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Measuring the Readiness of SMEs for Eco-Innovation and Industrial Symbiosis: Development of a Screening Tool

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Abstract: Despite the high business, innovation and sustainability potential linked with eco-innovation and industrial symbiosis, limited implementation can be observed in small and medium enterprises (SMEs). In order to enhance the implementation of these concepts in SMEs, the main goal of this paper is to propose a screening tool to identify and evaluate SMEs' potential for eco-innovation, with a special focus on industrial symbiosis and green business models aspects. In order to accomplish this goal, an action research was developed in two cycles: (1) development and testing of the screening prototype; and (2) improvement and scale-up of the enhanced screening tool, in close collaboration with the research partners. In addition to enabling a better understanding about their own internal processes and activities, the evaluation of the potential of 108 SMEs for eco-innovation provided them with detailed insights about how to reach the potential benefits with industrial symbiosis and green business models. Differently from the identified existing tools, the screening tool proposed in this research aims at supporting companies to understand what their potential for eco-innovation is, combining wider eco-innovation and industrial symbiosis opportunities and green business models, supplemented with a readiness evaluation to explore the existing potential.

Keywords: eco-innovation; industrial symbiosis; screening; SMEs

1. Introduction

Companies are at the core of most of the environmental impacts caused by society [1], contributing to generating impacts across the entire life cycle, from raw material extraction and manufacturing, through to distribution, product use and end-of-use/end-of-life.

Small and medium enterprises (SMEs) play an important role in this context, as they account for the vast majority of existing companies [2]. SMEs generates more than half of the total value added in Europe [3] through the manufacturing and delivery of products and services. Furthermore, SMEs still face a number of difficulties for integrating sustainability into their core businesses processes, being still largely reactive to environmental issues [2].

Currently, a large amount of concepts and tools are available to support the integration of sustainability into companies' core business. Eco-innovation is seen as one of the key approaches for SMEs [4,5], due to its potential to enhance the SMEs green competitiveness' through the development of innovative products, processes and organizational capabilities [3,5,6].

The main goal of this paper is to present research on the development of a screening tool to identify and evaluate SMEs' potential for eco-innovation, with a special focus on industrial symbiosis

and green business models aspects. The tool has been developed in the context of the Danish "Residue to Resource" project, and carried out in collaboration between the Danish Symbiosis Center, the Technical University of Denmark and six municipalities.

From a theoretical point of view, our aim is to advance the state-of-the-art by proposing a systematic methodology that enables the screening of the eco-innovation potential in SMEs, at a company-level, by using both quantitative and semi-quantitative measures. Furthermore, we aim to advance theory by combining eco-innovation, industrial symbiosis and green business models simultaneously, supported by a readiness assessment. Lastly, by focusing on the municipalities as the main drivers for the evaluation, we aim to provide a deeper understanding of their potential as eco-innovation agents.

The screening tool has been applied across 108 SMEs from a number of sectors, including service industries, distributed in six municipalities in Denmark characterized for the most part by a relatively low level of industrialization. This paper focuses on the approach employed for the development and enhancement of the tool. The results of the application of the tool i.e., the potential of the studied Danish SMES for engaging in eco-innovation are not within the scope of this paper.

The paper is structured as follows. In the next section, the theoretical background for the research is presented, followed by the methodology employed for the development of the screening tool. Section 4 describes the main characteristics, features and indicators of the tool. In Section 5, a discussion of the contributions and implications of the research are provided. Finally, the concluding remarks and next steps are presented in Section 6.

2. Theoretical Background

In this section, the key theoretical background employed for the development of the research is presented, focusing on three main areas: (1) key theoretical concepts underpinning the research; (2) eco-innovation implementation in SMEs, with a focus on industrial symbiosis and green business models; and (3) tools to measure the eco-innovation potential of companies.

2.1. Key Theoretical Concepts

The main underpinning theoretical concepts for the development of this research are four-fold: (1) sustainable development; (2) eco-innovation; (3) industrial symbiosis; and (4) green business models.

Sustainable development is defined by the Brundtland report as a development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" [7]. Since sustainable development has been proposed as a concept, in 1987, a number of attempts have been developed to make it applicable to different stakeholders, including governmental bodies, non-governmental organizations and companies [8,9]. Eco-innovation is seen as one of the most prominent approaches targeted at supporting companies towards sustainable development [4].

According to the Eco-innovation Action Plan [10], eco-innovation is defined as "any form of innovation resulting in or aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment, enhancing resilience to environmental pressures, or achieving a more efficient and responsible use of natural resources". In the scientific literature, eco-innovation can be defined as "all efforts from relevant actors that introduce, develop, and apply new ideas, behaviors, products and processes and contribute to reducing environmental burdens or ecologically specified sustainability targets" [9].

Considered a systemic eco-innovation approach [11,12], industrial symbiosis is a concept that promotes the engagement of communities of companies in improving their economic and environmental performance through collaborative strategies [13]. Industrial symbiosis has a high potential to create environmental improvements at the regional and local levels [14], through resource exchanges (incl. solid materials, energy, water) among collocated companies, where one company's residues become another (local) company's resource, hence representing a collective approach towards

sustainability [15,16]. Ultimately, industrial symbiosis potentially enables an enhancement of resource efficiency, by producing more value from the same resources [17].

　　More recently, eco-innovation has been defined by the United Nations Environmental Program (UN Environment) as "the development and application of a business model, shaped by a new business strategy that incorporates sustainability throughout all business operations based on life cycle thinking and in cooperation with partners across the value chain" [4], which brings an additional important strategic element to the definition, introducing business model innovation as a key concept to it. OECD (Organisation for Economic Co-operation and Development) considers business models as one of the key elements in determining the success of eco-innovation initiatives [11]. Business models are defined as "the rationale of how an organization creates, delivers and captures economic, social and other forms of values" [18]. Green business models, in turn, are defined as business models that entail enhanced environmental performance—which can bring radical innovations to reality.

　　Figure 1 schematically illustrates the links between the aforementioned theoretical concepts. Sustainability is seen as the ultimate goal, which can be achieved by Sustainable Development initiatives. Eco-innovation is one of the possible approaches for Sustainable Development, and can be defined by two main elements: industrial symbiosis (as a systemic eco-innovation model at the operational level) and green business models (as a strategic eco-innovation approach).
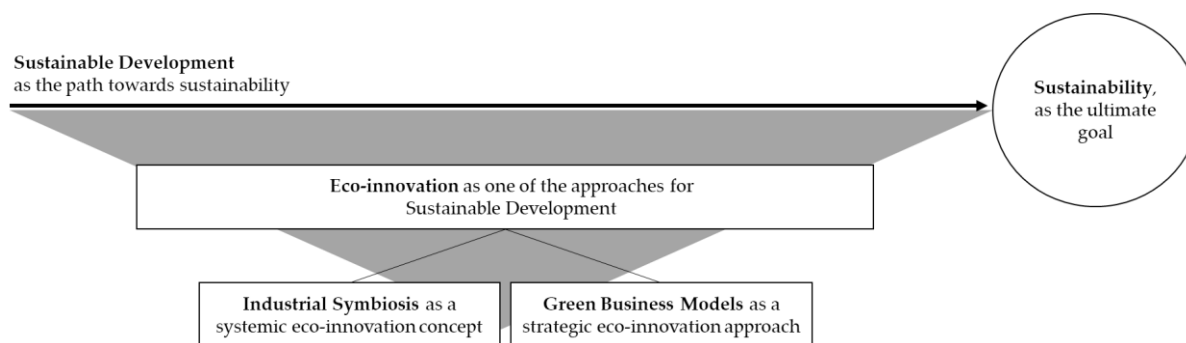

Figure 1. Representation of the links between the key theoretical concepts employed in this research.

　　It is important to note that the figure focuses on representing the links between the key theoretical concepts employed in this research, and it does not aim to be, by any means, a comprehensive overview of all concepts related to sustainability.

2.2. Implementation of Eco-Innovation in SMEs

　　The critical determinants for the enhancement of eco-innovation activities within SMEs are related to (i) establishment of supporting policies; (ii) enhanced perception of its strategic importance; (iii) technological advisory support; (iv) methods for product and process eco-innovation; and (v) collaboration within supply networks [19].

　　Eco-innovation can be applied in three main levels: (a) business strategy; (b) business model; and (c) operations [4], and is used within a multitude of research areas [5], including industrial ecology and industrial symbiosis [3,15]; cleaner production [20,21]; life cycle assessment [22]; sustainable manufacturing [23,24]; ecodesign [25,26]; and circular economy [27,28]. Circular economy aims at decoupling value creation from resource consumption, based on the development of solutions that are regenerative by design [28]. Circular Economy can be seen as an umbrella concept that is built upon by a number of other concepts, such as industrial symbiosis and life cycle thinking [29].

　　Despite its potential benefits, the adoption of Industrial Symbiosis approaches are generally limited worldwide; however, they are gaining much attention lately with the rise of the circular economy agenda. When it comes to SMEs, experiences are still very few [3]. Characterized by relatively small flows, SMEs often present difficulties to handle the costs associated in establishing

an industrial symbiosis initiative as well as regularly collecting and exchanging data regarding their input/output resource flows [30].

Barriers for a larger uptake of industrial symbiosis are related to (1) commitment to sustainable development; (2) access to detailed qualitative/quantitative data on residue streams; (3) cooperation and trust among companies; (4) technical feasibility; (5) regulatory framework; (6) limited community awareness; and (7) lack of a clear business case [14]. In this context, public administration bodies seem to play a key role in enabling enhanced eco-innovative initiatives [31].

Even though consolidated to a high degree in the so-called industrial symbiosis parks or eco-industrial parks [17,32], the establishment of symbiotic relationships among SMEs not located within industrial parks is still limited—despite their relatively large proximity and high collaboration potential [33]. Furthermore, recent definitions of industrial symbiosis highlight that the concept is not necessarily geographically related, but rooted in innovation and networks for knowledge sharing, resulting in improved efficiency in the use of materials [34].

Regional innovation networks are seen as enablers for the SMEs engagement in industrial symbiosis [35]. The identification of industrial symbiosis across neighboring SMEs within a given region can enable a higher uptake of eco-innovation, leading to a minimization of their environmental negative impacts, and enabling the establishment of the so-called green business models. In order to enable such initiatives, the identification of the SMEs' potential for engaging in eco-innovation initiatives should be further explored. While eco-innovation can be measured at different levels (e.g., company, sectoral, cluster/park, regional, national and international) [36], limited efforts could be found dealing with the measurement of the eco-innovation potential at the company level.

2.3. Tools for Measuring the Eco-Innovation Potential

In order to identify the state-of-the-art of existing tools for measuring the eco-innovation potential in companies, a systematic literature review (SLR) was carried out.

The SLR focused on the identification of related eco-innovation tools, using Scopus as the main database, due to its relevance to the topic. The employed search strings encompasses (TITLE-ABS-KEY ("tool" and "eco-innovation") and (TITLE-ABS-KEY ("tool" and "industrial" and "symbiosis"). The searches, last updated in June 2018 (with no timeframe delimitations), resulted in a total amount of 253 studies, which were subsequently checked in regards to their scope and focus.

In order to further filter the identified studies, the adopted exclusion criteria was "the study should present/propose/analyze a tool that aims to measure the potential in implementing eco-innovation in companies". The focus was expanded in relation to SMEs to all kinds of companies, in order to enable a broader understanding of the field. The exclusion criteria were applied in successive filters, which focused on the title/abstract; introduction/conclusion and finally the full paper, whenever necessary. Eventually, 76 papers were selected for further analysis—resulting in the identification of a number of eco-innovation tools.

The majority of the identified eco-innovation tools focus at the product level. Some examples of eco-innovation tools at the product level includes: creativity and ideation [37–42], Life Cycle Assessment and environmental evaluation [43,44], ecodesign [45–48], material selection [49] and biomimetic design [50]). In total, 13 tools linked with the company level were identified. Table 1 presents the identified tools, with a description of their main goal and link with the key theoretical concepts of eco-innovation (EI); industrial symbiosis (IS) and green business models (BM).

Table 1. Identified tools at a company level, classified according to their goals and focus (eco-innovation (EI), industrial symbiosis (IS) and business model (BM)).

Tool	Goal	EI	IS	BM	Ref.
Agent-based modeling & Innovation Diffusion Theory	Identifies opportunities for industrial symbiosis; network level	x	x		[12]
ASEM Eco-Innovation Index (ASEI)	Measure eco-innovation implementation in Asia; international level	x			[36]
By-product Exchange Network Model	Provides knowledge about possible and available by-product exchanges; network level		x		[51]
Eco-Innovation Scoreboard (Eco-IS)	Measures eco-innovation implementation in Europe; international level	x			[36, 52]
EcoWater Toolbox	Assesses eco-efficiency of innovative technologies in water use systems; value chain level	x			[53]
Energy Synergies Database	Contextualizes different energy flows by the classification of flows' end uses; network level		x		[54]
Industrial Environmental Sustainability Index (IESI)	Measures the efficiency of industrial sustainability policy; regional level	x	x		[55]
Industrial Symbiosis maturity grid	Helps monitor and assess the level of regional industrial collaboration and indicates a potential path for further improvements		x	x	[14]
J-Park Simulator (JPS)	Increases knowledge interoperability between different companies in EIP; network level		x		[56]
Knowledge repository for industrial symbiosis	Supports the identification of industrial symbiosis opportunities, through a database of cases and a exchanges database; network level		x		[57]
SCOR model for Eco-Industrial Parks management	Evaluates the performance of the processes along the supply chain to map substitution synergies; value chain level		x		[58]
SymbioSyS tool	Detects potential synergies for industrial symbiosis, based on a large database, and delivers feasibility studies; network level		x		[59]
Tool for industrial symbiosis evaluation	Evaluates the potential for establishing symbiotic relationships in eco-industrial parks; network level		x		[60]

A more in-depth analysis of Table 1 enables the identification of interesting highlights about the explored field:

(i)   Strong predominance of industrial symbiosis tools (10 out of the 13 identified tools contain IS elements), focused on the exchange of material and energy flows. Only one tool is related to business models (through a maturity grid), while five tools are focused on eco-innovation;

(ii) Limited number of multidisciplinary tools—only two tools combine industrial symbiosis and eco-innovation elements (at the network and regional levels); and only one tool combines industrial symbiosis and business models (focused on regional industrial collaboration);

(iii) Most of the identified industrial symbiosis tools focus on the development of knowledge-based platforms and databases for enabling the identification of potential symbiotic synergies among companies, rather than at understanding the company level potential;

(iv) Most of the tools are applied at a network/supply chain level (or product level)—none of the identified tools focus at the company level, which can be seen as an important gap in the current state-of-the-art.

In addition to the tools presented in Table 1, a number of industrial symbiosis optimization tools were identified [61–63], as well as policy-related tools [64,65]. Furthermore, many recent publications

are directly highlighting the link between industrial symbiosis and circular economy [59,66–68], an emerging concept. These publications focus on developing tools to facilitate resource exchange among companies [59], a state-of-the-art review linking Circular Economy with industrial symbiosis and related concepts [67] and exploring non-technical barriers and drivers for Circular Economy implementation by means of industrial symbiosis [68].

Overall, the literature review highlights the opportunity for developing eco-innovation tools that can support the identification of the implementation potential at the company level, linking industrial symbiosis and business model innovation in an eco-innovation context—which is aligned with the goal of this research presented in Section 1.

3. Methodology

In order to accomplish the aforementioned goal to develop a screening tool to identify and evaluate the potential of SMEs for eco-innovation, an action research [69] approach based on two development cycles was employed (Figure 2).
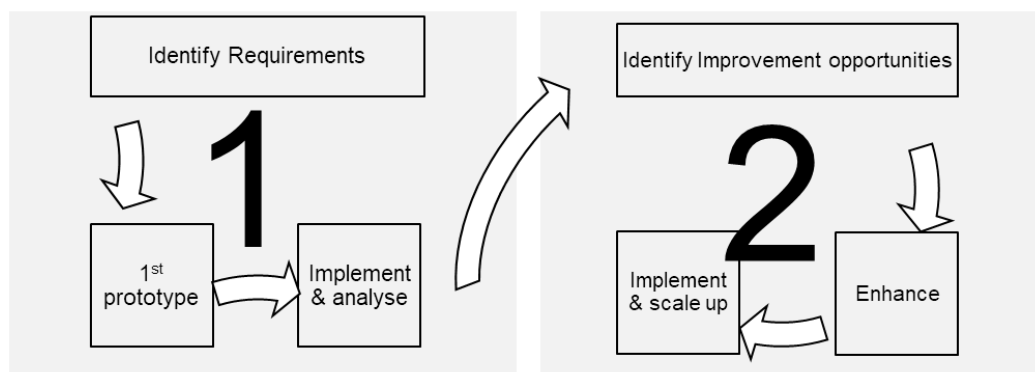

Figure 2. The action research was developed in two cycles: (1) Development and test of the screening prototype; and (2) improvement and scale-up of the enhanced screening tool.

Action research is a research methodology approach characterized by a problem solving focus, which is applicable to understand, plan and implement changes in organizations [69]. Action research employs a rigorous scientific approach to study the resolution of key organizational issues together and with the participation of the key involved stakeholders [69]. One of the main goals of action research is to make more effective action at the same time that scientific and theoretical knowledge is created. According to Reference [70], action research is widely recognized as an effective way of accomplishing productive and effective outcomes within business and industry, which are scientifically based and practically sound. The two action research cycles carried out in this research project are described in Sections 3.1 and 3.2, from a methodological point of view. The results are presented in Section 4.

3.1. Cycle 1: Development and Test of the Screening Prototype

The first action research cycle focused on the development of the first prototype version of the screening tool, and was composed of three main steps (Sections 3.1.1–3.1.3).

3.1.1. Step 1.1. Requirements Identification

In order to be able to understand the key features that the screening tool would need to have to enable the screening of SMEs potential for eco-innovation (with focus on industrial symbiosis and green business models), an in-depth identification of requirements was carried out.

The initial requirements list was elaborated based on a literature review of key features to be considered when implementing industrial symbiosis and eco-innovation in SMEs. The identification of requirements was carried out in three main areas: (1) content (i.e., what kind of data would be required

for the evaluation of readiness for industrial symbiosis and eco-innovation), (2) procedure (i.e., the steps to be taken for the performance of the assessment) and (3) analysis (i.e., how the collected data would be analyzed to provide an indication of the readiness level of the SMEs).

Subsequently, the list was used as a framework for the requirements consolidation based on a workshop involving key stakeholders in the project, the Danish Symbiosis Center and a number of municipalities. The workshop took ca. 2.5 h, and resulted in a consensus among the stakeholders regarding the key elements that the screening tool would need to consider (presented in Section 4.1.1).

3.1.2. Step 1.2. Development of the First Prototype

Based on the identified requirements and a literature review of key defining factors for eco-innovation, a first version of the screening tool was developed, bringing together the key elements that would enable the understanding of the potential of SMEs (Sections 4.1.1 and 4.1.2).

Special focus was paid to the development of a quick-assessment tool with information that is usually readily available in the SMEs, and would at the same time provide a good understanding of their potential for innovating. Furthermore, the tool was developed in a way to be easy to use, both for data collection and data analysis.

Internal validations of the prototype were carried out within the project working group, and aimed at providing additional consolidation and refinement of the tool before its pilot implementation. In addition to the content, different forms and means for the delivery of the tool (incl. paper-based, web or desktop-based assessments) were tested out. The key elements of the prototype are presented in Section 4.1.2.

3.1.3. Step 1.3. Implementation and Analysis of the Results

In order to enable the six engaged municipalities to perform the readiness assessment in the SMEs, a complete training regarding the screening tool and its main features was performed, so to ensure that there would be a good understanding regarding how to engage the SMEs in the assessment. In addition to a face-to-face run-through the tool, a detailed description of the different steps and types of required information were provided. Furthermore, specific knowledge transfer sessions were carried out to enable an enhanced literacy of the municipalities related to both industrial symbiosis and eco-innovation as well as business model development. Moreover, specific guidance was provided in relation to the capture of potential pitfalls with the use of the tool, looking at the feedback for its enhancement in the second action research cycle.

3.2. Cycle 2: Improvement and Scale-Up of the Enhanced Screening Tool

The second action research cycle focused on the enhancement of the screening tool based on the observed improvement opportunities from the first cycle; the development of the enhanced screening tool and its subsequent deployment and scale-up in the project. Three main steps were carried out in the second cycle, as the following section describes.

3.2.1. Step 2.1. Identification and Prioritization of Improvement Opportunities

Improvement opportunities for the further development of the screening tool were identified both from the researchers' observation of the use of the screening tool by the Danish Symbiosis Center and municipalities (by analyzing its application in practice during a number of evaluations), and also from the feedback received from the municipalities through feedback sessions (after the application in a number of companies has taken place). The feedback sessions were structured around the key elements of the screening tool (e.g., company characterization and readiness areas), based on three main perspectives (content, procedure and analysis)—following a semi-structure questionnaire.

In order to further develop the second version of the screening tool, the identified improvement opportunities in step 1.3 (cycle 1) were prioritized based on two main criteria:

- Relevance: The relevance of the identified improvement opportunities was evaluated in light of the initial requirements list and the project context (goals and scope). This was important to ensure that the identified improvement opportunities were not contradictory to the goals, scope and requirements defined in the project.
- Feasibility: The feasibility was evaluated in light of their implementation requirements within the timeframe of the project, and considering the available budget. The main goal was to ensure the implementation of the improvement opportunities that were possible within the context of the project, delivering the expected results to the key involved stakeholders.

The prioritized list of improvement opportunities was validated by the key project stakeholders and municipalities to ensure agreement on the changes to be implemented—and alignment on the next steps of the project. The identified and prioritized improvement opportunities are presented in Section 4.1.3.

3.2.2. Step 2.2. Enhancement of the Screening Tool

In order to be able to enhance the screening tool, a morphological matrix was developed to support the identification of the key alternative solutions that could be implemented to address each one of the prioritized improvement opportunities. Subsequently, alternative concepts were developed (by the combination of the key alternative solutions) and prioritized for implementation, for the development of the enhanced version of the tool. The enhanced version of the screening tool (presented in Section 4.2.2) was then evaluated by the municipalities and the Danish Symbiosis Center, and small adjustments were made based on their feedbacks before proceeding to the implementation by the other SMEs involved in the project.

3.2.3. Step 2.3. Implementation and Scale-Up

The implementation of the enhanced version of the tool was carried out by the six municipalities, the Danish Symbiosis Center and DTU, involving 108 SMEs in the Zealand region, in Denmark. Based on the screenings, the companies with the highest potential for industrial symbiosis and eco-innovation were selected to engage in the further steps of the project, which included the development of technical plans by associated consultancies (50 companies), the development of eco-innovative business models (30 companies) and the development of symbiotic collaborations (10 companies).

4. Results

The results of the action research employed for the development of the screening tool to measure the SMEs potential for eco-innovation are presented in this section, for each one of the steps presented in the methodology section.

4.1. Cycle 1: Development and Test of the Screening Prototype

4.1.1. Requirements for the Development of the Screening Tool

The requirements for the development of the screening tool were divided into three main areas: (1) screening content; (2) screening procedure; and (3) screening analysis. The consolidated requirements for each one of these areas are presented as following:

(1) Screening content—"What should be screened?" (the key factors are described in Section 4.1.2, with an indication of the supporting literature.)

- Characterization questions: Questions used to characterize the SMEs performing the screening should include registration information (e.g., name, address, CVR, size, etc.); financial information (e.g., revenue, costs for waste handling, etc.); certification according to management systems (e.g., ISO 14001 (environmental management systems), ISO 9001

(quality management systems), OHSAS 18001 (focused on occupational health and safety assessment), etc.); key manufacturing processes and services; overview of manufactured products; and previous experience with industrial symbiosis.

- Business model questions: In order to be able to support the identification of opportunities for green business models and eco-innovation, the key business areas to be focused on included value proposition, value chain and risks, customers, revenue, channels, key activities, key partners and suppliers, costs, key resources and willingness to take risks.

- Readiness questions: In order to be able to measure readiness, a number of areas should be included in the screening tool related to regulatory context, raw material and waste handling practices, technical feasibility (in terms of quality and quantity), capital feasibility (in terms of the required investments), payback period (short, medium and long-terms), potential for virgin resource use avoidance, potential for waste reuse/recycling, willingness to cooperate and share information, willingness to take risks, and practices for sustainable development.

(2) Screening procedure—"How should we perform the screening?"

- Time for screening: The time required for the screening (including data collection and consolidation) should be between 6 and 8 hours, which corresponds to 1 day of work at each one of the engaged SMEs.

- Type of assessment: The assessment should be performed by third parties (i.e., the engaged municipalities), and should not include a self-assessment module for the SMEs. The municipalities are responsible for the quality of the collected data and the consistency of the results.

- Organizations carrying out the screening process: The primary responsible organization to perform the screening are the municipalities, but support should be expected from researchers and staff from the other two partners in the project.

- Knowledge level of the person carrying out the screening: The screening tool should be developed considering an intermediate knowledge about industrial symbiosis, and limited knowledge about eco-innovation and green business models.

- Number of people involved for the screening in the SMEs: 5–10 people from the SMEs are expected to be engaged in the screening process, which brings the possibility of engaging people from different functions and hierarchical levels (incl. managing director and strategy, environment experts/responsible, production manager, finance manager and supply chain/logistics).

- Mode of assessment: The screening tool should be developed considering a combination of interviews (or group interviews), questionnaires (to support data collection prior to the screening process), and data collection on site.

- Tool for screening: A computer-based tool was selected (e.g., spreadsheet or text document), so to enable an offline assessment and to make sure that all SMEs would have access to the screening tool.

(3) Screening analysis—"How to analyze and communicate the results?"

- Time required for the analysis of the screening results: the analysis should take 4–6 h per SME, to be performed in collaboration between the key project partners and led by the municipalities.

- Communication of the results: Should contain both a single score with the readiness score, and an executive summary of the main conclusions.

In addition to providing the basic requirements for the development of the screening tool, the requirements identification also provides a structured approach for identifying the needs of multiple stakeholders, with a clear structure that can be used for the development of a large range of different tools and approaches, focusing on three basic elements: the tool content, the procedure for carrying out the evaluation, and the analysis of the results.

4.1.2. The First Screening Prototype

The first prototype of the screening tool was developed to address all the aforementioned requirements in relation to the screening content, procedure and analysis, with elements based on a literature review on readiness, industrial symbiosis and eco-innovation.

The screening tool was structured in four complementary blocks: (1) Company characterization; (2) analysis of input & output flows; (3) description of the business model; and (4) readiness areas, preceded by an overall introduction (Block 0). Each block contains a description of the goal, steps for application, stakeholders to be engaged, and data collection types. The screening tool was developed in a spreadsheet, with each block relating to one sheet.

Block 0: Introduction

Block 0 presents an overall introduction to the screening tool, with detailed information about its main elements and characteristics. It includes the following elements: goal of the tool (i.e., to screen the SMEs potential for industrial symbiosis and eco-innovation); the confidentiality issues (i.e., data use and ownership) and the overall tool structure (with the four main blocks).

Furthermore, a detailed description of the process for the screening is provided, with the indication of the key stakeholders to be engaged in the screened SMEs (Table 2).

Table 2. Engaged participants in the different blocks of the screening process.

Block	Participants
1 Company characterization	Municipality (lead) Finance and environmental managers
2 Analysis of input & output flows	Municipality (lead) Production, logistics and environment managers
3 Description of the business model	Municipality (lead) Leadership, product, purchasing, logistics and environmental managers
4 Readiness areas	Municipality (lead) Leadership, product, purchasing, logistics and environmental managers

In all the different blocks, the defined procedure for the use of the screening tool comprises four main tasks, as described below:

- Task 1: The municipality is responsible for initial data collection through databases, and knowledge from previous collaborations/engagements with the SME;
- Task 2: The municipality carries out site visit and face-to-face interviews with key stakeholders in the company, aiming to collect information for all the four screening blocks;
- Task 3: The company is then responsible for checking the collected data and adding additional information, if necessary.
- Task 4: Municipalities, the symbiosis center and the university partners validate the screening assessment and develop a report for the company, regarding their potential for industrial symbiosis and eco-innovation.

Block 1: Company characterization

The main goal of this block is to characterize the company, in relation to registration data, key products/manufacturing processes, and previous experience on eco-innovation and industrial symbiosis related topics. Key collected data includes:

- Company information: Includes the company name, address, municipality, registration numbers, sector/branch and number of employees.
- Contact information: Collects information from the key stakeholders to be engaged in the company (Table 1), including name, title/position, telephone number and email.
- Financial information: Includes financial information from the company for the past 2 years, related to revenue, income and profit.
- Manufacturing sites: Includes information of other manufacturing sites that the company might have (incl. address, number of employees, branch, manufactured products and key manufacturing processes).
- Previous experience: Open ended question, which aims to have an initial high level understanding of the company's experience with sustainability-related topics such as industrial symbiosis, green business models, environmentally friendly design, Life Cycle Assessment, cleaner production, environmental management systems, energy management, green branding, etc.

In addition to supporting the characterization of the companies, this block also enables future comparisons and correlation studies, which can be used to characterize the screened companies.

Block 2: Analysis of Input & Output Flows

The main goal of this block is to identify the material, water and energy flows of the screened companies in order to identify their potential for industrial symbiosis. Inputs for water, energy and materials are characterized in relation to their type, involved processes, average yearly consumption amounts, quality requirements, costs, key sources and transportation from the source (whenever applicable).

Output flows are mapped in terms of waste (residual water, dissipated energy and solid waste), the internal reuse percentage, average yearly generated amounts, quality specification, costs for disposal (if applicable), recipients of the waste and transportation from the source (whenever applicable). Furthermore, information is collected on whether the company has access to their own transportation means and the company's production area. The information collected in this block is used to determine the current potential to optimize material, water and energy consumption internally and in collaboration with other companies through industrial symbiosis.

Block 3: Description of the Business Model

This block is intended to describe the company's current business model, in order to identify opportunities for the development of green business models. Due to the large dissemination and uptake by industry, the business model canvas was selected as the key framework behind this block and adapted in a slightly simplified form. Furthermore, a number of detailed guiding questions were developed to support the municipalities to obtain data from the SMEs, for each one of the dimensions (Table 3). The questions were based on the traditional literature of business model innovation, with a strong foundation on the business model canvas and business model generation approach [18].

Table 3. Guiding questions to support the mapping of the current business model.

Business Model Area	Guiding Questions
Value proposition	What is our core product? What value do we deliver to our customers? What customers' needs do we satisfy? What are we competing for?
Customer segments	Who do we create value for? Who are our main customers? What is the importance of close/home markets versus global markets?
Customers relationships and channels	How do we reach out to customers? How is our relationship with our customers (stability/cooperation, etc.)?
Supplier relationships	Who are our main suppliers? How is our relationship with suppliers (stability/cooperation, etc.)?
Production organization	Do we produce ourselves or outsource? Are we part of a group or are we a stand-alone company?
Cost structure	What are our main costs? What key activities or resources are the most expensive? How much does waste/residual waste management account for our total costs?
Revenue structure	What are the main sources of income? What values are our customers willing to pay for and how do they pay now?

Furthermore, additional fields were available for reflections on the current business model by the SMEs and municipalities, with qualitative comments on additional key observations.

Block 4: Readiness Areas

The purpose of this block is to identify the company's readiness to be involved in eco-innovation and industrial symbiosis development projects, from a varied number of perspectives. In total, 10 readiness areas were evaluated following a 10-point Likert-scale (1–3 = low; 4–7 = medium; 8–10 = high) (Table 4). The Likert-scale is an ordinal scale, which was selected as a measuring instrument due to the possibility of representing qualitative properties based on a ranking of their relative importance/strength [71]. Furthermore, the Likert-scale allows the definition of relations within and across variables in terms of equalities, as well as inequalities—which would allow the comparison across categories and within companies.

Table 4 presents a consolidated review of key readiness dimensions in the literature for the implementation of eco-innovation, industrial symbiosis and green business models. In addition to providing a contribution to the state-of-the-art on the field, the readiness dimensions can be employed to further advance the theoretical understanding of the companies' readiness for eco-innovation, independent from the application of the full screening tool.

In addition to that, there was an additional field for the company/municipality to add additional reflections and comments in order to provide more qualitative data for the scores assigned to each one of the questions. By having the possibility of adding a qualitative assessment of the provided answers, the tool aims at bringing a higher reliability in relation to the obtained results as it allows for further reflections on the proposed answers (both by the SMEs and municipalities), and minimization of the potential bias related to the assessment. Furthermore, because the proposed tool is targeted at screening the potential of SMEs, it is important to ensure the tool's ability to process qualitative data. A similar approach has been adopted for other similar questions on the tool, both in the pilot version and also in the enhanced version of the screening tool (Section 4.2), after a positive feedback from its application.

In order to be able to capture the municipalities' reflections on the screening and the potential of the assessed SME, a number of additional guiding questions were suggested:

- Do you see opportunities for internal resource optimization in the company?
- Do you see opportunities for green business models innovation?

- Do you see opportunities for industrial symbiosis? With which input/output flows and with whom?

Finally, the companies' experience and interest in joining in network activities was explored.

Table 4. Overview of readiness areas and guiding questions.

Readiness Area	Guiding Question	Reference
Resource minimization	How do you rate the potential to minimize resource consumption (incl. water, energy and materials) in the company?	[14,54,65,67]
Reuse/recycle potential	How do you rate the potential for reuse/recycle your output flows (water, materials and energy)?	[14,72]
Raw materials	How do you evaluate the potential to change your raw materials for recycled materials and/or other sub-products?	[3,14,16,17]
Waste commercialization	How do you rate your options for starting providing your by-products (solid waste, energy excess and/or wastewater) to other companies as a raw material?	[14,59,72]
Business model innovation	How do you rate your readiness to change your business model towards eco-innovation and industrial symbiosis?	[3,4,11,73]
Investment potential	How do you rate the opportunity for investment in eco-innovation and/or industrial symbiosis projects?	[14,74,75]
Pay-back willingness	Where is your limit to repayment time on investments? (1–3 short term, 4–7 medium term, 8–10 long term)	[14,68,76]
Cooperation and communication	How do you judge your readiness to cooperate and communicate with other companies?	[3,13,14,17,76]
Knowledge sharing	How do you judge your readiness to exchange information with other companies?	[14,32,54,56,57]
Managing trade-offs	How do you judge your experience of reconciling environmental and economic aspects?	[3,68,77]

4.1.3. Implementation of the Tool and Analysis of the Results

During the pilot phase, the screening tool was used by the six municipalities in a total amount of 21 SMEs, from a varied number of sectors (incl. food processing, metal-mechanic, furniture, plastics, etc.). In order to enable the analysis of the results in a systematic and consistent way, so the companies' potential could be compared in future benchmarking studies, an additional approach was developed for the analysis of the results.

A customized report was developed for each company, containing background information about the project and evaluation methodology, key collected company data, the current business model, overview of input/output flows, and a readiness assessment. The overall potential was then summarized in a unique normalized score, ranging from 0–100.

As previously mentioned, our focus in this paper is on the development of the tool itself—the analysis of the results from the actual screenings are out of the scope of this paper.

4.2. Cycle 2: Improvement and Scale-Up of the Enhanced Screening Tool

4.2.1. Identification and Prioritization of Improvement Opportunities

The implementation of the screening tool by the municipalities and SMEs provided interesting insights related to the tool content, the procedure for carrying out the assessment and the analysis of the results. By following the methodology described in Section 3.2.1, a number of key learnings and improvement opportunities were consolidated. The main key learnings and improvement opportunities related to the pilot application of the screening tool are presented in Table 5.

Table 5. Overview of the key learnings and improvement opportunities related to the pilot application of the screening tool.

Block	Content	Procedure	Analysis
1 Company characterization	Most of the data required is readily available	SMEs were slightly protective of financial data	Enabled further characterization of the screened SMEs. Some data was not used for the analysis
2 Analysis of input & output flows	Limited data availability at the SMEs, especially related to output flows. Additional support required for filling out the tool, with more in-depth explanations and pre-filled answer options	Companies' role for the collection of the required input/output data is key. Significantly higher time required for the assessment than initially expected	Technical in-depth knowledge regarding the processes and company ecosystem required for the identification of industrial symbiosis opportunities. Need to ensure good data quality for meaningful results
3 Description of the business model	Due to the limited knowledge of the SMEs and municipalities regarding business model, the dimensions were not easily understood	Interviews with the SMEs proved to be the best approach for data collection. Good representation of the SMEs business areas was key for a comprehensive picture	Enabled the understanding of the current business model. Potential for changes was difficult to evaluate given the available information.
4 Readiness areas	Good coverage of addressed areas. Difficulty to understand some of the questions	Likert-scale well-received by the companies. Enabled discussion among the company staff	Analysis could be enriched with more qualitative data on the different questions, with an explanation behind the assigned scale. Likert-scale enabled an easier comparison across the companies

Overall, it was found the need to have more close-ended questions, similar to the readiness questions, in order to be able to have a more objective analysis of the results, to allow for a fair comparison among the screened companies, and their selection in the subsequent steps of the project. Despite being specific for the developed screening tool, these learnings can also be considered for the development of similar tools, which are focused on SMEs and are applied in a similar context to the one used in this research.

Furthermore, it is important to mention the initial resistance of the SMEs to engage with the municipalities in a joint project. Because of the traditional relationship of command-and-control between the municipalities and the SMEs, the companies had a difficult time understanding the role of the municipalities in supporting them to identify opportunities for industrial symbiosis and eco-innovation. Eventually, the barriers were minimized and a good level of collaboration could be experienced.

4.2.2. Enhanced Screening Tool

On the basis of the application of the screening prototype tool and the identification of a number of improvement opportunities, the screening tool was further developed and enhanced. The key implemented enhancements of the screening tool for each block are described in this sub-section.

Block 1: Company Characterization

In order to make the assessment more effective and dynamic, the open-ended question related to experience with sustainability-related topics was eliminated from the new version of the tool. Other than that, no other significant changes were implemented, except for a slight change in the layout. Due to the importance of the financial data for the characterization of the screened SMEs, the project team decided to keep this field in the tool.

Block 2: Analysis of Input & Output Flows

In order to enable the data collection, a number of guiding commentaries were added for each one of the input/output categories, which also provides best practices and guidelines for data collection. In that way, the municipalities and SMEs can have a better indication regarding how the required data can be collected and consolidated.

Due to the challenges identified in terms of data availability for the quantitative analysis of inputs & outputs flows, significant changes were implemented in this block—with the addition of a qualitative assessment. The assessment was divided into four sub-blocks, as will be detailed below.

Sub-Block 2.1: Preliminary Assessment

The preliminary assessment aims at (1) giving an indication of the company's general perception of the commercial significance of resource consumption for the company today; (2) understand what business significance resource-saving measures could be expected for the company in the future; as well as (3) to provide an indication of which of the resource streams the company would likely prioritize.

The purpose of the questions in the preliminary assessment are to find out the most significant resource flows (i.e., material, energy or water) for the company. A 5-point Likert scale was employed to support this evaluation: (1) very small importance; (2) small importance; (3) neither small or large importance; (4) large importance; (5) very large importance. The questions are presented in Table 6.

Table 6. Questions for the preliminary assessment of potential related to input/output flows.

Resource Flow	Questions
Energy	How important is energy consumption for the business? How important would it be if you could lower energy consumption or re-use surplus energy?
Water	How important is water consumption for the business? How important would it be if you could lower water consumption or re-use wastewater?
Materials	How important is material consumption for the business?
	How much importance would it have if you could reduce material consumption or lower waste?

In addition to the scores, the municipalities/SMEs can also add additional comments to each one of the questions, in order to justify their importance evaluation.

Sub-Block 2.2: Mapping Energy Streams

The mapping of the energy streams is sub-divided into four main areas: (1) energy sources; (2) energy consumption; (3) energy losses; and (4) evaluation of opportunities (Table 7).

Table 7. Mapping of energy streams: goal and collected data.

Area	Goal	Collected Data
(1) energy sources	Get an overview of the types of energy sources used, as well as the expenses for energy purchasing.	Source (incl. a dropdown menu with standard sources), consumption costs/year, consumption amount/year, measured unit (incl. a dropdown menu with energy units), and comments.
(2) energy consumption	Quantify energy consumption, for each provided energy source	Energy-consuming process (incl. a dropdown menu with standard processes), energy source (from area (1)), consumption amount/year, measured unit (incl. a dropdown menu with energy units), and comments.
(3) energy losses	Quantify the amount of energy losses	Energy loss (incl. a dropdown menu with standard losses), losses costs/year, losses amount/year, measured unit (incl. a dropdown menu with energy units), and comments.

<div align="center">**Table 7.** *Cont*.</div>

Area	Goal	Collected Data
(4) evaluation of opportunities	Evaluate the opportunities to optimize energy consumption/re-utilization	Indication of the agreement level in relation to six main affirmatives (5-point Likert-scale, from 1 (strongly disagree) to 5 (strongly agree)) (i) We can reduce energy consumption. (ii) We can replace our current energy sources with greener energy sources. (iii) We can further reuse our waste energy internally. (iv) Other companies nearby are able to use our waste energy (additional) (v) We can use energy excess from other nearby companies. (vi) Energy consumption in my company is more effective than other companies in the same industry.

Sub-Block 2.3: Mapping Water Streams

Similarly to sub-block 2.2, the mapping of water streams is sub-divided in a number of main areas: (1) water sources; (2) water consumption; (3) waste water; (4) water discharge; and (5) evaluation of opportunities (Table 8).

<div align="center">**Table 8.** Mapping of water streams: goal and collected data.</div>

Area	Goal	Collected Data
(1) water sources	Get an overview of the types of water sources, as well as the expenses for water purchasing.	Source (incl. a dropdown menu with standard sources), consumption costs/year, consumption amount/year, measured unit (m^3), and comments.
(2) water consumption	Quantify water consumption, for each provided water source.	Water-consuming process (incl. a dropdown menu with standard processes), water source (from area (1)), consumption amount/year, measured unit (m^3), and comments.
(3) waste water	Quantify the amount of generated waste water.	Wastewater type (incl. a dropdown menu with standard waste water types), water treatment costs/year, waste water amount/year, measured unit (m^3), and comments.
(4) water discharge	Quantify the deduction charges for waste water that does not lead to sewerage.	(i) Has the company water that does not drain into sewerage? (ii) If so, does the company have approaches to reduce the water management fee?
(5) evaluation of opportunities	Evaluate the opportunities to optimize energy consumption/re-utilization.	(i) Indication of the agreement level in relation to six main affirmatives (5-point Likert-scale, from 1 (strongly disagree) to 5 (strongly agree)) (ii) We can reduce water consumption. (iii) We can reuse secondary water to replace our current water sources. (iv) We can further reuse our waste water internally in the company. (v) Other companies nearby are able to use our waste water. (vi) We can use waste water from other nearby companies. (vii) Water consumption in my company is more effective than other companies in the same industry.

Sub-Block 2.4: Mapping Material Streams

The mapping of material streams is sub-divided into the following main areas: (1) material sources; (2) material consumption; (3) solid waste; (4) evaluation of opportunities for material inputs; and (5) evaluation of opportunities for material outputs (Table 9).

Table 9. Mapping of material streams: goal and collected data.

Area	Goal	Collected Data
(1) material types	Get an overview of the types of material, as well as the expenses for material purchasing.	Type (incl. a dropdown menu with standard material types), consumption costs/year, consumption amount/year, measured unit (incl. dropdown list with common units), and comments.
(2) material consumption	Quantify water consumption, for each provided water source.	Material-consuming/transforming process (incl. a dropdown menu with standard processes), material type (from area (1)), consumption amount/year, measured unit (incl. dropdown list with common units), and comments.
(3) solid waste	Quantify the amount of generated solid waste.	Solid waste type (incl. a dropdown menu with standard waste types), waste treatment costs/year, solid waste amount/year, measured unit (incl. dropdown list with common units), and comments.
(4) evaluation of opportunities for INPUT materials	Evaluate the opportunities to use alternative materials as inputs.	Indication of the agreement level in relation to four main affirmatives (5-point Likert-scale, from 1 (strongly disagree) to 5 (strongly agree)) for material input used in the company (i) We can reduce the consumption of this material. (ii) We can replace this material with more sustainable alternatives. (iii) We can replace this material with recycled materials. (iv) Material consumption in my company is more effective than other companies in the same industry.
(5) evaluation of opportunities for OUTPUT materials	Evaluate the opportunities to generation as solid waste as output.	Indication of the agreement level in relation to four main affirmatives (5-point Likert-scale, from 1 (strongly disagree) to 5 (strongly agree)) (i) We can reduce the generation of this solid waste. (ii) We can reuse the generated solid waste directly in the company. (iii) Other companies nearby are able to use our solid water as raw material. (iv) Solid waste generation in my company is lower than other companies in the same industry.

By enabling the analysis of Input & Output flows through a combination of quantitative measures (related to the flows) and qualitative measures (related to the opportunities for each evaluated area), the assessment enables a richer and more comprehensive evaluation of the potential for industrial symbiosis, which can help to overcome the challenges related to data availability and data quality, which is common in SMEs, and is also present in large organizations.

Furthermore, in order to have a better flow of the collected data, the order of the blocks were changed in the new version of the tool. Block 2 (Analysis of Input & Output flows) and Block 3 (Description of the business model) changed orders, in a way to ensure that the business model data would fit with the overall company characterization.

Block 3: Description of the Business Model

In order to make the characterization of the current business model clearer for both the municipalities and SMEs, examples on how to fill in the business model information were added as a complement to the guiding questions already incorporated in the first prototype version.

Furthermore, in addition to the qualitative description of the current business model, semi-quantitative questions were added to support the identification of the perception of the SMEs in relation to the opportunities to enhance the different business model dimensions. The questions are evaluated by the indication of the agreement level in relation to nine main affirmatives (5-point Likert-scale, from 1 (strongly disagree) to 5 (strongly agree)).

The affirmations (Table 10) were deployed from the business model's key factors and references presented in Table 2, and phrased in a way to be easily understood by the engaged SMEs, considering their knowledge level in relation to the explored concepts.

Table 10. Guiding affirmations linked with their respective business model dimensions.

Guiding Affirmations	Business Model Dimensions
We can increase our competitiveness by being greener	Cost structure. Revenue structure
We can attract new customers by offering green products/services	Value proposition. Customer segments
We can create green collaborations with our customers	Customer relationships and channels
We can create green collaborations with our suppliers	Supplier relationships
We can make our production more efficient	Production organization
We can lower our consumption of water, energy and/or materials	Production organization. Cost structure
We can increase our earnings by offering green products/services	Value proposition. Revenue structure
We have good experience working with the green area	All dimensions

The word "greener" was employed in order to enable an easier understanding by the companies, and can be understood in this project as "eco-innovation and industrial symbiosis" activities. In addition to the close-ended questions, comment fields for the more qualitative answers were also added in the enhanced version of the tool.

By combining the business model's elements into guiding affirmations, the proposed approach enables a streamlined approach for capturing the potential for enhanced sustainability performance in SMEs, with a simple and easily understandable language, further advancing the state-of-the-art in the business model innovation literature.

Block 4: Readiness Areas

In order to ensure alignment with the 5-point Likert-scale employed in the other blocks, it has been decided to adapt the same scale for the readiness areas in Block 4. Furthermore, the 10 guiding questions from the prototype were further consolidated into eight guiding affirmations, as presented in Table 11. The guiding questions related to the "resource minimization", "reuse/recycle potential" and "waste commercialization" were integrated into the Block 2, as previously presented. "Pay-back willingness" was broadened to more overall managerial support; "knowledge sharing" and "managing trade-offs" were excluded. Furthermore, three additional readiness areas were included: "importance now", "importance future" and "networks".

Table 11. Update of the readiness guiding affirmations.

Readiness Area	Guiding Affirmations
Raw materials	We have the opportunity and interest in participating in a project about increased recycling internally or with other companies.
Business model innovation	We are interested in developing our business model in a greener direction.
Investment potential	We have the opportunity to invest in a green project.
Cooperation and communication	We have the opportunity and are motivated to increase our cooperation and communication with other companies.
Importance now	We consider the green area to be of great importance to our business today.
Importance future	We expect the green area to get big or even greater importance for our business in the future.
Networks	We are interested in being part of green business networks focusing on strategic green business development.
Managerial support	There is managerial support for us to work (further) strategically with the green area.

Finally, in order to enable the capture of the municipalities' reflections on the screening and the potential of the assessed SME, the guiding questions were also transformed into affirmations, and evaluated used the same 5-pont Likert-scale.

4.2.3. Step 2.3. Implementation and Scale-Up

The enhanced version of the screening tool was delivered to the municipalities, which together with the Danish Symbiosis Center performed the screening in all 108 SMEs, from a varied number of sectors. On the basis of the analysis of the results, customized company reports were delivered to the engaged SMEs, with an overview of their readiness for both eco-innovation and industrial symbiosis.

The tool was revised four times, considering a trade-off between easiness of the screening, and the need for detailed data. Some quantitative data proved to be difficult to obtain especially in relation to the input/output flows, particularly for the smaller companies. The tool was accordingly simplified to enable a faster and easier screening process. The semi-qualitative data provided a good indication of the SMEs potential, which was then explored in the subsequent phases of the project.

The feedback from the municipalities and SMEs towards the enhanced version of the tool were mainly positive. The feedback was obtained using the same evaluation criteria for the first action research cycle (i.e., content, screening and analysis, presented in Section 3.2.1) for each one of the blocks within the readiness tool, covering the evaluation of both the usability and usefulness of the proposed screening tool. The tool, while somewhat comprehensive, seems to be fairly easy to use, easy to understand and accessible for the SMEs. Furthermore, it enables an objective analysis of the results, which is currently being performed directly by the municipalities.

5. Discussion

In this section, the results are discussed in relation to four main areas: (1) contributions of the research to the state-of-the-art; (2) contributions of the research to the eco-innovation practice; (3) potential implications with the application of the proposed screening tool; and (4) other observations.

5.1. Contributions to the State-of-the-Art

The main contributions of the proposed screening tool to the state-of the-art are described in terms of the theoretical background presented in Section 2, related to the eco-innovation literature. In addition to enabling the evaluation of the eco-innovation potential of SMEs, the proposed RTR screening tool differentiates from existing tools in a number of ways:

(i)   By enabling the evaluation of eco-innovation potential at the company level, using both qualitative and quantitative data (the existing tools tend to focus either at the product or at the network level, with significant limitations in relation to the evaluation of the potential at the company-level. Furthermore, the tools tend to be strictly quantitative, which makes the application by SMEs more difficult).

(ii) By addressing eco-innovation, industrial symbiosis and green business models simultaneously, combined with a readiness assessment for further evaluation of the feasibility in realizing the identified potential (the existing tools tend to focus on one or two of the dimensions, not fully considering the synergy effects with the others-furthermore; readiness was not identified as an element in any of the identified tools).

(iii) By enabling the screening of SMEs by municipalities, as key players for enabling eco-innovation among SMEs (the tools are usually applied by network consolidators, with limited involvement of governmental bodies—the involvement of municipalities can provide interesting reflections regarding their roles as eco-innovation agents).

Within this research, efforts were focused on developing a tool that can, ultimately, support researchers to understand the SMEs' potential for eco-innovation implementation. Furthermore, the

tool can support the identification of barriers and success factors for eco-innovation implementation in SMEs, which can lead to the development of a number of eco-innovation tools by academia.

5.2. Contributions to the Eco-Innovation Practice

In the context of the RTR project, the proposed screening tool served a dual purpose. First, it served as a tool to help SMEs to understand their eco-innovation potentials, from the industrial symbiosis and green business models perspectives, with an overview of the viability of the business cases. Furthermore, a number of green business model workshops were held under the guidance of DTU with the Danish Symbiosis Center and participating municipalities. In these workshops, the company screening reports served as a basis for prioritizing the identified interesting eco-innovation potentials and for symbiosis matching. Also, some individual meetings with companies were held with the same purpose. Second, it was serving as a support for the selection of companies to proceed to the next stage of the project, which involved the development of technical eco-innovative solutions based on the identified eco-innovation potential and opportunities. Based on the screening results, ca. 50 companies were selected for further involvement in the project, for the development of 'Green Technical Plans' of which 30 companies became engaged in the development of new 'Green Business Models' to explore eco-innovation and symbiosis examples. These activities were carried out with the support of consultants paid by the project.

Similar contributions are expected with the application of the proposed tool in a broader context, outside the context of the RTR project. In addition to supporting SMEs to understand their potential for eco-innovation, which can aid to an enhanced perception of its strategic importance, the screening tool can also be applied in a broader sense by municipalities, consultants, sector associations, SMEs associations, or any similar organizations that are interested in understanding the eco-innovation potential of companies in a given context, aimed at subsequent steps in the implementation of the concept.

5.3. Potential Implications

The use of the proposed screening tool in a large range of SMEs, across different geographies and sectors, has the potential to generate data sets that can enable a number of sectorial and regional analysis, which can potentially enhance the scale-up of eco-innovation initiatives.

Some of the potential applications of the datasets obtained through the extensive application of the tool include:

- Benchmarking studies: The application of the tool can enable the benchmarking of companies, sectors, regions, etc. regarding the readiness potential for eco-innovation, coupled with green business models and industrial symbiosis opportunities;
- Database of inputs & output flows: The data collected regarding material and energy flows can be shared with prior agreement of the participating companies, in regional databases, maximizing the matchmaking opportunities among companies with clear synergies and geographical proximity;
- Policy making support: The understanding of the barriers for realizing the identified eco-innovation potential in a given region/country can support the local governments to establish targeted and specific policies aiming at providing incentives for an enhancement of the eco-innovation uptake by SMEs;
- Measure progress an evolution over time: The application of the screening tool over time, in the same company, can enable the understanding of the company evolution in implementing eco-innovation, supporting the prioritization of next steps and communication of results.

Other minor potential implications are related to cross-sectorial collaboration (enabled by the networking among the engaged companies), value chain innovation (by the establishment of new partnerships based on eco-innovation potentials); and potential external dissemination of the eco-innovation potential.

5.4. Other Observations

Despite the initial reservation of the SMEs regarding the screening performed by municipalities (up until than largely seen as command & control bodies), the municipalities managed to establish themselves as eco-innovation agents, supporting the SMEs to identify and further implement eco-innovation initiatives. Furthermore, the knowledge of both SMEs and municipalities regarding the potential for eco-innovation in their regions was significantly expanded during the project—starting with the screening tool, and moving towards the subsequent steps of the project (i.e., technical analysis, green business model development and symbiotic networks). It is expected that the created municipal network will be continued after the termination of the project, due to the strong relationships created among the participants and the role of the municipalities in bringing the companies together towards a shared objective.

6. Concluding Remarks and Next Steps

In this paper, the development, test and enhancement of a screening tool to support the measurement of the potential of SMEs for eco-innovation was presented, with a special focus on industrial symbiosis and green business models. The screening tool was developed in the course of two main action research cycles, actively involving the Danish Symbiosis Center and municipalities as key stakeholders, as well as the screened SMEs.

Differently from the identified existing tools, the screening tool proposed in this research aims at supporting companies to understand what their potential for eco-innovation is, combining wider eco-innovation and industrial symbiosis opportunities and green business models, supplemented with a readiness evaluation to explore the existing potential.

In addition to enabling a better understanding about their own internal processes and activities, the evaluation of the potential of 108 SMEs for eco-innovation enabled the selection of companies to be further engaged in the project, and provided them with detailed insights about how to reach the potential benefits with industrial symbiosis and green business models.

Overall, from a theoretical point of view, the state-of-the-art is advanced by the proposition of a systematic methodology that enables the screening of the eco-innovation potential in SMEs, at a company-level, by using both quantitative and semi-quantitative measures. The main theoretical contribution of the screening tool and its constituent elements is related to three main areas, as detailed and described below:

- Combined quantitative and qualitative approach for the evaluation of the potential for industrial symbiosis, looking at the material, energy & water flows and at the opportunities for enhanced efficiency, combined with a pre-evaluation of the relative importance of the different flows for the business performance and long-term success;
- Streamlined approach for capturing key business models elements (e.g., value proposition and revenue streams) that represent a potential for enhanced sustainability performance, based on state-of-the-art literature for business model innovation and on the use of the guiding affirmations;
- Consolidated review and evaluation of key readiness dimensions for the implementation of eco-innovation, industrial symbiosis, and green business models—evaluated by means of a five-point Likert-scale, which enables also a comparison across the different dimensions;

By exploring the potential of municipalities as eco-innovation agents, the approach also highlights the importance of a multi-stakeholder approach for eco-innovation implementation. Last but not least, the use of the proposed screening tool in a large range of SMEs, across different geographies and sectors, has the potential to generate data sets that can enable a number of sectorial and regional analysis, which can potentially enhance the scale-up of eco-innovation initiatives and allow for a better understanding of the uptake and implementation phenomena in SMEs.

The project leadership of the Danish Symbiosis Center secured a coordinated action across their six municipalities. Because of the active involvement of both the Danish Symbiosis Center and the

six Danish municipalities as the main players in the screening assessments, we expect to ensure long-lasting relationships and connections with the participating companies beyond the project period.

Currently, the screening tool has been tested only within Danish companies, which poses a limitation to this research. Cultural aspects can have a strong influence in the results of the screening tool, and should be further explored. It is expected that the screening tool can be used by other stakeholders as a way to evaluate the potential of SMEs for eco-innovation, including consultancy companies, universities, other governmental bodies, non-governmental organizations, and the companies themselves (through a self-assessment)—all of these opportunities are yet to be explored, and were not considered in this project.

Furthermore, the expansion of the proposed screening tool towards wider product-oriented Circular Economy solutions should be further explored, as a way to ensure a broader perspective. Also, it is also worth exploring the potential of applying the proposed tool in larger companies, which brings an additional level of complexity in terms of data collection. Finally, the evaluation of the potential for eco-innovation at a company level should be combined with a network evaluation, so to evaluate the feasibility/probability of turning the potentials into reality.

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