

SME's, energy efficiency, innovation: a reflection on materials and energy transition emerging from a research on SMEs and the practice of Energy Audit

Andrea Declich^{*}, Gabriele Quinti, and Paolo Signore

Knowledge & Innovation, Rome, Italy

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Abstract. The paper presents some results emerging from the EC funded INNOVEAS project, particularly from a study on the non-economic factors that prevent (or facilitate) the adoption of energy efficiency measures and energy audits by SMEs. This study and its results are relevant for a reflection on the role of SMEs for the adoption of new business practices and technologies (including materials) that are conducive to a green transition. Attention will be paid also to those obstacles and facilitating factors that are relevant for the promotion of the circular economy – which is also, in fact, a strategy for achieving energy efficiency. The paper is based on the view that materials are a special type of technology and, as such, are the result of a social construction process. From this angle, materials can be thought of also by considering the actors involved in the process of their development and use. The life cycle of materials, in particular, must be analyzed also considering the role that different actors play in it; not only the technical characteristics of the materials have to be considered, but also the social context of development and application of materials. Such assumptions can be used also for interpreting the role of the actors in the challenges that contemporary societies are facing, particularly the promotion of energy saving and of the circular economy and more generally the transition towards decarbonization and dematerialization. In this paper, the focus is on a particular type of actors, Small and Medium Enterprises (SMEs). They constitute a plethora of economic actors operating in numerous production sectors and at different levels of the value chains. SMEs orientations are important for achieving a better knowledge of the cycle of materials, especially in relation to the possibility of directing it towards the pursuit of environmental objectives such as energy saving and the circular economy. The paper stresses that considering the role of SMEs in such wide social and economic innovation process should illustrate peculiar aspects of the “internal” life of SMEs (culture, organizational skills, etc.) as well as the interaction with other actors within the context of operation of SMEs.

Keywords: SME / energy efficiency / circular economy / materials / social innovation

1 Introduction

Materials are a special type of technology and, as such, are the result of a social construction process [1,2]. From this angle, they should be thought also by considering the actors involved in the process of their development and use. The life cycle of materials, in particular, must be also analyzed by considering the role that different actors play in it, therefore, not only the technical characteristics of the materials have to be considered, but also the social context of development and application of materials.

Such a perspective can be used also for interpreting the role of the actors in the challenges that contemporary societies are facing. In particular, in this paper, the focus is on those challenges related to the promotion of energy saving and of the circular economy and, more in general to the transition towards decarbonization and dematerialization [3]. The attempt is showing how the way in which actors are involved and interact among themselves in the development and use of materials is pivotal for achieving these objectives; indeed, such challenges imply various forms of coordination and consensus building among the social actors and are impacted not only by technological and economic factors but also by factors of a different nature (societal, cultural, psychological, etc.).

^{*} e-mail: andrea.declich@knowledge-innovation.org

The paper is based on the first results emerging from the EC funded INNOVEAS project¹, in the framework of which a study has been carried out concerning the non-economic factors that facilitate or prevent the adoption of Energy Efficiency Measures (EEMs) and, in this framework, of Energy Audits (EAs) by SMEs².

EAs are procedures for assessing the ways in which energy is used in a specific production site and implies the definition of measures to be adopted for saving energy. The practice of EAs for SMEs is a debated issue. It is recommended in the framework of various policies, both at the European and national levels. In many countries it is mandatory only for Large Enterprises but not for SMEs (in some countries such Italy for SMEs too if they use energy intensively). EA is a precondition for the promotion of energy savings, even if this result could be reached – in many cases – without the practice of such a formal procedure. Anyhow, it is part of a wider process through which enterprises change their operations and premises in order to achieve energy savings. It is supposed that the EEMs to be adopted, in general, are singled out through EA (or a similar, maybe less formal³, procedure).

The study was based on a literature review and on in-depth interviews with 42 key persons⁴, also on the obstacles to the practice of EEMs and, mainly EAs, by SMEs. A specific attention was paid to the entire process that begins with the set-up of an enabling frame that should allow the decision of a SME to change its current practices, undergo an EA and, then, introduce the appropriate changes to save energy. Focusing on the process implied considering not only SMEs, but also other types of actor that compose the context in which SMEs operate and affect their decisions, such as policy makers and local authorities, industry associations, consultants, financial institutions.

This study and its results are relevant for a reflection on the role of SMEs for the adoption of new business practices and technologies, including materials, that are conducive to a green transition. From it emerge also information on those obstacles and facilitating (or driving) factors that are relevant for the promotion of the circular economy (CE) (which is, in fact, also a strategy for achieving energy efficiency).

This paper is organized in four sections, in addition to this introduction.

In the following section, the relation between circular economy, energy efficiency and materials and the role of SMEs are explored. Section 3 presents the main results of the study, which mainly focus on obstacles and resistance to the adoption of energy efficiency measures by SMEs. In Section 4 an interpretative framework is proposed and in the Section 5 some considerations are made about the application of these results to materials.

2 Connections between energy efficiency, circular economy, and materials

The relation between the CE, the green transition and materials is not just generic, but is due to some specific reasons:

1. First of all, as largely acknowledged, the transition towards the CE is related to Energy Efficiency: there would be no point in promoting a CE that does not imply Energy Savings in any form; anyhow, “the coherence of the two approaches is not ensured” [4];
2. Secondly, materials are widely considered as connected to Energy Efficiency because the ways in which materials are used (e.g. by recycling them), designed and produced have relevant impacts on the possibility of saving energy (for the relation between CE and materials, [3–5]).

These relations have a general relevance. Furthermore, what is important is how they are actualized by the many actors concerned with energy efficiency, the practice of the circular economy and the use of materials.

For these reasons, it is important to properly understand the role of SMEs, which are among the actors who are involved in the promotion of CE and the practice of innovation in the use of materials. These relations have wide implications. By its very definition, CE involves value chains widely, in principle entirely. The same can be said for materials: new or innovated materials have to be adopted also by various producers including SMEs. Such changes are going to affect the ways in which a certain value chain is organized. CE and innovation in the Materials field, because of (1) and (2), are also connected since recycling implies different economic relations in the value chain, to a varying degree, including changes in the business models [5,6].

In brief, CE and materials related changes impact the value chains and all the SMEs within them. It is worth stressing, here, that value chains could be seen as part of “socio-technical systems” [7]. They are based indeed, on technologies concerning production, but they consist also in chains of exchanges that imply various types of economic and social relations and include choices of technologies and technological standards, formal and informal networks or relations, sets of relevant knowledge, production culture, regulation systems, industrial relations and so on.

It is for these reasons that it is relevant to consider the role of SMEs in these configurations.

¹ INNOVEAS – INNOVating the uptake of Energy Auditing Schemes for SMEs. This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement N° 847095.

² According to the title I of the Annex to Commission Recommendation 2003/361/EC of 6 May 2003, the category of micro, small and medium-sized enterprises (SMEs) 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.

³ In principle, EAs should be implemented according to ISO/EN standards (ISO 50001; ISO 50002; EN 16247; ISO 14001).

⁴ Interviewed in Belgium, Germany, Italy, Poland, Slovenia, Spain (which are the countries of the INNOVEAS Consortium’s partners), as well as in some European institutions.

First of all, SMEs in Europe are very important economic actors, since they have a big role in terms of overall economic output and employment⁵, as well as in terms of their presence in various sectors⁶, both upstream and downstream within various value chains, often managing the relationship with consumers.

Second, the large presence of SMEs in the economy produces several typical impacts. The literature on SMEs is endless, but it is important to highlight that SMEs are a complex economic and social phenomenon. Their size, in fact, must not lead to believe that they are simple actors whose action is easy to understand. On the contrary, they are very diverse [8] and various types of motivations support their entrepreneurial action, orientation toward innovation and possible participation in the transition toward a greener economy⁷. Their large number, associated with their diversity, is an important factor of complexity in the economy.

Furthermore, because of their importance and characteristics as economic actors SMEs and their orientations are important for achieving a better knowledge of the *social cycle of materials* [1,9], especially in relation to the possibility of directing it towards the pursuit of environmental objectives such as energy saving and the CE. Therefore, the big issue, in this framework, concerns the obstacles met by economic actors like SMEs in the practice of CE and innovation in the field of materials. These are the issues that this paper, through the research we have carried out, is dealing with.

This is the reason why the results of our study on the obstacles met by SMEs to EEMs and EAs (more on the first than on the second) may have a general meaning and are relevant also for analyzing the green transition process, particularly in relation with the CE, and the innovation on the materials sectors. Indeed, the study provides insights on how the SMEs behave in relation with changes in their operations, premises and technologies aimed at saving energy. Not only such changes are aimed at the same objectives as those connected with the green transition, but they also imply dynamics that are likely to emerge in similar contexts and that appeared to us as

typical of the SMEs sector once confronted with innovations of a wide outreach (such as those concerning materials).

3 SMEs and energy efficiency measures

As said above, the study was focused on obstacles met by SMEs to adopt EEMs, especially through the practice of EAs allowing them to identify the actions to be implemented for increasing their energy efficiency level.

It is preliminarily important to dwell upon the context of innovation in which this process of change occurs and to interpret it from the SMEs' viewpoint. Introducing EEMs, as well as adopting new practices connected to the CE innovation in the materials field, often represent for SMEs a real-life condition they have to cope with and adapt. The challenge, in this framework, is different from the typical entrepreneurial innovation – i.e. conquering new market shares, devising a new production process or defining a new product or service and marketing it. The issue is to adapt the firm to the novelty(ies) imposed by the market, or by the law, sometimes through the introduction of new standards (technical or operational). In these cases, the issue at stake is keeping up with the general trend of innovation. The case of the request to practice EAs in order to change the current operations and save energy (and, moreover, to introduce/adopt EEMs) is, under many respects, analogous to adopting a new material within the usual production function, or to promoting activities that facilitate recycling. In general, this type of innovations (that could be defined as “induced” or “derived”) in which economic actors innovate their current practices responding to some wide economic and/or societal trends is promoted by some particular agent. This is the typical case of innovation in agriculture, where new practices are introduced thanks to extension services (see the concept of extension in [10]). This is particularly true for “atomistic” actors such SMEs, especially the smallest ones.

3.1 The importance of the context

One interesting finding of our research study is that the success in the promotion of EEMs and EAs among SMEs does not depend solely on their orientation to change, but also on the behavior of other actors of the context in which SMEs operate. How SMEs are supported to practice EEMs – is crucial indeed, and many obstacles depend on it. Moreover, it turned out that a mix of support actions is essential for making EAs conducive to the practice of energy-saving. In this framework, it is important that help is provided in the implementation of the measures indicated through the EA; that the measures are appropriate to the structure of the individual SME (therefore that the consultants carry out their analysis properly); that viable financial tools are available; that information concerning the procedure is provided in the right way; that the support is provided all along the process

⁵ In 2018, in non-financial business sector (NFBS), approximately 25 million SMEs in Europe are esteemed, which employ almost 98 million people and produce more than the 56% of the EU's added value [23, p. 17].

⁶ In 2017, the SMEs shared of value added generated was around 19% in the manufacturing sector, 11% in construction, 14% in business services, 22% in wholesale/retail, 5% in accommodation and food services, 29% in other sectors [24].

⁷ E.g. the so-called innovative environmentalist companies [20], 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.

and is not limited to the period in which EAs are prepared and implemented⁸. The lesson to learn is that at least partly, SMEs' fate depend on what happens outside the firms' gate, and that the social context matters. For SMEs what is important is not only the demand coming from the market, and the signals that are relevant for their actions and decisions are not only those concerning prices and costs. What is important is also the context that brings about certain decisions, the actors each SMEs cooperate with and their orientation, the policies implemented and so forth. This result – that emerged clearly from the literature – led us to investigate the role of the actors of the context in promoting EEM and EAs.

This lesson is probably relevant also for the subject we are focusing now, the role of SMEs for the promotion of CE and innovation in the field of materials. In this context, connection among firms is crucial, especially because of the integration within the value chain (e.g. through the introduction of new technologies or new standards). Indeed, it is meaningless to talk of CE without considering a strong coordination among firms [4,5, p. 3]. In the CE this connection is relevant because materials and products, in order to be recyclable in a greater or lesser way, impose operating standards different from the current ones. Especially when the involved firms are small, such a coordination is the result of what happens – or does not happen – outside their gates. Something similar happens in the case of innovation in the materials field. If a certain innovation occurs upstream, the adoption of a new version of a certain material cannot be taken for granted, but needs a process of adaptation to the specific needs and characteristics of the different firms (sometimes a huge number of atomistic actors like SMEs). Especially in the case where the adopters are SMEs, this cannot take place without the support of actors outside the firms, who assist them in understanding the novelties, how to marketing them and so on. This process, in general, takes place differently, depending on the specific industry and local contexts. It is to stress that not all the innovation effort can be based on SMEs' resources, especially for what concerns the expertise and the training needs connected to the innovation. Therefore, also in the case of CE and materials, the context is very relevant and, for this reason, some of the information coming from our research on how these

contexts actually work are relevant and can be applied. In the following, some interesting aspects of these contexts are presented.

The various obstacles that have been identified in our research to the practice of Energy saving and EAs have therefore concerned both SMEs as such and the “actors of the context”. Not everything that emerged, while highly relevant, can be applied mechanically to the context of CE and innovation in materials, for the following reasons. The promotion of the energy efficiency is, to a certain degree, more limited in scope and more standardized. In particular, we also focused on the practice of EAs, which is, in most cases, a procedure defined by ISO/EN standards⁹. On the opposite, the range of innovations we talk about when dealing with CE and materials could be, in general, wider and, on also more disruptive. Therefore, we can assume that the type of obstacles identified in our research are, in general, larger once transposed in the realm of CE and materials innovation. Keeping this in mind, we can describe the obstacles we found and present some thoughts concerning their relevance for CE and Materials.

Now that we have presented the first interesting findings of our study, concerning the importance of the context in which SMEs operate and of the interactions implied thereby, it is possible to proceed to present the obstacles (or set of obstacles) met analytically, respectively by SMEs (Sect. 3.2) and by the actors working with SMEs (the “actors of the context”, Sect. 3.3).

3.2 Obstacles met by SMEs

A first set of obstacles concerning the promotion of EEM and EAs among SMEs, were the following [11,12]:

1. The lack of funds and/or access to finance;
2. The fear of facing unnecessary costs (and the so-called “hidden costs”);
3. The lack of internal (in the SME) human resources or the lack of appropriate skills among the human resources present;
4. The difficulty of using external human resources.

The common thread is that most SMEs appear as relatively “weak” actors who have to be careful in practicing innovation. They do not have so many resources for introducing innovations; therefore, they have to consider several types of constraints. It is not just a matter of financial resources (1), but also of access to human resources (3 and 4) that are critical for changing production routines. These problems are compounded by the fact that the obvious lack of mastery in a certain type of innovation increases uncertainty over the implementation process and, consequently, fear of the emergence of unexpected problems (the so-called “hidden costs”, (2)). All this can be considered as the result of the fact that, oftentimes, SMEs operate at the limits of their capacity and they do not have a too large margin of error (using the innovation language, we could say that for them the so-called “death valley” is wider). We can assume that these obstacles are likely to exist also for the transition of SMEs towards the CE and/or

⁸ On this regard, we can mention the German experience of the Learning Energy-Efficiency Network or LEEN; cfr. [21,22]. LEEN (and, more broadly, 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 an insourced energy manager. More broadly, it could be interesting to consider that in such networks “companies get support for a period of three to four years from an external network coordinator to determine energy efficiency potential, implement energy-efficiency measures, and monitor energy performance” [21, p. 295]. “Knowledge and experience exchange take 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” [21, p. 300]

⁹ See footnote 3.

for the adoption of new or improved materials. These are typical obstacles to innovation, especially in the case in which the innovations have many similar traits.

Other similar obstacles were identified through the literature review concerns other aspects of the obviously lower level of development of SMEs as organizations. They are:

5. The lack or inadequacy of technical resources;
6. The difficulty of planning in the medium and long term;
7. Organizational deficiencies.

Smaller organizations tend to perform less organizational functions. This fact implies that they are not as ready as larger organizations to manage technical resources or devote efforts to planning (the shorter planning horizon of SMEs has been also indicated by the interviewed key persons as one of the obstacles in the promotion of innovation whose life span, especially for financial support measures, exceed the one normally considered by small entrepreneurs). In this case too, we can assume that similar obstacles are at work for what concerns the transition to the CE and innovation in the field of materials.

Of course, both the two groups of obstacles could be imagined as less pronounced if the innovation at stake is connected to the core business of the enterprises, basically because such SMEs, even if confronted to a certain lack of resources, or with a low level of internal complexity, are more familiar with that innovation. For example, energy saving and EAs are more practiced within sectors that use energy intensively; the same could be imagined for when talking of CE within sectors that are already used to some form of recycling or, within industry clusters where cooperation among firms is already developed.

Among the obstacles reported in the literature (and generally recognized also by key persons) we can list also those connected to the policies practiced for supporting EEM and EAs. They are:

8. The lack of subsidies and incentives or the lack of knowledge about them;
9. Legislative and/or regulatory difficulties;
10. The lack of information and its imperfections.

Policies for supporting these kinds of innovation, i.e. innovation that should involve the economic system as a whole – or some sectors – are in general very complex, since they work if a huge number of actors operate in a coordinated way. In practice, the energy saving practice of one SME could be negligible in itself, but is relevant if it is a common practice within an entire value chain, district or by the economic system. The problem, therefore, is diffusing practices that, in themselves, could be not particularly profitable. It is, therefore, important that the sets of provisions of policies (subsidies, regulations, etc.) are feasible and well known by the concerned actors. As a matter of fact, obstacles to the promotion of EEMs and EAs emerged as related to the implementation of policies. We can easily assume that such types of obstacles would emerge also in the case of policies aimed at promoting CE and innovation in the materials field. Such policies, indeed, would be similar being addressed to the same targets (SMEs) and implying wide-ranging changes

concerning entire value chains and also impacts on the production routines of firms. It is worth stressing here that these types of obstacles originate outside firms' gates and entails mainly actors that define the context in which SMEs operate. As a matter of fact, resources and subsidies should be made available by policy makers, who produces also regulations, maybe through consultation with SMEs associations; information on the policies provisions should be spread by dedicated bodies; and so on. Of course, entrepreneurs are responsible of keeping themselves informed over policies that are relevant to them, but this is exactly one of the functions that they are not always able to perform correctly (for various reasons, see above). This confirms that the quality of the actors of the contexts in which SMEs operate matters.

Another important group of obstacles that has been identified in the literature concerns the so-called cultural factors. As stated in the frame of the INNOVEAS project [11,12], as a general rule, we could include within Culture visions, beliefs, and representations of reality, that is aspects that impact on the decisions of social actors (therefore also entrepreneurs). The practical relevance of culture can be understood by using the reflection proposed by Geels et al. [7] 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”.

The presence of an energy culture is considered important, in the literature (but emerged also in our interviews to key persons), for the promotion of EEM and the practice of EAs. We classified the phenomena emerged in the literature review into the following areas.

- The general propensity towards technological innovation.
- 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.

Examples of phenomena related to SMEs culture emerged in the literature (and generally also from the interviews). SMEs, according to various studies, do not pay attention to EEM because of:

11. The lack of sensitivity to environmental issues;
12. The internal lack of time;
13. The emergence of more urgent priorities.

These phenomena have all to do with a specific conception of the firms' core business in which environmental issues are not relevant. The lack of sensitivity to environmental issues, that is often indicated as an important

obstacle, is clearly an aspect of energy culture. The lack of time is certainly a fact of reality – entrepreneurs are in general very busy people and human resources tend, in general, to be used as much as possible. On the other hand, the lack of time is also the result of an assessment based on a scale of priorities and values. A similar comment could be done for the existence of “more urgent priorities”.

In the literature emerged other phenomena that are connected to culture of SMEs, and concern the fact that Energy issues are sometimes divisive issues, or that there is no agreement within enterprises over the impact of the innovation introduced.

14. The plurality of interests (perhaps divergent) and points of view and, more generally the malfunctions in decision-making processes;
15. The lack of trust (in the market; in other interlocutors; in the announced future benefits; in the future, etc.).

We can assume that cultural dispositions are relevant not only for the pursue of Energy efficiency, but also for the promotion of the CE. Both Energy Saving and CE have to do with a vision of the future connected to the environment, and with the idea that the firms’ core business could be positively informed by such a vision. Of course, this implies also materials, as long as innovation in this field is connected to the promotion of CE.

In general, what is relevant about the cultural factors is that they matter on SMEs decisions over production and innovation. Culture –by its very definition– goes beyond individuals and single organizations, being related to the context. In practice, we can expect that the culture of producers (in this case, of SMEs) is related to the culture of the social context in which SMEs operate. In general, from our research emerges that we cannot expect a wide (i.e. impacting several traits of value chains) innovative effort if it is not backed by a shared orientation among various actors. A “visionary” small entrepreneur would risk of not being understood by those who provide credit, by employees, and by other actors who have some stake in the practice of innovation. Not to speak of the clients, who would be impacted by the new practices as long as they belong to a certain value chain, or of the local contexts. This is one of the results of the studies of the pioneer initiatives of “industrial symbiosis”, that concern not only CE but also the materials field [13].

3.3 Obstacles met by the actors working with SMEs

In some cases, as stressed before, obstacles emerge in the context in which SMEs operate. For this reason, we have dedicated our research also to investigate the obstacles specifically related to the actors operating within such a context (and, of course, that are external to SMEs). We have singled out two types of actors:

- a. actors who enter directly in contact with enterprises such as Energy Auditors and other SME’s consultants;
- b. actors who do not maintain relations directly with enterprises, such as SMEs associations, policymakers, financial actors, etc.

The types of obstacles they meet are partly different and, also in these cases, they seem relevant for the promotion of CE and the related innovation in the field of materials.

The actors working directly with SMEs, meet the following types of obstacles:

- I. Lack of a general Energy Efficiency expertise;
- II. Lack of specific skills on the target of SMEs;
- III. Difficulties in language and communication with SMEs;
- IV. Skepticism from SMEs considering the complexity of the consultants’ world;
- V. Quantitative shortage;
- VI. Lack of motivations.

These actors are important since they are those who are at the interface between the technical-production core of SMEs and external inputs, also of a technological type. In general, it seems that there are difficulties of different nature in playing this “brokering” role. It turns out that, mainly for what concerns regulations on Energy efficiency and the practice of EAs, they lack expertise (we have seen above that regulation are very uncertain). Furthermore, consultants are reported as being somehow not very well equipped with the specific skills needed for providing services to SMEs (from the ability to consider the great variety of production processes and to follow innovation projects all along their life-cycle, to the capacity of approaching SMEs properly). Furthermore, these professionals and consultants tend to use a specialized language and, in general, there is a certain lack of trust toward them and skepticism about their role (it is reported that once this barrier is overcome, relationships become easier). Another obstacle that has been singled out is that consultants are not particularly motivated to provide services to SMEs, because of the obstacles listed above and of the uncertainty and relatively small profitability of this activity. Finally, it came out that the number of skillful consultants is not sufficient to cover the demand.

In general, we could expect that similar obstacles might emerge in the course of the transition toward the CE and also for the promotion of innovation connected to materials. We might also expect that these types of obstacles could be bigger since the technological and economic aspects of the transition to CE are more complex (more advanced knowledge is required, as well as deeper changes in the core business) compared to the relatively simpler implementation of EEM (or of the EAs). Furthermore, we can expect that the need of a more complex coordination among the actors –especially within value chains– would compound these sets of difficulties, especially for what concerns technological and operational standardization. The insufficient number of competent consultants able to deal directly with SMEs can be expected to be relevant too.

Similar conclusions might be drawn concerning the second kind of actors of the context, those who do not enter in the SME’s internal dynamics. The types of obstacles that emerged to their contribution to the practice of EEM and EAs were the following:

- i. EEMs and EAs costs;
- ii. Energy culture-related barriers;

- iii. Lack of awareness about the benefits of EEMs and EAs;
- iv. Lack of personnel with appropriate skills;
- v. Ineffective action for involving SMEs;
- vi. A limited focus on SMEs specificities;
- vii. Their limited capacity to orient policies in the right direction.

The first type is of a particular nature. Whether EEMs and EAs costs are high or low is almost a matter of interpretation: would SMEs consider EE as a priority, the lack of firms' funds could, indeed, be offset by credit and paid back in due time. The "actors of the context" contribute to the definition of the most common interpretation and some actors like SMEs associations, according to some key persons, accept the idea that EAs' costs are too high for SMEs.

Obstacles to the practice of EEMs and EAs, more generally, have also a cultural nature (ii). This is a very relevant issue, as highlighted above, and what is important is that, in many cases the actors of the context – for example SMEs association – tend not to consider energy as a priority and they do not always have an energy culture to act consequently, and the same could be said for financial institutions (of course, in both cases there are exceptions and culture is reported as changing towards more environment friendly positions). The idea that these actors have about SMEs' "lack of time" to devote to EEMs tend to be similar to those of entrepreneurs. Overall, it can be said that the presence of a widespread culture conducive to Energy Efficiency cannot be taken for granted. From the interviews it seems that cultural barriers to EEMs and EAs are not located only among SMEs and that a weak energy culture is oftentimes shared among the diverse "actors of the context". Not surprisingly, SMEs demonstrate a lack of awareness (iii) of the importance and relevance of Energy issues. Therefore, there is not much effort on the matters among the actors of the context (including, according to some, consumers' associations).

Other obstacles of an operational nature (iv–viii) (as opposite to the cognitive nature of culture) characterizes this type of actors. Personnel working in these organizations are not always well trained for supporting EEMs and EAs policies and implementation, including because of a lack of deep knowledge of energy issues. This concerns the ability to keep relations with other actors of the context (e.g. the auditors), as well as to communicate with them or to provide services to SMEs appropriately (because of the knowledge of financial or funding mechanisms). This issue is particularly relevant as long as SMEs, as stressed before, lack the organizational characteristics, skills and knowledge needed for implementing those innovations connected to EE and EA. This limited orientation of the actors of the context towards SMEs has resulted in a generalized lack of mobilization of firms on EEMs and EAs, including through approaches that, when implemented, proved to be effective, such as the promotion of Energy Efficiency Networks (see also footnote 8). In general, the actions promoted by these actors of the context was not much

focused on SMEs needs and specificities: SMEs, for example, are not very confident in the financial system and this obstacle is not particularly addressed and, in some cases, the support policies for accessing credit foresaw repayment periods that are longer than the usual time horizon in which SMEs feel confident. Policies for EEMs and EAs are very fragmented, but no significant initiatives were taken in order to make them more practicable for SMEs and also to reduce the uncertainty that normally characterizes these policy tools. Policies, sometimes, have been reported as implemented without being preceded by a wide dialogue with enterprises.

These sets of obstacles originated not among SMEs but within the milieu in which they operate could be probably replicated when proposing other wide innovations, such as those connected to the CE or to materials. The problem is connected to the atomized and diverse SMEs sector and to the actors that operate in the same context. It was singled out, in our research, a lack of "consonance" of SMEs and the other actors of the context. The lack of appropriate skills, or an appropriate culture of change among the actors of the context is likely to emerge again in relation to innovations that are more challenging, technologically and societally, than only energy savings.

3.4 Some remarks about "drivers" to the practice of EEMs and EAs

Our research included also an analysis of the factors that facilitate (or the "drivers" of) the practice of EEMs and EAs. The results were in line with what was highlighted by the study of the obstacles. Basically, the drivers mirrored the obstacles proposed above (e.g. the presence of subsidies is a driver whereas their lack represents an obstacle). The relevance on "internal motivations" that could be included – or be considered – as "cultural drivers" were also stressed, particularly in the literature. A study implemented by Thollander et al. [14] in various European countries (Finland, France, Germany, Italy, Poland, Spain, and Sweden) on the drivers to EEMs in a sample composed mostly by SMEs confirmed the importance of factors such as the long-term strategy, or the environmental company profiles.

An element of particular interest emerged from the analysis of the drivers consist in the confirmation of the importance of the context in which SMEs operate. External assistance to SMEs has proved to be a relevant factor of success in the promotion of Energy Efficiency and it is recommended by the EU [15], that stresses also the importance of approaches targeted to SMEs. Not only external support is considered as relevant, but is stressed the role of a milieu that is able to provide it. In this framework, SMEs networks are considered a very positive experience (described, among others by Thollander et al. [14]; see footnote 8). External assistance – duly targeted to SMEs – as a relevant facilitating factor for the practice of Energy saving could be considered relevant also for the

transition to CE and innovation in materials¹⁰. Of course, we should consider also the differences: generally speaking, EEMs could impact firms' operation in several ways, but – in general – they are aimed primarily at lowering energy consumption and energy costs, at least in the mid-term. On the contrary, interventions on CE and the use of materials, in principle, have wider impact on the firms' core business and operations, because they involve not only the individual organization but also the value chains and the clusters, i.e. they affect the firms' milieu more strongly. This leads to infer that the positive impacts of external assistance and motivational and cultural factors could play a bigger role.

4 An interpretative framework

We have tried to demonstrate so far that the findings of our study can be extended so to cover other areas of innovation such as the green transition, the CE and materials field.

In this framework, it is worth focusing the attention on one of the most important, i.e. that the actors of the policies for promoting EEM and EAs have to be considered holistically.

In order to do this, we used a representation of the actors based on four components (or aspects). On this basis, we (re)read the results of the research concerning the “actors of the context” and of the SMEs, all relevant in determining the action in favor of the EE and the possible practice of EAs [16–18]. We referred to the following components:

1. The culture of the actors, therefore their values and worldview that inspire and give foundation to their action; particularly, the focus will be on the energy culture
2. The orientation to change (or agency), i.e. their motivation to act in order to promote energy efficiency and, in this framework, to practice Energy Audits and the related measures
3. The action, i.e. the operational aspects (and difficulties) met by the actors connected to the actual implementation of activities aimed at promoting energy efficiency
4. The identity, i.e. the capacity of an organization to implement its own objectives and programs related to the promotion of EE and EAs through its staff, internal regulation, routines and infrastructures, through the relationships with external players; the endowment of human resources and skills.

Such a perspective is based on a double assumption: each actor has a “cognitive” dimension and an “operational”¹¹ one, and its efforts are both aimed at self-construction and at

modifying external reality. Culture is cognitive and is inward-looking, while orientation to change is cognitive but has to do with the modification of external reality. Action, is both operational and outward-looking, while identity is an operational aspect of the life of an organization dealing with its internal reality.

This fourfold approach is useful also because it helps in comparing diverse actors. It is possible, in other words, to check if an obstacle is originated in the culture or in the orientation of the actors or in the ways they act or organize themselves. Because of the centrality of the context, this approach makes it possible to understand if the actors are in consonance among themselves in relation to certain components (e.g. the culture or the orientation to change). Furthermore, it is possible to control if each of them is experiencing a certain degree of internal dystonia (e.g. an actor has a positive energy culture but does not have the strength, or the capacity, for acting accordingly).

On this basis, we classified the barriers singled out through our sources according to these four categories as shown in Table 1 (that is not exhaustive, but includes most of the main important barriers).

Such a scheme helps us to better frame the issue of how to promote a wide innovation effort that is societal in scope, since it does not only involve the enterprises. We see, for example, that cultural issues concern various actors (cell 1) and this does not make the issue of how promoting a cultural shift towards energy friendliness so trivial, since those who should promote such a shift are not necessarily in line with this value. But the issue is not just cultural, since the decision to change (cell 2) depends also on the interaction among the actors (e.g. lack of mutual trust). Furthermore, action is made difficult by “objective barriers” (cell 3) and should be implemented by actors who are not strong enough to undertake such changes (cell 4). This interpretation scheme is useful also because it helps us understand that barriers are both “cognitive” (cell 1 and 2) and operational (cell 3 and 4), and they can be overcome through different strategies: discursive and aimed at producing more consonance among different actors in the first case, and “institutional”, based on rules, incentives and other typical policy levers, aimed at facilitating and strengthening the actors, in the second case.

Furthermore, such changes should be promoted consistently: energy culture is meaningless if it is disjunct from the ability to practice it or if actors cannot deploy their orientation to change because of systematic hindrances to action. Finally, policies should involve all the diverse types of actors and not just SMEs.

This perspective is interesting also for figuring out other aspects of the obstacles that are relevant for CE and materials. Cultural issues and orientation to change emerge as specific aspects that are not only relevant for individual players, but that should be considered important for the milieus in which firms operate (composed of diverse actors). As for more operational issues, obstacles might emerge not only for the very practice of innovation, but also when individual actors' internal characteristics are considered. We could imagine that “weakness” of the actors should be fully considered, including the ability of the actors of the context (consultants, policy makers, industry association,

¹⁰ The importance of an enabling environment composed of diverse actors is recognized as fundamental for these kinds of innovation, as in the somehow “ideal-type” case already mentioned above of industrial symbiosis.

¹¹ The cognitive dimension concerns the mental aspects of action, that is ideas, representations, interpretations, worldviews and values; the operational dimension has to do with external (to individuals) and explicit aspects of action such as the use of resources, technologies, norms, institutions, etc. (see below).

Table 1. Classification of barriers according to four catégories.

<p>1. Barriers related to energy culture Lack of a strong generalized energy culture among SMEs and the “actors of the context”, for example:</p> <ul style="list-style-type: none"> ●Lack of a widespread awareness of the relevance of EE, including of EAs ●Specialized/engineering culture among Auditors and Consultants that create difficulties in communication ●Energy issues are not a priority among many actors, including those of the context ●Scarce consonance among the “actors of the context”. 	<p>4. Barriers related to the strength of the actors SMEs and “actors of the context” are, generally not well equipped for the effective practice of EAs and EEMs.</p> <p>SMEs, in general, have little or no expertise concerning EE and EAs issues or people dedicated to them; especially in micro and small firms, the entrepreneurs have to cover several roles, no specific attention is put on these issues and oftentimes the time to devote is very limited.</p> <p>As for the “actors of the context”, it can be said that they:</p> <ul style="list-style-type: none"> ●Are not able to interact properly all the various types of SMEs; ●Oftentimes are weak from several points of view relevant for dealing with SME because of inadequate knowledge of the funding systems for the promotion of EAs and EEMs, scarcity of human resources to dedicate to the promotion and implementation of EEMs and EAs ●Have difficulties in adopting correct communication approaches.
<p>2. Barriers related to orientation to change Scarce orientation to change among the actors, for example:</p> <ul style="list-style-type: none"> ●Reluctance of SMEs to undertake EEMs and EA because of the possible economic and operational burden ●Reluctance of Auditors to support SMEs ●Low level of mutual trust among different “actors of the context” ●Just a minority of actors has taken on a proactive orientation towards EEMs and EAs. 	<p>3. Barriers related to action Type of barriers to action are:</p> <ul style="list-style-type: none"> ●SMEs’ resources to dedicate to EEM and EAs are, normally quite limited ●Regulations aimed at favouring the practice of EAs and EEMs, in general, is very complex ●Lack of clear information concerning the procedures for practising EAs and EEMs ●The practice of EA is different for different types of firms. The need for protocols that fit the specificities of SMEs is not addressed ●Difficulties in communicating among the diverse actors involved in the promotion and practice of EAs and EEMs ●Lack of coordination among the actors in the promotion, implementation and evaluation of policies.

local authorities, etc.) to deal with SMEs. All this implies that policies consider CE and innovation in materials not only under the angle of the strict economic rationality, but also in terms of interactions within industry, culture and “orientation to change” (or “agency”).

5 Conclusion: obstacles to energy efficiency, obstacles to new materials

Our research provided an overview of a complex issue that has been dealt with widely in the scientific debate. The nature of data we collected – through a literature review and qualitative interviews of key persons – made any kind of quantification difficult. Nevertheless, we think that we provided useful elements to orient policies aimed at promoting the practice of EAs and EEMs by SMEs. We think that the study provided also useful insights concerning the promotion of green transition, and of a wide innovation related to the CE and materials among a broad set of actors and SMEs. This article’s aim was not scrutinizing specific policy choices and practices. Such an aim would request some further fieldwork to go beyond the

(re)interpretation of the results of the INNOVEAS project. We aimed, instead, at singling out, based on such results, some principles for new policies and practices related to green transition, CE and the materials.

We have argued in the paper that many of the conclusions of our study can be extended since the promotion of EEMs among SMEs is an innovative effort that shares similar characteristics with innovation in the field of CE and materials. An important aspect is that promoting innovation among SMEs implies considering what happens outside their gates, in a milieu composed of various actors. Another aspect should be considered: the innovation in these fields are aimed at producing not so much a competitive advantage for the individual firm, but a diffuse upgrade of firms productive and operational capabilities (in terms of using new materials and entering a wide recycle system). The degree of profitability of such changes should be seen more as a “*conditio sine qua non*” of their implementation than the main motives for being practiced.

In short, it seems that the introduction of energy efficiency measures and innovation about materials have more the character of “social innovation” than of an economic innovation. This perspective could change how

the transition to CE or materials innovation is understood. Social innovation has a wider meaning than economic one, being defined by the EU as

“new ideas (products, services and models) that simultaneously meet social needs (more effectively than alternatives) and create new social relationships or collaborations. They are innovations that are not only good for society but also enhance society’s capacity to act” (European Commission 2011, 33).

Using the concept of social innovation, according to some¹², implies considering the new practices in terms of the following 4 characteristics:

- Inclusiveness (diverse actors have to be included in the innovation process, including those external to SMEs and not only the actors strictly implementing a certain new practice);
- Contextualization (actors are involved in specific territorial, market and historical contexts; innovations are not related to just the individual firm, that is too small for implementing this innovation alone);
- Reflexivity (mobilizing various actors, including firms, implies that they reframe somehow their ordinary routines and core business under various respects);
- Responsiveness (the actions of individual economic actors, especially of SMEs, take place by resonating with those implemented by other actors; the related choices should be negotiated, somehow, with other actors within the respective operational context).

The use of these 4 categories for promoting the transition toward CE and the related innovation in the materials field could represent a significant change in the approach that could be worth being experimented.

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¹² SMARTEES project. See <https://local-social-innovation.eu/>.