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Published in:
Sustainability (Switzerland)

DOI:
10.3390/su131810108

Published: 01/09/2021

Document Version
Publisher's final version

sustainability

MDPI

Article

Enabling Small Medium Enterprises (SMEs) to Become Leaders in Energy Efficiency Using a Continuous Maturity Matrix

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Abstract: SMEs play a crucial role in economies by providing large scale employment and contributing to much of the GDP. Despite their vital role, SMEs face a plethora of challenges, and often, the aspect of energy efficiency is overlooked. This paper conducted studies across Finland, Switzerland, Austria, Italy, France, and Germany and devised an easy and ready-to-adopt approach to improve energy efficiency in SMEs. The new approach is based on a maturity matrix that supports continuous learning and development and provides expert recommendations on energy efficiency for SMEs around the world. The expert recommendations are based on a final score and aim to address the various challenges that SMEs face, such as limited access to knowledge and lack of awareness of energy efficiency. The approach may be easily adopted by any SME around the world.

Keywords: SME; energy; people; behavior; maturity matrix; energy efficiency

Citation: Fatima, Z.; Oksman, V.; Lahdelma, R. Enabling Small Medium Enterprises (SMEs) to Become Leaders in Energy Efficiency Using a Continuous Maturity Matrix. *Sustainability* **2021**, *13*, 10108. https://doi.org/10.3390/su131810108

Academic Editors: Cristina Piselli and Verena M. Barthelmes

Received: 24 May 2021
Accepted: 3 September 2021
Published: 9 September 2021

1. Introduction

Over the past five years, the European Union (EU) has marked significant progress within the internal market for electricity and gas, sponsoring energy efficiency action, promoting energy deployment, emphasizing greenhouse gas (GHG) emissions reductions, and a stronger carbon price signal. In 2019, the EU introduced the European Green Deal (EGD), having a set of 50 actions for the coming five years across all sectors to prepare the EU economy for climate neutrality by 2050. However, in order to achieve climate neutrality, the focus must be placed on transport, industry and buildings, alongside policies that support energy system integration. Evidence showed that in 2020, the EU face 7–10% economic downturn owing to the COVID-19 health crisis. While the crisis led to a decline in energy and lowered the levels of carbon dioxide and air pollution in Europe, this should not lead to complacency. Experts foresee a rebound in emissions and an increase in energy use, supported by very low global commodity prices. The fact that the energy sector—production and use—accounts for 75% of the EU's greenhouse gas emissions, efforts are required to mitigate such a rebound across the economy, including in buildings/heat, industry, and transport [1].

1.1. SMEs as Contributers to the Economy

Small and medium-sized enterprises (SMEs) play a vital role in most economies, particularly in developing countries. SMEs contribute to the majority of businesses across the world and are essential for job creation and global economic development. Evidence shows that SMEs represent about 90% of businesses and provide more than 50% of employment worldwide [2]. In particular, formal SMEs contribute up to 40% of national income (GDP) in emerging economies, while the numbers rise significantly when informal SMEs are included. According to the World Bank, 600 million jobs will be needed by 2030 to cater to

the need of the growing global workforce. Thus, SME development must be a high priority for governments around the world. In emerging markets, most formal jobs are generated by SMEs, which create 7 out of 10 jobs [2].

In Europe, there are 25 million SMEs and altogether they contribute to roughly 50% of the GDP. Two out of three jobs are provided by SMEs and in addition, 50% of all SMEs undertake innovation activities [3]. The European Commission considers SMEs and entrepreneurship as key to ensuring economic growth, innovation, job creation, and social integration in the EU. However, in official statistics SMEs can currently only be identified by employment size as enterprises with fewer than 250 persons employed [4].

1.2. The Need for an Energy Efficiency Intervention for SMEs

Energy efficiency in SMEs remains limited due to a number of challenges that SMEs face [5,6], as also explored in this paper in the next section. To the best of the authors' knowledge, there has been little focus on SMEs to improve their energy efficiency. Richert [5] created an energy management framework for SMEs using six-steps that included (1) staff sensitization, (2) energy measurement, (3) analyses, (4) optimization, (5) reflection, and (6) strategy alignment. The framework described a resource-light way, while creating managerial awareness with the help of real-time data measurements. Kannan and Boie's [6] study on energy management in SMEs focused on the operation of a bakery in Germany. The study identified areas for energy saving, such as conservation in baking ovens, lighting, managing use of hot water, insulation of pipes, and recalibration of the thermostat. Latapi et al. [7] identified and categorized the barriers related to corporate social responsibility, but the focus was Nordic energy companies. Trianni et al. [8] investigated 10% of Slovenian small and medium-sized manufacturing firms, and claimed that decision-makers carefully look at the multiple effects (either positive or negative) that energy efficiency measures may have on a number of other production resources, particularly on those closer to the production (shop floor). Very often more energy intensive SMEs do not give higher priority to energy [8]. A study conducted in Derbyshire, UK showed that the majority of SMEs had taken steps to reduce their carbon impact, but most do not monitor or set targets for managing carbon usage. Furthermore, very few publicized their activities, despite some successful results [9].

It must be highlighted that energy audits may not suit the SME circumstances as they are not enough to explore the full range of efficiency potentials due to the barriers inherent to the SMEs and the "one-size-fit-all" nature of such programs [5,10]. SMEs offer great energy savings potential, such as 37% as achieved by Richert [5], particularly because SMEs' have the advantage of flexibility, direct communication, as well as immediate employee impact [5]. Research shows that change in perception of managerial staff is known to make a remarkable difference and develops a more continuous approach through use of maturity matrix instead of a one-time evaluation of SMEs [5].

1.3. The Purpose of This Paper

This paper presents an energy culture approach to boost energy efficiency in SMEs. It is not enough to only focus on constructing sustainable buildings, since occupants play a significant role. Gill et al. [11] investigated the energy performance of UK EcoHomes and described that energy-efficient behavior accounts for 51% of the variation in the heating use and 37% of the variation in electricity consumption. With the improvement in building technologies and materials, the associated impact of behavioral factors becomes more significant [12]. Occupants interact with building systems to secure comfort, such as by adjusting lighting and temperature, which affect the building energy demand [13]. Occupant behavior is nonetheless always uncertain, which limits the capability of energy models to correctly predict actual building performance [14].

The paper serves two important purposes together: First, it places a strong emphasis on the individual managerial level i.e., the Energy Manager. Second, this paper illustrates a new continuous maturity matrix method that integrates the human factor and employee

(occupant) participation to a high degree while also including the managerial staff. The continuous evaluation method of the maturity matrix ensures that the energy evaluation of the SME is not only one-time, but it can be evaluated continuously and as many times as possible to ensure the energy efficiency measures are effective in terms of productivity impacts and the goals set by the management. This paper also ensures that the employees adopt energy efficient ways and are aware of energy efficiency matters, thus leading towards building energy savings.

The new method may be adapted for each SME with no capital costs while providing them all necessary energy related information readily. This new approach has been developed as part of the EU H2020 IMPAWATT [15] project that strongly focuses on supporting SMEs to become highly energy efficient by networking with experts and training the staff on energy efficiency to enhance in-house energy culture. The approach has been developed by taking into account real end users (employees) and by working together with the SME managers themselves to understand the complete situation. Hence, the project diagnosis is not based on imaginary end users. The IMPAWATT approach integrates the technical, managerial and behavioral aspects simultaneously. It may be readily adapted without compromising daily obligations and work hours.

The research questions have been formulated as follows:

- What are the current practices within SMEs and what is the opinion about energy efficiency?
- What tool can be used in SMEs to encourage awareness and more energy efficient behavior?

This paper is structured as follows: Section 1 is the introduction. Section 2 describes the background study conducted during the project to understand the SME energy practices. Section 3 describes the new approach developed to support SMEs with energy efficiency. Section 4 is the discussion and conclusion.

2. Materials and Methods

The background study was conducted in several steps which provided valuable support in developing the new energy efficiency approach for SMEs (Table 1).

Table 1. Research questions of the paper.

Research Question	Method
What are the current practices within SMEs and what is the opinion about energy efficiency?	Direct interviews with stakeholders
	Literature review on barriers of energy efficiency in industry
	Developing an online questionnaire for selected SMEs and key findings from the online questionnaire
What tool can be used in SMEs to encourage awareness and more energy efficient behavior?	Understanding the potential role of maturity matrices in enhancing energy awareness

2.1. Direct Interviews

A set of direct interviews were held with a group of significant stakeholders, such as representatives of associations, energy managers, energy experts, and policy makers who have strong experience in energy efficiency in industrial and service sectors. These experts also belonged to the project advisory board and remained active during the project lifetime. A total of six expert interviews were organized in Finland, Switzerland, Austria, Italy, France, and Germany.

2.2. Literature Review on Barriers for Implementation of Energy Efficiency in Industry

The review was completed in collaboration with the project partners. Each partner identified relevant studies and reports, which allowed identification of the state of art, better specifications of the online questionnaire content, and better identification of specific barriers to investigate through the questionnaire.

Existing studies on energy efficiency barriers, such as Chan and Kantamaneni [16], refer to different types of categories in SMEs. The lack of access to internal or external capital is observed as a major barrier, and as such, the priorities for capital investments will predictably focus on increasing output rather than energy efficiency. Sorrell et al. [17] developed a taxonomy of barriers for energy efficiency and categorized them into four main theoretical frameworks: economic non-market failure, economic market failure, behavioral, and organizational. Cagno et al. [18] further developed this taxonomy by adding 'perspective' as a potential barrier. This is supported by the fact that policy makers often address barriers from an external perspective, which results in policies lacking sufficient buy-in from the enterprise. This creates a situation where internal and external perspectives diverge. Although the Energy Efficiency Directive aims to address such internal issues, there is still a lack of focus on internal perspective, which leads to many under evaluated behavioral elements and irrational choices from an external perspective [18].

Several other studies on barriers also exist, for example, Nagesha et al. [19] identified five barrier categories (1) awareness and information, (2) financial and economic, (3) structural and institutional, (4) policy and regulatory, and (5) behavior and personal in two small scale industries in Karnataka, India and prioritized them based on the perceptions and experiences of entrepreneurs and stakeholders using the analytic hierarchy process (AHP). Flieter et al. [20] reviewed bottom-up models to understand their capability to model barriers in adopting energy efficiency measures, and discovered that market failures and other barriers for energy-efficient technologies are only partly considered in bottom-up energy demand models.

Trianni et al. [21] looked at 222 manufacturing SMEs located in a Northern Italy region revealing that besides economic barriers, energy efficiency awareness and behavioral issues critically affect the decision-making process. In a similar study, Cagno and Trianni et al. [22] investigated 71 Italian manufacturing SMEs, claiming the need for public financing and external pressures for energy efficiency, such as increases in energy prices and fees on both resources consumed and on emissions of pollutants. Lack of interest in energy efficiency and the existence of other priorities indeed exist as a major barrier and therefore decision-makers tend to downgrade energy efficiency to a marginal issue [23]. A study conducted on Dutch enterprises revealed that external actors mostly consider economic barriers as being the primary barrier, which leads to large mismatches between actors and enterprises [24]. Rohdin and Thollander [25] found cost/risk of production disruption, lack of time, cost of obtaining information on the energy consumption of purchased equipment, other priorities for capital investments, lack of sub-metering, and split incentives as major barriers to energy efficiency in Swedish enterprises. In particular, Thollander et al. [26] discovered that lack of time and other priorities for capital investment were found to be the biggest barrier during a 15-year study in Sweden. Some studies also mention the concept of real barriers and perceived barriers as they both directly contribute to the SME's decision making [18,23]. Indeed, as stated by Cagno et al. [18], the perceived value drives the decision for investment, while the real one is the barrier that the SME should overcome.

Nonetheless, by using intermediaries like local authority energy consultants and regional energy agencies, energy efficiency may be better adopted by SMEs [26,27]. More importantly, the discovered barriers indicate a clear need for external support and ideally this support should be of low cost and be an information resource for the companies [27].

The three following barrier categories were identified through the direct interviews and literature review for the purpose of this article (Table 2):

Table 2. Identified barriers for the article.

	Category Details
Economic barriers of internal origin	• Hidden costs (need for additional resources, training, or equipment) • Additional risks associated to the implementation of energy efficiency measures • Restricted financial and economical capacity
Non-economic "internal" barriers, basically related to organizational and behavioral aspects	• Low sensitivity and awareness levels • Lack of competences and skills at staff level • Energy is not included in the core business • Staff attitude and behavior • Lack of information and imperfect evaluation criteria
"External" barriers, mainly related to the supply chain, the capital suppliers, and the market readiness in terms of innovation and available technology providers	• The supply chain is not developed or the production has still not adequately reached the market (non-industrialized production) • Solutions are complex and hard to be integrated in the context of the organization • Legislative and regulatory constraints • Costs and difficulties to access incentives • Residual uncertainty of the credit system and capital suppliers in the process of assessing the bankability of investments

2.3. Developing an Online Questionnaire for Selected SMEs

Once the barrier categories were identified, the next step was to understand the views of the industries and SMEs and gather additional information on energy efficiency. This was achieved by developing an online SME questionnaire to collect opinions and perceptions that industries and SMEs encounter day by day in the implementation of their energy efficiency measures (Table 3). For example, in some cases obstacles may have been identified through mandatory or voluntary energy efficiency auditing activities. A total of 85 SMEs were invited to the online SME questionnaire. The priority was to have SMEs that have more than 20 employees. The questionnaire (see Appendix A) was developed using Google Forms and included the following details:

Table 3. Online SME questionnaire.

Online Questionnaire
○ Company profile
○ Approach to energy management
○ Analysis of the energy efficiency measures planned/implemented by the organizations
○ Evaluation of barriers in implementation of energy efficiency measures
○ Analysis of the drivers in implementation of energy efficiency measures
○ Analysis of the barriers in planning energy efficiency measures
○ Personal information and contacts

2.4. Key Findings from the Online Questionnaire

Some of the key insights obtained through the online SME questionnaire are highlighted below.

A total of 65 responses were received from the six partner countries (Table 4). About 60% of organizations had a size between 10 and 249 employees, with the rest of enterprises split between those having less than 10 employees or more than 249 (Table 5). The survey also revealed that only 3% of the surveyed companies have an 'Energy Manager'. In

particular, in about 40% of enterprises the energy management tasks were assigned to another position, such as QSE manager or facility manager (Table 6).

Table 4. Surveyed companies for the SME questionnaire.

	Surveyed Companies (Total = 65 SMEs)
France	34%
Italy	15%
Germany	16%
Switzerland	12%
Finland	10%
Austria	13%

Table 5. Number of employees in the surveyed SMEs.

	Sizes of Enterprises
>249	29%
0–9	10%
10–49	31%
50–249	30%

Table 6. Person in charge for managing energy matters in the company.

Person in Charge of Energy Matters	**Responses**
Marketing and IT	1
QSE manager	8
Facility manager	10
External consultant	1
Purchasing manager	1

Out of the 65 responses collected from the SMEs, economic barriers were the most evident for the surveyed SMEs (Figure 1). These include obstacles such as lack of personnel, lack of incentives, and the uncertainty about the real performance achievements in terms of energy saving (conditioning the payback time) and were highlighted by 75–80% of the companies. In addition, difficulties (procedures, time, and cost) for providing necessary data for monitoring the measure was also considered a significant barrier with 52% of answers considering it as important and 23% as very important. The integration of energy efficiency with the context of the organization seems to be a significant barrier with 68% of enterprises having claimed difficulties in integration with the production processes and within the actual organization. Additional barriers included lack of qualified experts and not being able to prioritize energy efficiency measures, and this was highlighted by 50% of the respondents. Table 5 shows the opinion of the respondents for each SME barrier. Figure 2 shows the level of importance of each the listed barrier according to the questionnaire where 'Lack of internal resources for personnel', 'Uncertainty about energy savings, 'Cost', 'Difficulties in providing data, and 'Lack of knowledge about energy savings' were given the highest level of importance by the SMEs. In particular, it is interesting to note that 50%, i.e., at least 30 of the surveyed companies, declared energy efficiency as not being recognized by the company management.

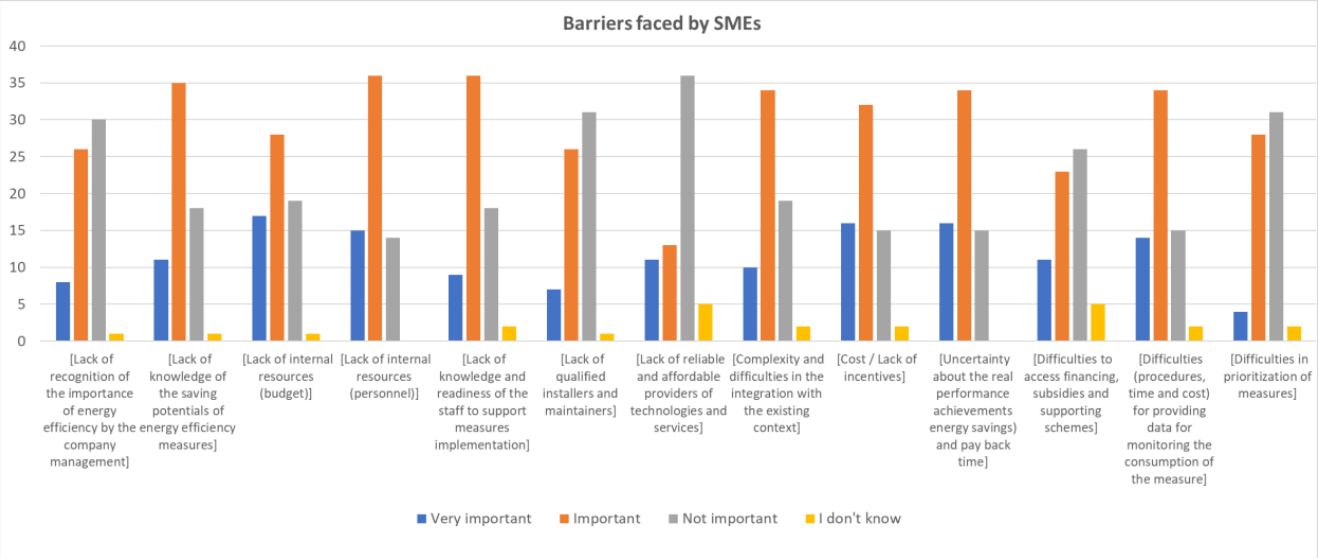

Figure 1. Barriers in the implementation of energy efficiency measures (vertical axis—number of companies, horizontal axis—barriers).

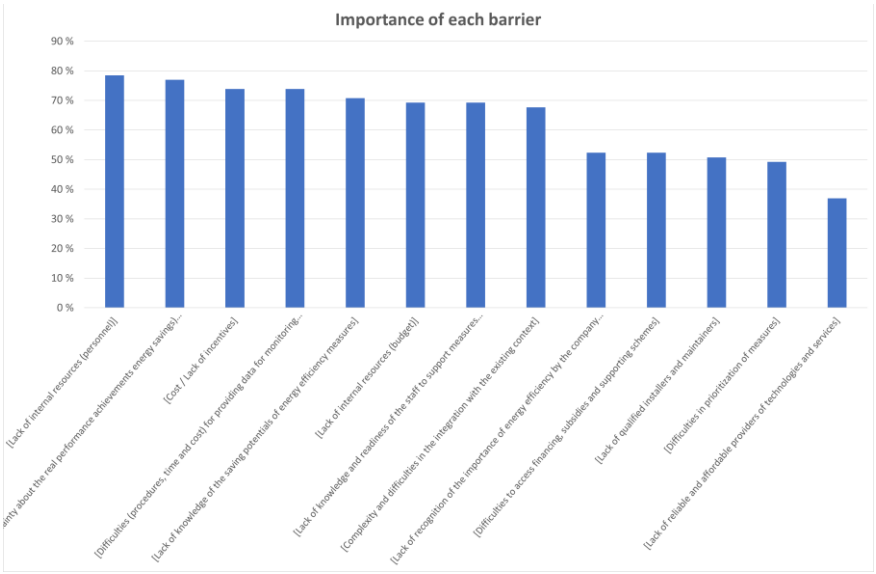

Figure 2. Importance of each barrier according to the online SME questionnaire results.

2.5. Understanding the Potential Role of Maturity Matrices in Enhancing Energy Awareness

Energy-maturity is the ability of an enterprise to efficiently manage its energy consumption [28]. The idea of maturity assessment using maturity grids for an economic control of the quality can be attributed to Shewhart [29] and Crosby [30], after which it soon became a popular tool to process improvement [31]. The industrial applications of the maturity models have been explained in healthcare [32], manufacturing [33], construction [34], and IT services [35].

In definition, a maturity model is a conceptual framework made up of parts that show the development of a selected area over time [36]. Through this process, an organization can develop or achieve something desirable, for example, a set of capabilities or practices, eventually resulting in a more mature organization [37]. Maturity models can be used for three main purposes [33,38–40]:

- Assessment of strengths and weaknesses ("as-is" assessments)—descriptive tool;

- Development of a roadmap for improvement ("to-be" maturity)—prescriptive tool;
- Evaluation of the company, compared to standards and best practices of other organizations—comparative tool

Moreover, maturity models allow presentation of a simplified development path consisting of a limited number of maturity levels (usually 4–6), which are ordered sequentially and characterized by certain requirements to be met [36]. Higher levels of maturity are gradually built on top of the requirements for lower levels [41]. Examples of well consolidated maturity models developed for business applications include the Capability Maturity Model Integration (CMMI) [42] and the organizational project management maturity Model [37].

Maturity grids or matrices are advantageous tools for leading discussions and providing management with a roadmap for next steps [43]. Evidence shows that maturity models or matrices have been of crucial importance in the evaluation of SMEs and their progress in respective fields. Yahiaoui et al. [44] developed a supply chain (SC) maturity model for automotive small and medium-sized enterprises (SMEs) based on the concept of critical success factors (CSFs). Stenqvist et al. [45] describes the maturity matrix as a dialogue tool for sustainable building renovation in Sweden. Rafael et al. [46] focused on the Machine Tool sector that provides high tech products and services to the digital industry and concluded that tools such as the maturity model are very useful as they allow evaluating the initial state of the company and planning a development road map for implementation of Industry 4.0. Mittal et al. [47] review available Smart Manufacturing (SM) and Industry 4.0 maturity models, and examine how they to cater to the specific requirements of SMEs. Pigosso et al. [33] developed a maturity model based on a comprehensive systematization of ecodesign practices to support companies in the continuous process of ecodesign implementation. Jin et al. [48] suggest a maturity model for China based on ISO 50001:2018 and propose five levels of maturity: (1) initial, (2) managed, (3) systematic, (4) improved, and (5) optimized, which occur in four phases. Maturity models can be a toolkit for SMEs and customized maturity models may help by providing a better definition of vision, roadmap, and strategic projects.

Knowing the various types of barriers that exist within SMEs and by further confirming the existence of barriers through direct discussions and the online questionnaires, there is a need to develop a well-rounded approach that caters to enhancing energy efficiency while also addressing the financial, technical, organizational, and behavioral gaps in SMEs. The fundamental role of a maturity assessment is to capture the company's own understanding of the present situation [41]. Thus, the maturity matrix may help SMEs to take the next step towards improving and implementing energy efficiency within the companies and it may serve as a continuous learning-teaching tool to avoid mismatches in decision-making, change behavior, increase staff knowledge, and provide expert advice.

3. Results

With support from the literature review, direct interviews, knowledge about barriers, and the benefits of incorporating a maturity matrix for teaching and learning purposes, the new approach to enhance energy efficiency in SMEs may be summarized in three steps: (1) capturing the current energy culture status in the SME, (2) evaluating the energy culture maturity, and (3) tailored material (Figure 3).

3.1. Capturing the Energy Culture Status in a SME

Energy culture in an organization may be described as an interaction between three highly interactive behavioral elements: cognitive norms (beliefs and understandings), material culture (technologies, buildings, and infrastructure), and energy practices (activities) [49]. When discussing energy culture in a company, the management of the company plays an important role to define the energy policy and setting the goals for energy consumption [7,8]. In addition, energy culture in a company is determined by technological choices and materials used that lead to certain energy behaviors. The concept of energy

cultures may also be drawn from Bourdieu [50], who claims that social life practices are largely generated and regulated by 'habitus', described as 'persistent patterns of thought, perceptions and action' and serve as a response to the objective conditions within which the individual exists [50]. As claimed by Stephenson et al. [49], cultural traits are alterable, and they can be rapidly adopted by new groups in conducive conditions.

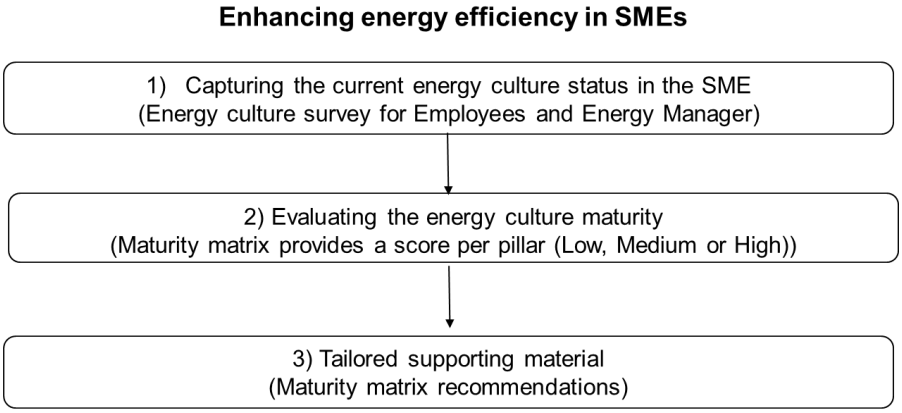

Figure 3. Enhancing energy efficiency in SMEs.

Following the previous studies and incorporating the knowledge about the barriers that SMEs encounter, five pillars were developed to cover all possible and wider influences of energy efficiency in the SME. The pillars provide a strong foundation and identify what sort of interventions may be effective to bring about change in SMEs considering the identified barriers in (See Tables 7 and 8). Each SME may have a distinctive energy culture when carefully studied, however it will always be the interaction of cognitive norms, material culture and energy practices that determine the overall status quo of energy efficiency within the SME [49].

Table 7. Response received for each listed barrier in the survey.

List of Barriers	% of Respondents That Identified This as an Important Barrier
Lack of recognition of the importance of energy efficiency by the company management	52%
Lack of knowledge of the saving potentials of energy efficiency measures	71%
Lack of internal resources (budget)	69%
Lack of internal resources (personnel)	78%
Lack of knowledge and readiness of the staff to support measures implementation	69%
Lack of qualified installers and maintainers	51%
Lack of reliable and affordable providers of technologies and services	37%
Complexity and difficulties in the integration with the existing context	68%
Cost/Lack of incentives	74%
Uncertainty about the real performance achievements energy savings and payback time	77%
Difficulties to access financing, subsidies, and supporting schemes	52%
Difficulties (procedures, time, and cost) for providing data for monitoring the consumption of the measure	74%
Difficulties in prioritization of measures	49%

Table 8. The five pillars formulated to evaluate the SME energy culture.

Pillar 1 Awareness of Technologies	Pillar 2 Specific Cultural Habits, User Beliefs and Aspirations, Motivations, Lifestyle, and Social Class	Pillar 3 Current Energy Practices (Activities and Processes)	Pillar 4 External Factors Such as: Community Thinking, EU and National Regulatory Framework in Place, Social Network, Forum Discussion	Pillar 5 Effect and Perception of Barriers Mapped
This pillar addresses the workplace awareness of the SME staff and whether they take the initiative to control the features, such as energy use of a process machine.	This pillar covers the area about employees' daily life, such as concern about fuel-technology combination, climate change, low-carbon lifestyle or energy demand and pricing [49,51,52]. Furthermore, since the IMPAWATT project includes SMEs from Switzerland, Austria, Italy, Germany, France, and Finland, this gives an opportunity to understand similarities and differences in cultures when addressing energy efficiency.	This pillar is closely related to Pillar 2 and observes how the individual or company raises awareness on energy efficiency, such as engaging employees through in-house programs.	This pillar considers the local and national policies that may support or inhibit the implementation of energy efficient measures considered by the SME.	This pillar gained influence from Pillar 1 about understanding the associated barriers to energy efficiency and is based on the online SME questionnaire that helped identify the three barrier categories (see the previous section).

Once the five pillars were developed, an energy culture survey was developed for the Energy Manager and employees to fully evaluate the energy culture status within the SME. By the term Energy Manager, we mean a person who might be responsible for building matters or have a managerial role. The survey for the Energy Manager acts as a self-assessment tool and collects an understanding about the organization's commitment to energy efficiency, such as information about energy targets set by the organization. These aspects are covered by Pillars 1, 3, 4, and 5. The survey for employees provides an understanding about the personal lifestyle and habits, such as switching off lights, daily mode of transportation, and general awareness about energy consumption. These aspects are covered by Pillars 1, 2, and 3. The remaining two pillars are excluded as employees are not necessarily aware of regulations and barriers.

Research shows that energy efficiency within organizations is better enforced with the presence of people with great ambition, an entrepreneurial mind, and the management sensitivity to the issue [16,22]. An individual such as the Energy Manager will report energy performance, communicate, and facilitate resources while also promoting awareness within the enterprise [16]. Nonetheless, the need for people with real ambition has also been highlighted as a key driver for energy efficiency. These individuals may be given the authority to influence investment decisions and create a long-term strategy, as seen in the Swedish case studies where the company having the highest implementation rate of energy measures had one responsible person with the described characteristics [25].

The survey contains 13 questions for the Energy Manager and 12 questions for the employees. The survey was intentionally kept brief to avoid the survey being lengthy, time consuming, and too demanding in terms of information. Table 9 shows some examples of the energy culture survey questions.

3.2. Evaluating the Energy Culture Maturity

Earlier studies showed authors selecting different numbers of maturity levels, for example several studies chose five levels of maturity [28,48,53]. For simplification and easier understanding, this paper selected three levels: Low, Medium, and High.

Table 9. Examples of energy culture survey questions for Energy Managers and employees in the SME.

	Energy Manager	Employees
Pillar 1: Awareness of technologies	Has the organization defined and documented its energy management strategy?	How often do you use these modes of transport for your work and traveling for work?
Pillar 2: Specific cultural aspects	X	Which of the following things do you regularly do to decrease emissions or save energy? (purchasing regional products, car sharing)?
Pillar 3: Current energy practices in the company	How does the organization communicate internally with regard to its energy performance?	Awareness of energy use at workplace—Which of your workplace conditions are you able to control? (temperature, lighting, recycling)
Pillar 4: External factors (e.g., community thinking, EU and national regulatory framework in place)	Does the company policy include a commitment to energy efficiency regulations and recommendations at municipal or state level?	X
Pillar 5: Effect and perception of barriers mapped	Rate the effect of barriers affecting energy saving behaviors in your company.	X

Each question in the energy culture survey is related to one of the five pillars and offers a number of answers for the respondent to choose. In turn, each answer has a score, and depending on the selected answer, the final score of the pillar would be either Low, Medium or High. The Likert scale from 1–5 is used for scoring of the survey questions. By allocating a score to pillars, the alignment (or misalignment) of the three core elements of cognitive norms, material culture, and energy practices may be easily analyzed.

Appendix B shows the breakdown of questions per pillar and which answer options correspond to which maturity level. The scoring has been randomized in the survey to avoid any bias.

The energy culture survey may be conducted several times over within the SME and can be independently conducted by the Energy Manager himself/herself. By conducting the survey several times, it will be possible to observe the change in maturity of each pillar, for example a pillar may have had a High score but may decline to a Medium or Low score due to various reasons, such as change in managers. Similarly, a pillar may see drastic improvement with more commitment from the managerial staff and more expert knowledge available to the SME. The energy culture survey has been integrated as part of the project platform [54].

3.3. Tailored Supporting Material

Once the maturity of the pillar (energy culture) was determined, the next step for the SME would be to take the necessary steps for improvement, if needed. For this purpose, a set of energy efficiency recommendations were created corresponding to the final maturity of the pillars. A Low score in any pillar would give three action recommendations, a Medium score will suggest two action recommendations, and a High score in a pillar would give one action recommendation, serving the purpose to maintain the high maturity level of the pillar in this case. Appendix C shows the tailored recommendations.

Upon completion of the surveys, the Energy Manager may then choose the actions that are easiest to implement and decide which ones are feasible to do or vice versa (due to lack of resources or other reasons etc.). Ideally, the Energy Manager may make a 12-month timeline that highlights the starting and ending time of each planned action and eventually follow the maturity of energy culture and each of the five pillars overtime.

The full concept of the new approach created for the SMEs has been illustrated in Figure 4.

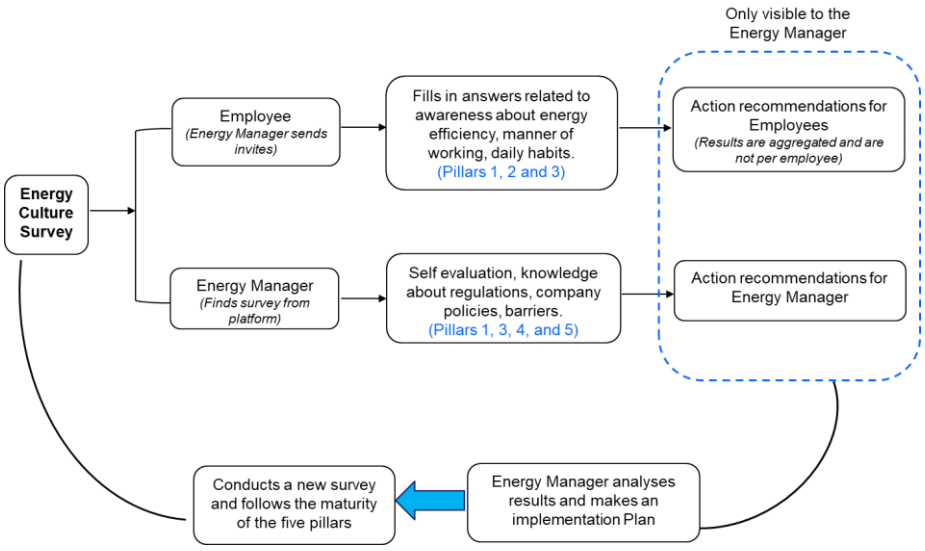

Figure 4. Energy culture and maturity matrix.

3.4. Application of the New Approach

In order to observe the applicability of this new method, the project experts con-ducted the new method in 16 SMEs located across Finland, Switzerland, Austria, Italy, Germany, and France. The experts conducted the energy culture survey for Energy Managers and employees and analyzed the recommendations given for both based on the maturity matrix score (Figure 5). The maturity matrix calculates the score and shows the result as shown below in Figures 6 and 7.

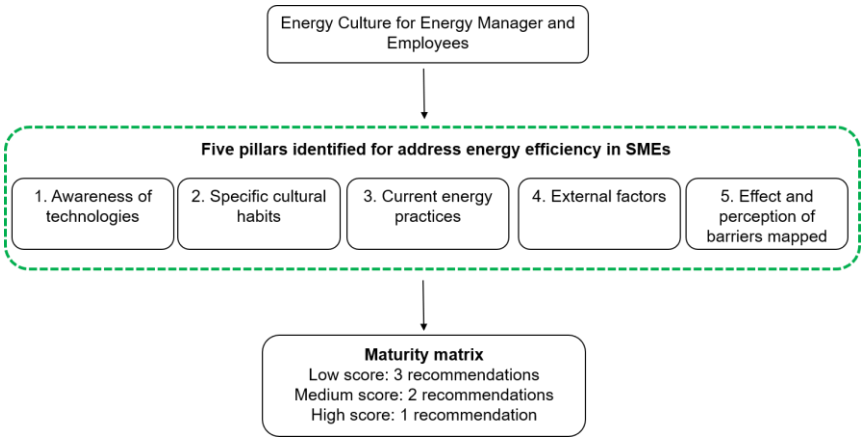

Figure 5. The new approach created for SMEs to address energy efficiency.

Tables 10 and 11 show the results obtained for the 16 SMEs that completed the Energy Manager and employees surveys. The numbers show how many times each recommendation appeared, thus it allows to see which recommendation is the most popular. For example, in Table 9 the recommendation of "*When considering investments or refurbishments, find out about energy efficient alternatives that usually also have lower lifetime costs*", this recommendation was given to four SMEs in Finland, one SME in Switzerland, two SMEs in Italy, two SMEs in Germany, and two SMEs in France. Similarly, in Table 10 the recommendation for "*Choose systems with low base consumption (e.g., LED lighting, laptop instead of ordinary PC)*" occurred for four SMEs in Finland, one in Switzerland, three in Austria, one in Italy, two in Germany, and three in France.

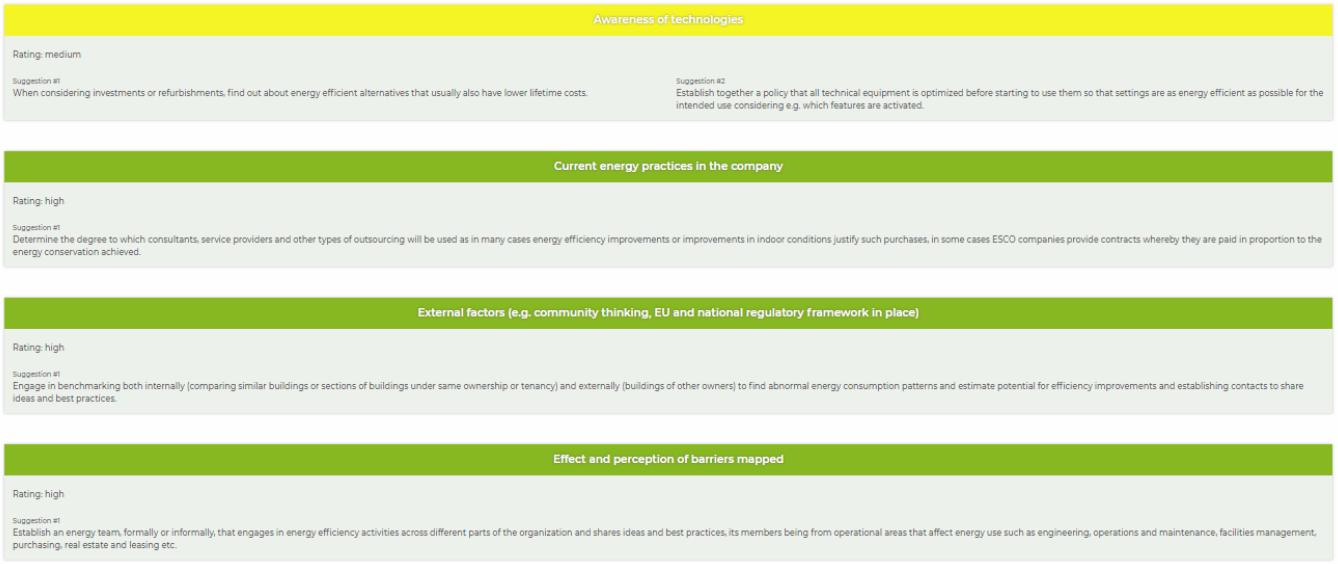

Figure 6. Example of maturity matrix result for Energy Manager. Yellow means a medium score and therefore shows two recommendations. Green means a high score and therefore it shows only one recommendation. Red (not visible) is a low score.

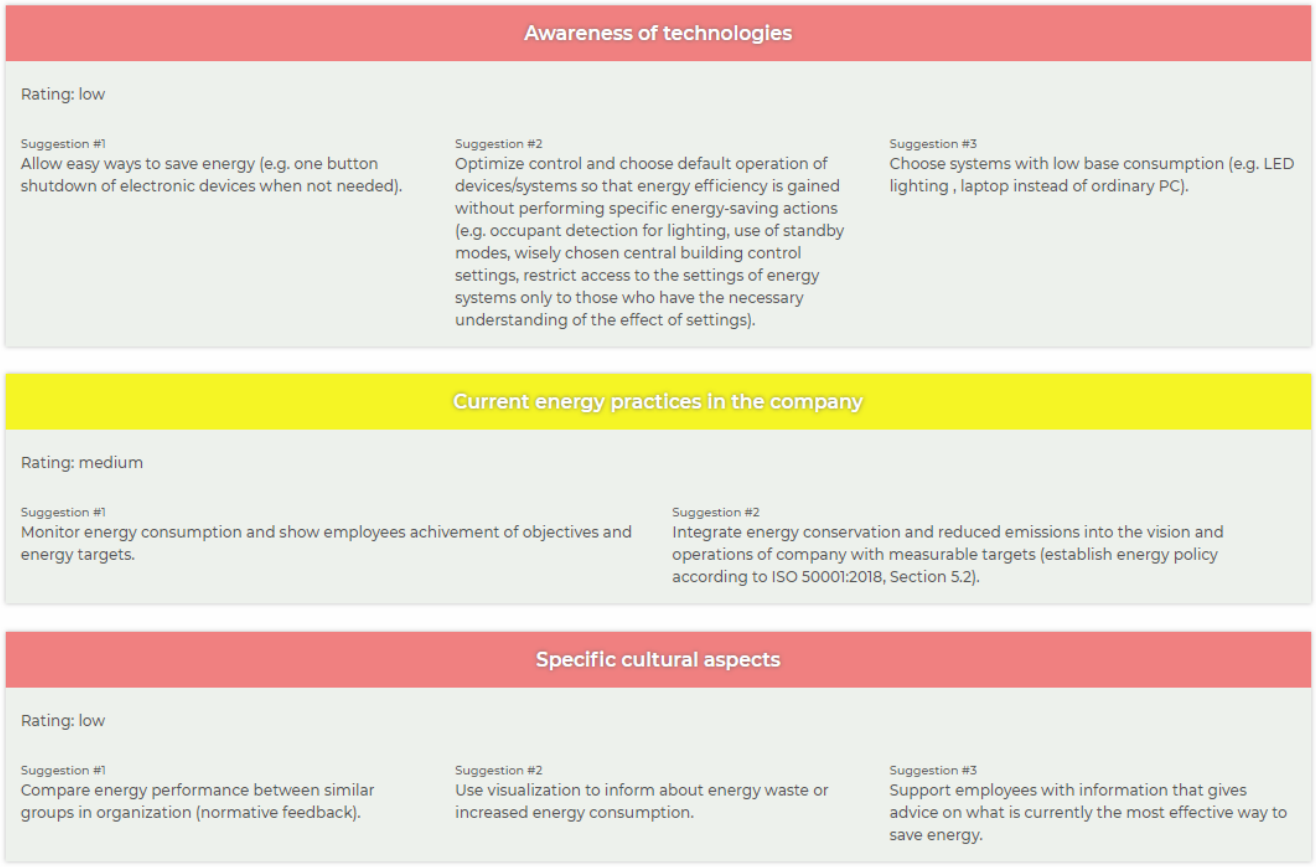

Figure 7. Example of maturity matrix result for employees. Red means a low score therefore it shows three recommendations. Yellow means a medium score and therefore shows two recommendations. Green means a high score and therefore it shows only one recommendation.

Table 10. Results of Energy Manager survey in the 16 SMEs.

	Finland	Switzerland	Austria	Italy	Germany	France
When considering investments or refurbishments, find out . . .	4	1	0	2	2	3
Establish together a policy that all technical equipment is . . .	4	1	0	2	2	3
Make sure that technical systems are correctly maintained, the . . .	0	1	0	0	0	2
Decide with the management clear energy conservation emissions reduction . . .	0	1	0	2	0	3
Determine the degree to which consultants, service providers and . . .	4	1	4	2	2	2
Systematically gather and track data from energy use across . . .	3	1	3	2	2	3
Find out what energy-related programs and projects are running . . .	2	1	0	1	2	3
Build capacity in the organization, yours and other key . . .	2	1	0	1	2	3
Engage in benchmarking both internally (comparing similar buildings or . . .	4	1	4	2	2	3
Create a communication plan to provide targeted information for . . .	2	1	4	2	2	3
Include the different departments in energy efficiency improvements by . . .	1	0	1	1	1	1
Establish an energy team, formally or informally, that engages in energy . . .	4	1	4	2	2	3

Table 11. Results of employee survey in the 16 SMEs.

	Finland	Switzerland	Austria	Italy	Germany	France
Choose systems with low base consumption (e.g., LED lighting . . .	4	1	3	1	2	3
Optimize control and choose default operation of devices/systems so that energy . . .	3	1	3	2	2	3
Allow easy ways to save energy (e.g., one button . . .	0	0	0	0	0	0
Support employees with information that gives advice on what . . .	4	1	1	2	0	3
Use visualization to inform about energy waste or increased . . .	0	1	4	2	0	2
Compare energy performance between similar . . .	0	0	0	0	0	0
Integrate energy conservation and reduced emissions into the vision . . .	4	1	4	2	1	3
Monitor energy consumption and show employees achievement . . .	1	1	4	2	0	2
Organize workshops where employees learn to know . . .	0	0	0	0	0	0

4. Discussion

Energy saving is not the result of addressing one barrier, but multiple barriers and also understanding the interconnections between each recognized barrier [17,18]. A deep knowledge of barriers is essential for enterprises and for the formulation of future energy policies [18]. Often, energy saving opportunities focus too much on the external perspective to the enterprise and mismatches between internal and external perspectives lead to further difficulties in adoption of energy efficiency measures [16,24]. This study has performed an investigation of several European SMEs to provide a novel approach of using the maturity matrix to enhance energy efficiency within the enterprise with the support of the Energy Manager. The new approach to enhance energy efficiency in SMEs is based on three steps: (1) capturing the current energy culture status in the SME, (2) evaluating the energy culture maturity, and (3) tailored material.

The energy culture plays an important role in the company in defining the energy policy and setting the goals for energy consumption [7,8]. The presented approach developed the energy culture survey based on five pillars to assess the SME's status quo on energy efficiency. The five pillars are 1. Awareness of technologies, 2. Specific cultural habits, 3. Current energy practices, 4. External factors, and 5. Effect and perception of barriers. The five pillars aim to capture the wide influences of energy efficiency while also knowing that each SME is different. The energy culture survey addresses both the Energy Manager and the employees, but in separate surveys as the Energy Manager will have a different view of energy efficiency than the employees. This helps to obtain a holistic unbiased view of energy efficiency in the SME. With regard to the evaluation of the energy culture, this is achieved by the maturity matrix. Each question in the energy culture survey has an associated score and depending on the selected answer, the final score of the pillar is either Low, Medium, or High. The Likert scale from 1–5 is used for scoring of the survey questions. Based on the final score, a set of tailored information is provided in the form of expert recommendations developed by the six partner countries. Together, the three steps allow the SME to take the necessary steps towards energy efficiency in a way that is no burden in terms of finance or time.

It has to be highlighted that no policy and regulatory initiative will be successful in improving energy efficiency issues unless the critical problems of finance, market, technology, attitude, information, etc., are prioritized [19]. While the maturity matrix approach caters to improving energy efficiency within the SME, it also addresses the important hidden SME aspects in an indirect manner such as involvement of the management, ensuring networking and collaboration, being up to date with local regulations, and ensuring energy related qualifications of the staff. The energy efficiency barriers in SMEs identified in this paper are aligned with previous studies [17–21,23,24] and therefore support the necessity to provide SMEs with an easy, cost-free, and adaptable solution to increase energy efficiency.

According to the questionnaire, more than 75% of the enterprises considered lack of internal resources (personnel/budget), the cost in relation to the lack of incentives, and the uncertainty about the real performance achievements as barriers to energy efficiency. Organizational capacity was also highlighted a large barrier as 82% of the SMEs with more than 50 of employees declared lack of personnel as important than lack of budget. Lack of experts and qualified personnel to contribute to energy efficiency was also identified as one of the barriers, both in relation to the introduction of new solutions with the existing processes (68%) and in gathering energy related information for the optimization of the implementation process (74%). Financial and behavioral factors are the two biggest barriers in SMEs [19]. While investment capability may be lacking in SMEs, most entrepreneurs also do not have the aptitude, knowledge, and dynamism for energy efficiency and instead believe that they cannot make any significant contribution to energy efficiency. More importantly, awareness and behavior influence the first steps of the decision-making process, therefore educational campaigns, visits to the best performing SMEs [19], and training of stakeholders, such as manufacturers, technology suppliers, installers and ESCOs (Energy Service Company) supporting SMEs, is of vital importance [21].

It is indeed true that each SME has an individual culture and firm size, therefore the "one-size-fit-all" approach is not feasible [5,10]. This creates the need to have one individual, such as the Energy Manager, work on the SME's energy matters, such as contributing to decision making, developing employee training programs, and investing in better quality equipment for each SME. The new approach has the potential to not only influence internal and external SME matters related to energy efficiency, but it may also improve employee (occupant) behavior as they will be more aware of energy consumption and energy efficient lifestyles. Moreover, the need for an Energy Manager has been brought to light by several studies as being one of the key drivers in energy efficiency, such as in the review of Swedish companies by Johannson [55], Johansson and Thollander [56], and in the energy policy report by Chan and Kantamaneni [16].

Our study shows that the maturity matrix plays a vital role in bridging the gap of knowledge and implementation with regard to energy efficiency. Maturity matrices easily identify gaps and allow continuously improving until the highest achievement level is reached, i.e., the target is reached. Unlike energy audits which may or may not provide continuous, comprehendible information, maturity matrices are a continuous learning-teaching tool for the organization in the short and long term. Together with the knowledge of the Energy Manager about the SME and the ability of the maturity matrix to be a continuous monitoring tool, each SME may work on its own implementation plan to improve energy efficiency.

Moreover, the developed approach in this paper comes at no cost at all for the SME, considering the financial restraints, and it is supported by expert knowledge from six countries which can be easily used for staff and personnel educational purposes. The approach has been experimented in 16 SMEs located across Finland, Switzerland, Austria, Italy, Germany, and France and received positive feedback in terms of usage and understandability. The provided energy efficiency recommendations have also been translated into local languages such as French, German, and Italian to further promote uptake of the energy measures. Additional knowledge on how to implement each recommendation is also provided to the user through the project platform. The provided recommendations were analyzed per country as shown in Tables 9 and 10. This gave the opportunity to see which recommendation was common amongst the six countries, and thus show what the Energy Managers need to start with in each country if they wish to take energy efficiency forward within their SME. Further research could be performed by having case studies in different local contexts and observing their use of the maturity matrix over a certain period of time, for example, two years. This will also give the opportunity to know whether or not the maturity matrix needs to be adapted and expanded to cater to the local needs of each country.

While the approach has been experimented in the European SMEs, it nonetheless has the potential to be applied across all developing countries and emerging economies. This may be attributed to the fact that SMEs across the globe could be facing similar challenges and could greatly benefit from the developed approach of using the maturity matrix.

5. Conclusions

The new approach allows monitoring of energy efficiency in the most resource and time friendly manner in SMEs. Having expert knowledge is of crucial importance for SMEs due to resource and time constraints. Moreover, the presented approach can be easily understood by the technical and non-technical audience, which is vital for encouraging employee participation and maintaining motivation of both managers and employees. A successful energy efficiency implementation in SMEs will require the manager to focus more on the management of skills, employees, knowledge, and culture rather than just addressing financial and technical aspects [6]. Providing adequate awareness to employees and having an employee-inclusive approach to measures will result in more success as the set rules will be followed, and could have a larger impact as these employees will disseminate information further outside of work, thus enabling a positive chain reaction in adopting

energy efficient ways. Most importantly, the developed energy efficiency approach is simple and may be readily adopted by SMEs across the globe immediately, eventually leading towards building energy efficiency due to increased employee awareness and improvement in occupant behavior when using building spaces.

Author Contributions: All sections Z.F., V.O. developed the energy culture survey, Minor revision and commenting R.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by EU H2020 IMPAWATT, grant number 785041. The APC was funded by Aalto University.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors are grateful to Luca Galeasso from Environment Park S.p.A. for reviewing the article and providing valuable insight regarding data about barriers that SMEs face. The author would also like to thank Francesco Reda for providing valuable support in developing the paper.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

SME Online Questionnaire

The questionnaire was translated by each partner in their own language and submitted online to the target organizations, by the use of Google Form application.

The questionnaire is available at the following links:
https://goo.gl/forms/34gCsY5OU7tVNHbY2 (FRENCH)
https://goo.gl/forms/17HrTmmi5hc8eOMk1 (SWISS)
https://goo.gl/forms/HZN3WADJZQtcS2Ev2 (DEUTCH)
https://goo.gl/forms/GN3lOQ58IyqIigFV2 (ITALIAN)
https://goo.gl/forms/nOPaL9uF1QnVktId2 (FINNISH)
https://goo.gl/forms/PEalMK9dAFAf2Zi23 (AUSTRIAN)

Appendix B

Energy Culture Survey

Table A1. Randomization of energy culture survey answers for scoring for the Energy Manager.

Energy Manager Maturity Matrix			
	Low	**Medium**	**High**
1. Awareness of technologies	19 a, d 25 a, b	19 b 25 c	19 c 25 d, e
2. Specific cultural aspects	-	-	-
3. Current energy practices in the company	20 a, c 21 a, b 23 a, b 24 a, b	21 c 23 c 24 c	20 b 21 d, e 23 d, e 24 d, e
4. External factors (e.g., community thinking, EU and national regulatory framework in place)	22 a, c		22b
5. Effect and perception of barriers mapped	26a 4–5 26 b 4–5 26 c 4–5 26 d 4–5 26 e 4–5 26 f 4–5 26 g 4–5 26 h 4–5 26 i 4–5 26 j 4–5 26 k 4–5 27 a 4–5 27 b 4–5 27 c 4–5 27 d 4–5 28 a 4–5 28 b 4–5 28 c 4–5 28 d 4–5 28 e 4–5	26 a 3 26 b 3 26 c 3 26 d 3 26 e 3 26 f 3 26 g 3 26 h 3 26 i 3 26 j 3 26 k 3 27 a 3 27 b 3 27 c 3 27 d 3 28 a 3 28 b 3 28 c 3 28 d 3 28 e 3	26 a 1–2 26 b 1–2 26 c 1–2 26 d 1–2 26 e 1–2 26 f 1–2 26 g 1–2 26 h 1–2 26 i 1–2 26 j 1–2 26 k 1–2 27 a 1–2 27 b 1–2 27 c 1–2 27 d 1–2 28 a 1–2 28 b 1–2 28 c 1–2 28 d 1–2 28 e 1–2

The letters refer to the questions that come up in the energy culture survey.

Table A2. Randomization of energy culture answers and scoring for the employees.

Employee Survey Maturity Matrix			
	Low	**Medium**	**High**
1. Awareness of technologies	7 a–b 10 a 1 10 b 1 10 c 1 10 d 1 10 e 1 10 f 1 10 g 1 11 a 1–2 11 b 1–2 11 c 1–2 11 d 1–2	7 c 10 a 2 10 b 2 10 c 2 10 d 2 10 e 2 10 f 2 10 g 2 11 a 3 11 b 3 11 c 3 11 d 3	7 d–e 10 a 3 10 b 3 10 c 3 10 d 3 10 e 3 10 f 3 10 g 3 11 a 4–5 11 b 4–5 11 c 4–5 11 d 4–5

Table A2. *Cont.*

Employee Survey Maturity Matrix			
	Low	**Medium**	**High**
2. Specific cultural aspects	12 b 1–2 12 c 1–2 12 j 1–2	12b 3 12 c 3 12 j 3	12 b 4–5 12 c 4–5 12 j 4–5
3. Current energy practices in the company	8a 1–2 8b 1–2 8c 1–2 8d 1–2 9 a, b 12 a 1–2 12 d 1–2 12 e 1–2 12 f 1–2 12 g 1–2 12 h 1–2 12 i 1–2 12 k 1–2 12 l 1–2 12 m 1–2 12 n 1–2 12 o 1–2 12 p 1–2	8a3 8b3 8c3 8d 3 9 c, d 12 a 3 12 d 3 12 e 3 12 f 3 12 g 12 h 3 12 i 3 12 k 3 12 l 3 12 m 3 12 n 3 12 o 3 12 p 3	8a 4–5 8b 4–5 8c 4–5 8d 4–5 9 e, f 12 a 4–5 12 d 4–5 12 e 4–5 12 f 4–5 12 g 4–5 12 h 4–5 12 i 4–5 12 k 4–5 12 l 4–5 12 m 4–5 12 n 4–5 12 o 4–5 12 p 4–5
4. External factors (e.g., community thinking, EU and national regulatory framework in place)	-	-	-
5. Effect and perception of barriers mapped	-	-	-

The letters refer to the questions that come up in the energy culture survey.

Appendix C

Table A3 and Table A4 show the recommendations created:

Table A3. Tailored recommendations for the Energy Manager depending on the score.

Pillar	Recommendations
Pillar 1 Awareness of technologies	When considering investments or refurbishments, find out about energy efficient alternatives that usually also have lower lifetime costs. Establish a policy that all technical equipment is optimized before starting to use them so that settings are as energy efficient as possible for the intended use considering e.g., which features are activated Make sure that technical systems are correctly maintained, the settings are correct and removable parts such as filters are checked, cleaned and changed periodically.
Pillar 3 Current energy practices (activities and processes)	Decide with the management clear energy conservation emissions reduction goals with measurable targets, after studying the energy efficiency potential with e.g., benchmarking or by estimating the potential of each technical system separately. Determine the degree to which consultants, service providers, and other types of outsourcing will be used, as in many cases energy efficiency improvements or improvements in indoor conditions justify such purchases, in some cases ESCO companies provide contracts whereby they are paid in proportion to the energy conservation achieved. Systematically gather and track data from energy use across different parts of the building and different technical systems to develop perspective and context for future actions and decisions and to establish baselines for energy use to detect abnormal energy use and measure progress.

Table A3. *Cont.*

Pillar	Recommendations
Pillar 4 External factors such as: community thinking, EU and national regulatory framework in place, social network, forum discussion	Find out what energy-related programs and projects are running in your country or city and what benefits they could offer, be it funding opportunities for energy improvements or sharing of best practices for example. Build capacity in the organization, yours and other key personnel, by providing and participating in training and events where successful practices and technologies can be shared and lessons learned. Engage in benchmarking both internally (comparing similar buildings or sections of buildings under same ownership or tenancy) and externally (buildings of other owners) to find abnormal energy consumption patterns and estimate potential for efficiency improvements and establishing contacts to share ideas and best practices.
Pillar 5 Effect and perception of barriers	Create a communication plan to provide targeted information for key audiences about energy management and to generally raise awareness of energy goals and how everyone can contribute. Include the different departments in energy efficiency improvements by e.g., organizing brainstorming sessions to identify ways they can contribute. Establish an energy team, formally or informally, that engages in energy efficiency activities across different parts of the organization and shares ideas and best practices, its members being from operational areas that affect energy use such as engineering, operations and maintenance, facilities management, purchasing, real estate and leasing etc.

Table A4. Tailored recommendations for the employees depending on the score.

Pillar	Recommendations
Pillar 1 Awareness of technologies	Choose systems with low base consumption (e.g., LED lighting, laptop instead of ordinary PC) Optimize control and choose default operation of devices/systems so that energy efficiency is gained without performing specific energy-saving actions (e.g., occupant detection for lighting, use of standby modes, wisely chosen central building control settings, restrict access to the settings of energy systems only to those who have the necessary understanding of the effect of settings) Allow easy ways to save energy (e.g., one button shutdown of electronic devices when not needed)
Pillar 2 Specific cultural habits, user beliefs and aspirations, motivations, lifestyle and social class	Support employees with information that gives advice on what is currently the most effective way to save energy Use visualization to inform about energy waste or increased energy consumption Compare energy performance between similar groups in organization (normative feedback)
Pillar 3 Current energy practices (activities and processes)	Integrate energy conservation and reduced emissions into the vision and operations of company with measurable targets (establish energy policy according to ISO 50001:2018, Section 5.2) Monitor energy consumption and show employees achievement of objectives and energy targets Organize workshops where employees learn to know the energy targets of company and participate in finding the ways how to save energy in the workplace

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