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Procedia CIRP 122 (2024) 354–359

www.elsevier.com/locate/procedia

31st CIRP Conference on Life Cycle Engineering (LCE 2024)

Advanced Sustainability Action Plan: Supporting manufacturing SMEs on a sustainability pathway

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Abstract

The manufacturing industry faces numerous challenges: increasing energy and material costs, limited resources availability, customers' and legal requirements on product quality, climate action, social standards. An example for a political and regulative push is the European Green Deal and the Industry 5.0 strategy announced by the European Commission, which requires manufacturing enterprises to take actions to improve sustainability. Especially small and medium enterprises (SMEs) require support to identify potentially suitable actions to implement.

This paper proposes a guided decision support method for SMEs to help them on the sustainability pathway. With a multi-step procedure, the current status of a specific company regarding sustainability actions, their development goals, challenging fields of action, plans and interests in application of advanced technologies and social or environmental services can be identified. Starting from a questionnaire-based self-assessment, relevant fields of actions are derived and potential advanced technologies, social innovations and environmental services are identified. The developed approach combines evaluation of the assessment results, as well as online workshops with SMEs to refine the obtained information, align the suggested set of actions with needs of the companies and prioritize them. As result of this procedure, participating SMEs receive an advanced sustainability action plan (ASAP), which helps them to prioritize available measures to implement on their individual sustainability pathway. The ASAP has been implemented for 41 companies within an online community hub system designed to match and join technology and service providers with manufacturing SMEs. "Processes and Production system" was identified as the most important action field for 41% of SMEs, highlighting the need for efficiency improvement in production processes.

Keywords: advanced technologies, sustainability assessement, decision support, social innovation, environmental services, LCA

1. Introduction

Increasing energy and material costs, limited availability of resources, fragile supply chains, changing customers' demands and legal requirements, climate change, social standards, new technologies and data security – these are just some of numerous challenges that manufacturing industry faces nowadays. The *European Green Deal* [1] and the *Industry 5.0* strategy [2] announced by the European Commission (EC) are examples for a current political and regulative push, which requires manufacturing enterprises to take actions for improvement of their environmental sustainability performance and increase the level of digitalization while considering contribution to society. Furthermore, this imposes new priorities: To care for wellbeing of employees at the center of the production process, introduce new technologies and still strive for a competitive and profitable business in a rapidly changing market environment while respecting the limitations of sustainable resource availability.

10.1016/j.procir.2024.01.052

While large enterprises often have specific personnel for the development of sustainability strategies, especially small and medium enterprises (SMEs) need support to identify issues and prioritize potentially suitable actions for implementation.

In literature and management practice, numerous approaches and decision support methods to develop sustainability pathways for enterprises can be found. For instance, continual improvement process usually used in business process management, quality or project management can be applied on the environmental sustainability implementation in an enterprise. The plan-do-check-act (PDCA) cycle [3] is one of frameworks that can be implemented for e.g. environmental management [4] or energy efficiency [5]. *Müller and Pfleger* suggested evaluation of corporate activities on each of the three sustainability dimensions within maturity levels, thus building a "Sustainability Maturity Cube" and identifying the field for action [6]. *Hsien et al.* have suggested a self-assessment tool to enable SMEs to identify maturity levels of their current sustainability performance and continuously improve it [7]. Whereas this self-assessment mainly concentrated on environmental aspects (e.g. water, energy, material etc.), *Eisner et al.* have added the connection of environmental sustainability with digitalization and business transformation [8]. *Lee et al.* have extended this framework to a methodology which helps organizations to create their transformation plans [9]. The described approaches usually require high effort, time and specialized personnel to lead the needed individual transformation of a company. A common challenge for decision support methods in this context is to ensure universality and simplicity in application and also to consider complexity and multitude of potential solutions as well as the unique circumstances for each specific enterprise. Furthermore, the state of the research does not specifically address the requirements of the European Commission on integration of advanced technologies.

To support SMEs to comply with European Commission's regulatory requirements on sustainability, methods and tools are required to provide guidelines for the identification and implementation of potentially beneficial advanced technologies, social innovations and environmental services fostered by the *European Green Deal* and *Industry 5.0*.

This work presents an approach for a structured action plan development for SMEs, which helps them identify needs and potential actions, considering technologies and non-technological elements.

2. Theoretical background

To address the economic, social and environmental dimensions within sustainability pathways of enterprises, related innovation areas are identified and described in this section: advanced technologies, social innovation and environmental services.

2.1. Advanced technologies (AT)

To promote the competitiveness of European industries and support the implementation of policies and initiatives, the European Commission (EC) monitors trends and data on advanced technologies (ATs) within the Advanced Technologies for Industry (ATI) project. 16 ATs have been identified by the EC as enabler for a shift towards a low-carbon and knowledge-based economy for industries: Advanced Manufacturing Technology, Advanced Materials, Artificial Intelligence, Augmented and Virtual Reality, Big Data, Blockchain, Cloud Computing, Connectivity, Industrial Biotechnology, Internet of Things, Micro- and Nanoelectronics, Mobility, Nanotechnology, Photonics, Robotics and Security [10].

2.2. Social innovation (SI)

As digital solutions and new technologies can only be implemented with acceptance and knowledge of workers and stakeholders, social innovation services have to be considered in the transformation process [11]. Social innovation (SI) means the development of a "new combination and/or new configuration of social practices in certain areas of action or social contexts prompted by certain actors or constellations of actors in an intentional targeted manner with the goal of better satisfying or answering needs and problems than is possible on the basis of established practices." [12]. SIs can be used from a company perspective focusing on delivery of non-technological (organizational, people-related) contributions to solutions on sustainability challenges within the company (e.g. developing new working, management or collaboration practices). This is often associated with changing mindsets and behavior [12].

In this way, services on social innovation can be added to services on advanced technologies, which can include a business model review to analyse the extent to which SMEs can become both more sustainable and more successful entrepreneurially (following a shared value approach by [13]). Further potential services are assessing the effects of the transformation process on skill requirements of employees (and how to meet them), shaping stakeholder engagement processes (meeting their requirements on sustainability) and designing implementation processes of new (technological) solutions getting the employees as end-users involved.

2.3. Environmental services (ES)

In literature, environmental services are often referred to conservation of natural resources through supporting programs or payments [14,15]. In the context of this publication, however, ES imply services of Life Cycle Assessment (LCA) [16,17], Life Cycle Costing (LCC) [16] and Social Life Cycle Assessment (S-LCA) [18] with consideration of social sustainability as well as resources management. In this context, following resources were considered: Energy, water and wastewater, materials and wastes. The goal of the environmental services is to analyze existent resources flows, identify potential hotspots in production processes or building shell and derive recommendations for improvement.

To foster sustainability within one or more dimensions, implementation of the described innovation areas and combination of those should be enabled.

3. Advanced Sustainability Action Plan (ASAP) - Method development and elements

To support manufacturing SMEs on their pathway to meet defined sustainability targets, a multi-step approach for the creation of an Advanced Sustainability Action Plan (ASAP)

was developed and implemented within an online community hub. The goal of this method is to provide an advisory and decision support for SMEs for identification of next steps in the near future. The output of this method is the ASAP document consisting of four sections: Company profile and general data, Status Quo, Goals & Scope as well as Action plan with set of seven prioritized actions. This document provides companies with an overview of their current situation and helps to prioritize future steps.

3.1. Definition of actions and main elements

Actions are the core element of the ASAP structure and provide concrete starting points for companies to implement beneficial AT/SI/ES. Every suggested action consists of the following elements (Figure 1): Action fields that can be influenced by the action (e.g. energy, water, etc.), challenges to be solved (e.g. high energy demand), involved activities or resources (e.g. specific manufacturing processes, such as injection molding), action type (e.g. feasibility study), AT/SI/ES (e.g. advanced manufacturing), key performance indicator (KPI) (e.g. number of parts produced, amount of energy per part etc.) and expected results (e.g. decreased energy demand etc.). The action title consists of the combination of the action type and AT/SI/ES. Whereas this combination is identified using the described scoring method, the rest of the elements is identified for particular actions in desk research.

3.2. ASAP development pathway

The ASAP development pathway is shown in Figure 2. First, manufacturing SMEs undergo a self-assessment to identify potential action fields – those are areas for improvement or hotspots. In total, eleven fields of action were set to be analyzed after the self-assessment: Energy, water, materials, waste management, product(s) life-cycle, processes and production, value/ supply chain, workers (skills & training), workplace (wellbeing and technology relation), stakeholders' engagement and sustainable business model innovation. The answers of the self-assessment are then being analyzed and weighted to estimate the importance of each action field and the total sustainability score in each dimension. More details to the self-assessment can be found in [19].

Ranked action fields as well as answers on environmental, social and economic sustainability, internal management, digitalization and use of advanced technologies resulting from an initial self-assessment are the main inputs for the ASAP development. Those results are used to identify the set of potential actions. Each action is a combination of an action type (e.g. feasibility study, pilot testing, consultancy, etc.) and an advanced technology (AT) (e.g. artificial intelligence, robotics, etc.) or social innovation (SI) / environmental service (ES) (e.g. business model revision or life cycle assessment etc.). To define, which combination comes into consideration for a particular SME, a classification table for a weighted scoring on the linkage to the "solution elements" – advanced technologies and social innovation or environmental service, the fields of actions and the action types – was developed.

3.3. Scoring system

The identification and ranking process of the potential actions is organized in a three-step sequence and based on numerical values awarded for specific congruence of input data and solution elements. The output of this classification procedure is a set of actions that can be suggested for the SME based on their results. In the first step, the answers on usage of or plans to use AT/SI/ES in near future define which action types can be considered with which AT/SI/ES. If a company is considering to use a technology soon, feasibility study or prototyping will be the most likely action types for this case and assigned with the highest class-rating, whereas demonstration or coaching services would be ranked lower. In the second step of the ASAP classification process, a numerical value for each action field from the self-assessment is integrated: The higher value implies a higher expected improvement potential in this area. These values are added up in a total sum and then assigned with a percentage equivalent to its relative value, which in turn are multiplied with a pre-defined impact matrix that provides values between 0 and 3 for each combination of an action field with a technology or innovation. In the third step, the scores for the combinations of the advanced technologies, social innovations and environmental services with the action fields are put through a

Defined main elements of an action:						
Action Fields or Hotspots that will be influenced by the action	Challenges that can be faced with the action	Activity/ resource influenced by the action	Action type	Advanced technology / social innovation / environmental service	Suggested KPIs with which the action implementation can be measured	Suggested results that can be expected after the action implementation

Exemplary action:

Coaching for Worker skills definition and Training

Action Field	Challenge to be solved	Involved processes	Action Type	AT/SI of choice	KPI	Expected result
Workers (skills & training) Process(es) and production Workplace (wellbeing & tech.)	Skill gaps, need for upskilling of workers	Staff training	Coaching services (identity, skills, corporate culture, etc.)	Worker skills definition & Training	Number of employees trained; defined set of training goals	Decreased gap of required and available skill level of workers, higher job satisfaction and work efficiency

Figure 1. Structure and the main elements of an action (above) and exemplary action from the ASAP (below).

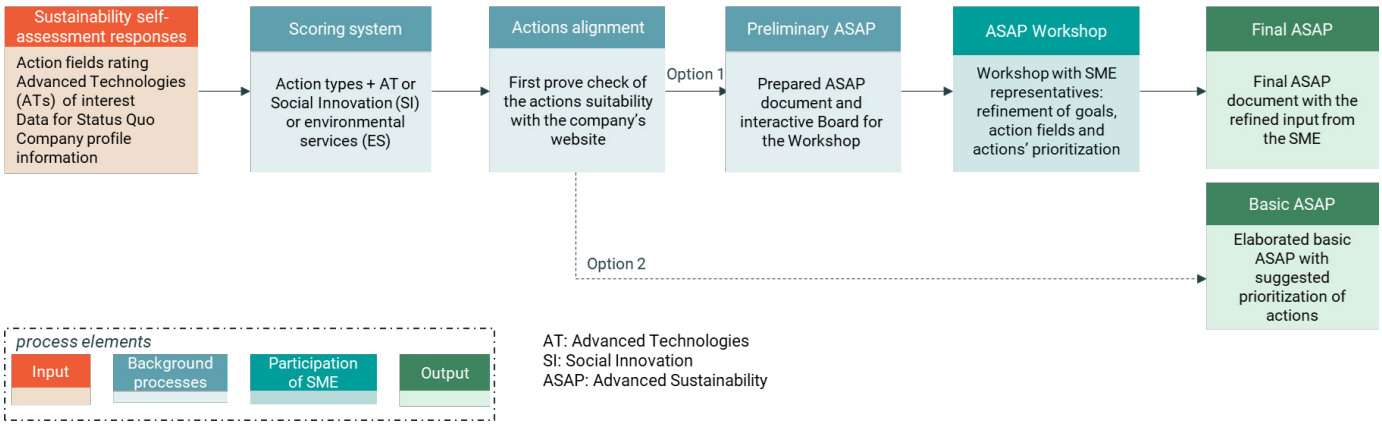

Figure 2. ASAP development pathway.

weighted multiplication to result in the final action identification heatmap. Technical details to the scoring system can be found in [19]. The set of actions from the classification steps is then validated with the SME's website to exclude action elements that are already represented within the company's expertise or include/specify potential actions of interest.

3.4. Actions prioritization

One of the most valuable outputs of the ASAP is the prioritization matrix. With this qualitative method SME representatives are guided to estimate potential effort (in terms of costs, personnel, etc.) and benefits (e.g. savings, customer value proposition etc.) that could occur with each action's implementation and place each action in a suitable field of the matrix [19]. Actions with high benefits and low effort (dark green field in (4) Figure 3) are of the highest priority and can be implemented in the nearest future. Actions with low priority are estimated to show low benefits and cause high efforts. Placing actions within the matrix provides a visual support for SME to decide on next action. In case of the Basic ASAP, this prioritization is suggested by the advisor based on the available information on the company's results. It is however recommended to the SME to revise the suggestions and rearrange the priority, if needed before finally deciding on the action.

3.5. Differentiation of Final ASAP and Basic ASAP

Participating companies can decide to receive advisory service within an online-workshop, where together with an advisor they have a focused look at the status quo, goals and potential actions (Option 1). They also prioritize the suggested actions to identify some of the highest priority. After the workshop the SME receives a final ASAP containing refined results from the workshop. Another option is to get a Basic ASAP (without a workshop) with suggested and prioritized actions by sustainability advisors.

4. Application on "greenSME" Hub

The described ASAP-method has been developed and applied within the "greenSME" project funded by the EC. The project's goal is to encourage European SMEs in their sustainable development and to foster projects between manufacturing SMEs and sustainability and technology providers. The scope includes three sustainability dimensions (environmental, social and economic) as well as digitalization technologies. SMEs can assess their status quo within those dimensions, define goals, derive improvement actions, find suitable providers and receive funding in case of successful project implementation. Following the outlined pathway, interested SMEs and providers can register on the greenSME Hub [20] and become part of an online community. The community can be used as the exchange platform for experience, knowledge and best practices. Moreover, the section "Knowledge Hub" provides learning sessions (e.g. on environmental sustainability, predictive maintenance, business model innovation etc.) and news on best practices from the industry. After registration, manufacturing SMEs undergo the self-assessment while providers receive greenSME accreditation.

After the self-assessment SMEs receive an elaborated report showing their performance in sustainability and digitalization dimensions. Each company can then decide for an advisory service within an online-workshop or Basic ASAP (see Figure 2). After receiving the ASAP (basic or final), companies use the search function on the Hub to find accredited providers that offer the desired services from the actions (either on advanced technologies or environmental / sustainability services). One SME can also choose two providers to combine technological with non-technological solutions (e.g. combine Internet of things with Live-LCA or robotics with workers' skills definition). When the team of SME and provider(s) is set, they define the project scope for the chosen action and write the project proposal for the open call. After the evaluation of the project proposals by the external evaluator panels, the highly rated projects are eligible to receive additional funding for an implementation phase [20].

4.1. Application results

Within this scope, the presented ASAP method was applied for 41 European SMEs and the main findings of this process are illustrated in Figure 3. 13 SMES have chosen to undergo advisory service within an online workshop whereas the remaining 28 requested a more comprised version with the Basic ASAP. The review of all self-assessment shows, that from the eleven chosen action fields "Processes and Production system" resulted as the most important action field for 41% and as important for 46% of the assessed companies ((1) in Figure 3). This implies the need for efficiency increase within the

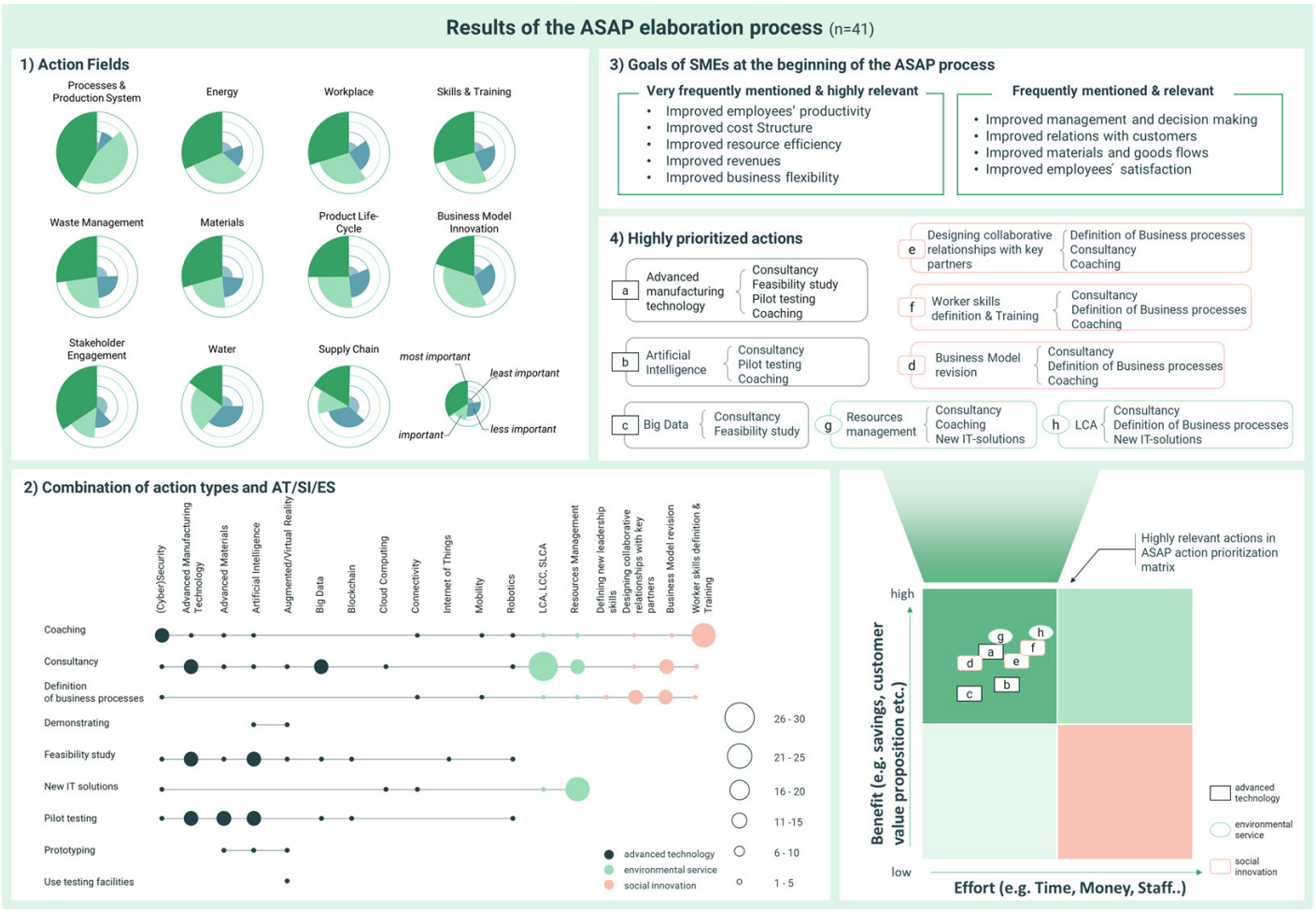

Figure 3. Infographic for results of the ASAP elaboration process applied for 41 SMEs.

production processes. Energy, materials, workplace, skills & training were estimated as the most important action field for approx. 30% of SMEs. Stakeholders' engagement was identified as the most important for 34% and the least important for 39% of assessed organizations. Value and supply chain resulted to be important and the most important action field only for 12% and 17% of SMEs respectively.

The most frequently mentioned and highly relevant goals were: Improved employees' productivity, improved cost structure, improved resource efficiency, improved revenues and improved business flexibility. Further relevant goals were: Improved management and decision making, improved relations with customers, improved materials and goods flows and improved employees' satisfaction ((3) in Figure 3).

The scoring system resulted in various combinations of AT/SI/ES and action types: 12 out of 16 advanced technologies were suggested in combination with nine action types (e.g., feasibility study, pilot testing, etc. in (2) in Figure 3). Environmental and social innovation services were suggested within consultancy, coaching, IT-solutions or definition of business processes. From the suggested combinations, the actions were then prioritized by the SME in the workshop or by the greenSME advisor (within the basic ASAP). The most frequently highly prioritized actions contained Advanced manufacturing technology, Artificial Intelligence, Big Data, Designing collaborative relationships with key partners, Worker skills definition & training, Business Model revision, Resources management and LCA ((4) in Figure 3).

4.2. Discussion

The presented methodology offers a targeted decision support for SMEs to identify potential actions for sustainability improvement and contribute to the goals of the *Green Deal* within a manageable timeframe. It aims at simplified implementation of complex processes and eased accessibility for manufacturing SMEs.

The modular structure of the presented approach allows to adapt to the specific requirements of SMEs and to choose the desired support degree in a flexible timeframe. Analysis of the conducted workshops has shown that they have proven to be helpful in refining the important action field and enabled SMEs to reflect on issues and goals. SMEs have also received a better vision for the future development steps after the action prioritization, instead of aiming at improvement in all sustainability dimensions at once. Therefore, several suggested actions were regarded as irrelevant in the near future allowing highly prioritized actions to be further considered.

The level of detail for actions in the ASAP method is, however, limited by the conflicting goals of accessibility and universality. The actions are suggested within the pre-defined set of action types, ATs, SIs and ES, action fields. This method also contains subjective steps such as ranking of the goals and action prioritization, results of which can vary from one

representative of the same organization to another and could potentially impart biases based on personal experience. Furthermore, the action development is based on the results of the self-assessment with several qualitative and partly subjective answers. As a result, this approach provides a clear direction for potential improvements with action elements but not a concrete step-by-step improvement plan. Consideration of the emerging technologies increases uncertainty on their potential impact. Therefore, this approach should continuously be updated with the technological development.

5. Conclusion and outlook

With increasing requirements for sustainability in manufacturing industry, especially SMEs need support to identify current issues and potential actions for improvement. This described multi-step approach for Advanced Sustainability Action Plan (ASAP) development originating from the EU-funded project greenSME has proven to be an effective mean to provide advisory and decision support for SMEs, helping them identify the next steps for sustainability improvement. The ASAP method was applied to 41 European SMEs, 13 of which participated in a detailed workshop. "Processes and Production system" was identified as the most important action field for 41% of SMEs, highlighting the need for efficiency improvement in production processes. The most frequently mentioned goals for sustainability development were: Improved employee productivity, improved cost structure and resource efficiency. After prioritization of actions, Advanced Manufacturing Technology, Artificial Intelligence and Big Data were the most relevant among the advanced technologies, whereas all of the environmental and social innovation services occurred within the relevant actions. The ASAP method offers SMEs a feasible way to contribute to sustainability, and its modular structure allows for flexible implementation, whereas it has several limitations such as subjective elements (e.g., action prioritization) and qualitative data base. In summary, the ASAP method provides manufacturing SMEs with a structured approach to sustainability improvement, offering flexibility and decision support. The presented approach has helped participating companies to develop their sustainability roadmap. The impact quantification of the actions will be conducted within the evaluation process after their implementation. In near future, this approach will be further developed with experience data of submitted projects and emerging advanced technologies to better identify the needs of SMEs, improve advisory services and increase the efficiency of the ASAP elaboration.

Acknowledgements

The presented methodology was developed within the research project “greenSME” funded by the European Commission (Grant Agreement: 101058613). We thank the whole greenSME consortium for providing feedback during the method development and joint conduction of workshops.

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