review (almost completed) to the consultation of key-informants among the concerned actors, such as:

- SMEs sole directors, CEOs and other officials
- Energy auditors working with SMEs
- The institutional actor who can contribute to the creation of a favourable regulatory environment for the implementation of energy audits
- Industrial association leaders
- Trade unions
- Financial institutions officials working with SMEs
- Scientific community studying these issues.

These key informants will be consulted at the European level, beginning in the partner countries: Germany, Italy, Poland, Belgium, Spain and Slovenia.

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Although we are at the halfway of the process, we already know a lot on the existing non-technical barriers that hinder the use of energy audit; also because many of them correspond more or less to some of the non-technical barriers in the energy efficiency/management improvement we deal with in the previous chapter (although with many specificities).

It is with this argument that we conclude this text. This topic will be the subject of the next deliverable planned under WP2.

6.2. First elements on barriers that hinder the use of energy audit to uptake energy-saving measures

Such kind of barriers is explicitly mentioned in some studies consulted during the literature review. In some other cases (most frequently) these barriers are among the ones that in general hinder the improvement of energy efficiency/energy management in SMEs.

The main barrier is that, since many SMEs show a strong reluctance to use energy efficiency criteria – and to consider its added value in terms of higher profit potential and multiple "non-economic benefits" (NEBs – cf. Paragraph 3.1.) –, there is no reason for implementing any energy audit.

Beyond this barrier, there are many specific barriers directly linked to the implementation of an energy audit. Some examples are reported below.

- A small number of the SMEs has appointed an energy manager (or, at least, a person specifically in charge of energy issues) or have a specific procedure to systematically enhance energy efficiency. Primarily in micro and small enterprises, there is no energy expertise. Therefore, the possible energy auditors do not have quite relevant interlocutors in many SMEs.
- In many SMEs the entrepreneur has to cover several different roles: operations, safety, administration, sales, marketing, planning, and he/she may also be employed within the factory. Briefly, energy is just one of the issues and there is not a specified focus on it. Therefore, energy auditors may not receive enough attention.
- Moreover, time devoted to energy efficiency activities is usually quite limited and often.
- Also in the (more or less rare) cases where the entrepreneurs are deeply aware of the importance of energy issues (and perhaps on climate change challenges too) they have limited access to economic resources to be devoted to energy efficiency analyses and measures (than a larger enterprise). Therefore, they will do what they can without losing time and resources in an energy audit of which it may not perceive the possible "added value" (with respect to what he believes he already knows about the EEMs to be implemented, he considers that the energy audit would not yield any important further indication).
- Broadly, entrepreneurs are unwilling to spend money for the audit without the certainty of the results (sometimes, he can be also almost certain of a lack of results, etc.).

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- At the same time, in many territorial contexts, not enough subsidies or other incentives are available as well as other tools, such as “energy networks” that can compensate for this possible unwillingness.
- Where such tools exist, there is often a lack of information. Therefore the entrepreneur (that, as noted above, cannot dedicate time to these issues) is not aware of their existence.
- The image of an energy audit is sometimes influenced by previous experiences in energy audits in which the main interest was that of selling a single commercial solution (e.g., selling a new piece of equipment) instead of analysing the whole production process to identify the best opportunities for energy efficiency.
- Energy auditors’ ability is not enough focused on specific energy issues characterizing SMEs (in particular the micro-enterprises); moreover, many SMEs need “personalized” assistance that does not fit a lot with energy audits.
- There is sometimes a worry in disclosing data on production processes (however, these data are needed in an energy audit).
- A remarkable lack of data on energy consumption is common (however, these data too are needed in an energy audit).
- Information regarding energy-efficient technologies and economic incentives (e.g., financing for energy efficiency investments) is not available to relevant decision-makers, or it is only available in a very generic form, not tailored to the company needs.

The foregoing is only a partial list or, if you want, even an “imperfect reasoning” that attempts to explain the low propensity to implement energy audits in SMEs. It represents, together with the vast information contained in this deliverable the base for the continuation of the INNOVEAS WP2 implementation devoted, precisely, to the analysis of barriers that hinder the use of energy audit to uptake energy-saving measures and understand how they can be overcome. Considering, of course, also the so-called “super-barrier”, i.e., all the factors pros and cons better management of energy issues, an improvement of their energy efficiency and rooting of an “energy culture” (and, broadly, an awareness of climate change challenges) in European SMEs.

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8. Appendix

Studies on barriers to energy efficiency

Overview of empirical studies on barriers to industrial energy efficiency, integrating the contributions from recent reviews – Trianni et al. (2016), *Applied Energy* 162

Sector	Area	Main barriers
All sectors	India	Lack of awareness and high initial costs
All sectors	Australia	Low rates of return; long payback periods; auditors assessment inaccurate
Industrial sector	UK	Other priorities for capital investments; lack of time and technology not appropriate
Chemical, Basic Metals, Metal products, Horticulture, Food, Paper	The Netherlands	Other investments more important; technology can only be implemented after existing technology has been replaced; energy costs are not sufficiently important
Electric motor market	Germany	Split incentives; lack of information; hidden costs
Manufacturing SMEs	USA	Too expensive initially; lack of staff for analysis/implementation; cash flow prevents implementation
Mechanical engineering industry	Ireland	Other priorities for capital investments
Non-energy-intensive manufacturing	Sweden	Cost of production disruption/hassle/inconvenience; lack of time or other priorities; cost of obtaining information about the energy consumption of purchased equipment
Foundry, Brick	Karnataka, India	Financial and economic barrier; behaviour and personal barrier; awareness and information barrier
Manufacturing SMEs	Sweden	Lack of time or other priorities; other priorities for capital investment; access to capital
Foundry	Sweden	Access to capital; technical risks such as risk of production disruptions; lack of budget funding
Commerce – services	Germany	Split incentives; lack of information about energy consumption patterns
Pulp and paper	Sweden	Technical risks such as risk of production disruptions; cost of production disruption/hassle/inconvenience; technology is inappropriate at the mill
SMEs	China	High initial capital cost; absence of economic incentives policies; lack environmental enforcement
Metals, Machinery, Food/Drink, Chemicals, Paper, Textiles	Greece	Bureaucratic procedures to get governmental financial support; limited access to capital; increased perceived cost of ECM
Commerce – services	Germany	Lack of information about energy consumption patterns; lack of time; low status of energy efficiency
Petrochemicals	OECD	Shortage of staff and time; competition from other prioritised projects; unfavorable economic conditions
Energy-intensive chemical industry	The Netherlands	Budget restrictions and investment priorities; rules of investment decision making; technology fitting in actual process
Manufacturing industry	Thailand	Other priorities; cost of production disruption; lack of financial incentives
Manufacturing industries	USA	High investment costs
ISI	Japan	Other priority for financial investment; inadequate national policies and regulations; technology not applicable to process
Electricity-intensive commercial and industrial sectors	Switzerland	Lack of interest in energy-efficiency interventions; other priorities for capital investments
SMEs	Germany	Investment costs too high; other investments have higher priority; measure not profitable
Non-energy-intensive manufacturing SMEs	Northern Italy	Access to capital; scarce information regarding energy efficiency opportunities and winning solutions; poor information for the energy efficiency decisions
Process industries with a focus on a low grade heat utilisation	UK	Availability of appropriate infrastructure; utilisation of low grade heat; high capital costs
SMEs	China	Lack of interest in energy efficiency; information and other priorities
Foundry	Finland, France, Germany, Italy, Poland, Spain, and Sweden	Lack of budget funding; other priorities for capital investments; lack of time or other priorities
Primary metal manufacturing SMEs	Northern Italy	Information issues on energy contracts; lack of interest in energy-efficiency interventions; hidden costs
Manufacturing SMEs	Northern Italy	Investment costs; information issues on energy contracts; hidden costs
Selected industries (Iron and Steel, Aluminium, Food, Plastcs, Chemicals)	Ghana	Lack of budget funding; access to capital; other priorities for capital investment
Ceramice, Cement, Lime	Belgium	Other priorities for capital investments; hidden costs; technical feasibility was not studied before
Iron and steel industry	Sweden	Internal economic and behavioural barriers
Primary metals manufacturing SMEs	Italy	Other priorities and lack of competences in implementing the interventions; barriers vary significantly according to the intervention considered
All sectors	Australia	Low rates of return, long payback periods, auditors assessment inaccurate

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