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Improving the Readiness for Industrial Symbiosis Adoption: The Case of Industrial Park De Zwette

Nela Votápková

S5732182

n.votapkova@student.rug.nl

Academic Supervisor: Dr. Sven Kilian

Co-Assessor: Dr. Mariana Cardoso Chrispim

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ABSTRACT

Growing environmental concerns highlight the negative impact of industrial sectors, emphasizing the need for adopting circular solutions to mitigate these consequences. This study aims to improve the readiness for Industrial Symbiosis implementation based on findings from the De Zwette industrial park in Fryslân in the northern Netherlands by identifying the inhibiting and enabling factors that influence adoption and providing strategies to facilitate the implementation of Industrial Symbiosis (IS). The research is structured around Agudo et al.'s (2022) framework, which proposes dimensions of readiness for IS implementation and offers further analysis of influencing factors for each dimension. The research employs a qualitative approach by conducting semi-structured interviews with actors operating in De Zwette industrial park. The findings revealed several inhibiting and enabling factors influencing the readiness for IS, including regulatory challenges, financial constraints, and the need for increased awareness and collaboration. It proposed tailored strategies for the context of De Zwette, such as proactive engagement, government support, and educational initiatives to enhance IS readiness. These findings contribute valuable insights for promoting sustainable industrial ecosystems locally and globally, with implications for achieving circular objectives.

Keywords: Circular Economy, Industrial Symbiosis, Industrial Parks, Readiness Improvement, Sustainable Entrepreneurship

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1 INTRODUCTION

The escalating global waste output, particularly from industrial sectors, poses a serious threat to the environment, necessitating urgent action (Alves, 2023). The amount of waste generated worldwide has increased dramatically in recent years and is expected to continue rising, potentially leading to severe negative environmental consequences. Current waste disposal practices, such as incineration and landfilling, contribute to air and water pollution, endangering ecosystems and human health (Smith et al., 2001). Furthermore, industrial waste presents a significant threat due to its potential environmental repercussions (OECD, 2013).

In the European Union, the industrial sector is one of the major contributors to waste generation, especially the manufacturing, mining, and construction industries (European Environmental Bureau, 2022). To address this pressing issue, initiatives like the UN's Sustainable Development Goals and EU policies emphasize the importance of sustainable waste management practices (UN, 2023). Moreover, the EU's Green Deal prioritizes the adoption of circular economy principles, with Industrial Symbiosis (IS) emerging as a promising strategy (Council of the European Union, 2023). Implementing circular solutions such as Industrial Symbiosis might facilitate collaborative efforts involving diverse stakeholders and foster sustainable development (Roemers, 2015). Therefore, implementing Industrial Symbiosis would be beneficial and might mitigate the negative effects of industrial waste and support the transition towards a more sustainable future.

Industrial Symbiosis is a collaborative approach of various industrial actors operating in the same geographical location (Baldassarre et al., 2019; Oughton et al., 2022). The objective for businesses involved in this connection is to form a network that will enable the transfer of resources, energy, water or by-products. Numerous IS projects are already operating worldwide and have shown promising results, especially in aspects such as cost cuts and the reduction of waste and initial resources (Teräs & Mikolla, 2016).

Researchers examining Industrial Symbiosis collectively underscore the importance of addressing challenges to enhance compatibility and readiness for IS adoption. They highlight the significance of tackling technological, economic, and policy-related hurdles, alongside emphasizing trust-building and enabling mechanisms to facilitate the adoption (Agudo et al., 2024; Oughton et al.,

2022). Similarly, the need for an essential exchange of resources is underscored, while barriers like information sharing, trust-building, and infrastructure are identified (Islam, 2016). However, existing literature lacks a comprehensive understanding of specific factors which could effectively enhance companies' readiness to adopt Industrial Symbiosis, particularly in the early stages of forming initial connections to form symbiotic relationships (Mortensen & Kørnøv, 2019). Additionally, there is limited research on strategies for initiating and facilitating circular transformations, such as Industrial Symbiosis (Azevedo et al., 2021). This research gap stresses the need to delve into the compatibility and readiness of companies to engage in Industrial Symbiosis and explore strategies for scaling up circular initiatives within industrial areas.

In line with these discussions, this research aims to make significant academic contributions by empirically validating Agudo et al.'s (2022) framework on readiness for Industrial Symbiosis implementation and further developing each of its dimensions. Therefore, the research will contribute to the robustness and credibility of the theoretical framework by analyzing inhibitors and enablers regarding the readiness for the IS concept. As for practical contribution, the study provides particular insights and suggestions for the specific context of the Fryslân region in the north of the Netherlands. These insights might assist with complying with the regional objective of becoming fully circular by 2050. Furthermore, the study proposes valuable observations which might improve the readiness for IS adoption in industrial ecosystems across the globe. Lastly, by deepening the knowledge about IS readiness, this research provides practical guidance on facilitating this transition. An actor who wants to initiate such circular transformation within this case of industrial zone De Zwette could significantly benefit from the proposed findings, which offer specific strategies and suggestions for deepening the readiness for IS implementation.

De Zwette is an industrial park located on the outskirts of Leeuwarden in the province of Fryslân consisting of approximately 400 businesses, ranging from small-scale enterprises to larger corporations, enclosing office spaces and manufacturing facilities producing a diverse range of goods (De Zwette, 2024a). Businesses within De Zwette differ in their sustainability engagement, with ongoing efforts to foster sustainable initiatives across the park by providing examples and strategies to less sustainable companies and aligning with the overarching sustainability goal. By addressing this gap, the research

aims to contribute to both theoretical knowledge and practical implementation by proposing appropriate strategies for initiating and scaling up circular transitions in industrial settings (Personal Communication with Transition Manager of De Zwette, 2024). Therefore, the research strives to answer the following question:

How can the readiness for Industrial Symbiosis implementation be facilitated among members of an industrial park?

The discussion surrounding the potential implementation of Industrial Symbiosis in De Zwette is still in its early stages, with limited available information regarding businesses' readiness to engage in the development of this novel industrial ecosystem (Personal Communication with Transition Manager of De Zwette, 2024). The first aim of this research is to conduct an empirical study focusing on the De Zwette industrial park to examine the readiness for Industrial Symbiosis implementation. That involves identifying and analyzing the factors that influence the potential of businesses in this specific context to adopt IS practices. The second aim is to provide a thorough explanation of the findings, emphasizing the stimulating and hindering factors for IS readiness. These research goals aim to establish conclusions that deepen the understanding of the factors influencing IS readiness. By ensuring the longevity of these findings, the study seeks to contribute to ongoing improvements in the field of Industrial Ecology.

This thesis is divided into multiple chapters. Firstly, the description of the background and rationale standing behind the research were addressed in the *introduction* alongside explaining the research gap, research objectives and also the research question. Hereafter, the *theory* section examines in detail existing literature and will give the reader a comprehensive overview of what Industrial Symbiosis stands for and describe concepts which are relevant to this topic. Furthermore, the *methodology* chapter delves deep into clarifying the methodological approaches towards data collection and data analysis. The *findings* section provides insights obtained from the conducted research. Finally, the *discussion* comprising multiple subsections serves to clarify the essence of the study, provide actionable propositions, acknowledge limitations, and guide future research directions.

2 UNDERSTANDING INDUSTRIAL SYMBIOSIS

2.1 Conceptual Background

Industrial Symbiosis is a well-established circular approach that has been thoroughly studied and examined for over 29 years, with additional years of practical application (Henriques et al., 2021). The concept of IS should be viewed as an evolving approach rather than a rigid framework. Instead of perceiving IS as a static condition, it is more beneficial to regard it as a journey in which businesses progressively enhance their interconnectedness (Boons et al., 2017).

The term *symbiosis* originally stands for a biological relationship in which two or more organisms of various species co-exist in close physical proximity and interact with each other in a way that benefits at least one of the organisms involved (Smith & Douglas, 1987). This concept has been further applied in industrial contexts to illustrate how organizations can benefit from shared resources (Chertow, 2000).

Industrial symbiosis, a significant concept in the evolving field of Industrial Ecology, emphasizes the circulation of material streams and energy within local and regional economies (Albino et al., 2013). Industrial symbiosis is a collaborative approach among businesses within a specific geographic area. Scholars associate the concept with the existence of industrial parks or zones at a regional level (Neves et al., 2019). Adoption of IS involves sharing resources such as waste streams, by-products, energy and water. This cooperation aims to optimize resource use and improve overall efficiency among participating industries. These resources are exchanged among businesses to reuse or recycle with the ultimate goal of maintaining productive use for a longer time period (Chertow, 2004; Lombardi, 2018).

The principal aim of IS is to produce more without using additional energy or resources through cooperation among industries or business actors (Oughton et al., 2022). It is an approach to connecting the dots in particular ecosystems, fundamentally from the material point of view, contributing to the transition to a circular economy. This concept encourages traditionally separate industries to collaborate with the shared goal of gaining a shared business-related advantage. By exchanging various resources and leveraging geographic proximity, these industries can create synergies and work together more efficiently (Chertow, 2000; Mantese & Amaral, 2018). IS emerges when two or more businesses

collaborate to exchange resources for mutual benefit. Achieving this requires long-term, functional, and trusting business partnerships (Shi et al., 2018).

2.2 Proposing the Benefits of Industrial Symbiosis

As previously explained in the conceptual background, Industrial Symbiosis challenges the linear economy perspective. This approach aims to connect formerly individualistic companies, fostering a more efficient and sustainable production system. While it might seem that IS burdens companies by diverting their focus from primary operational goals and requiring significant time and effort, evidence from several pilot projects worldwide and extensive research in the field indicates otherwise. These studies demonstrate clear advantages across economic, environmental, and social dimensions, proving that IS is a socially desirable concept that helps achieve overarching sustainability objectives and generates greater prosperity (Liu et al., 2018; Salomone et al., 2020; Yuan & Shi, 2009; Zhu et al., 2021).

The adoption of IS enables businesses to collaborate and share surplus resources. IS can reduce expenses or even provide cost-free access to needed resources (Esty & Porter, 1998; Rizos et al., 2016). Waste streams from one industry can be valuable inputs for another, balancing resource consumption (Babbitt et al., 2018). IS lowers production costs through waste exchange, cooperative efficiency gains, and shared resource utilization, optimizing resource allocation (Nidumolu et al., 2013). Additionally, IS increases market competitiveness by lowering operating costs and enhancing resource efficiency (Yuan & Shi, 2009; Zhu et al., 2021). IS also helps organizations reduce risks and become more resilient to market changes, resource shortages, and supply chain disruptions, fostering long-term financial stability (Chopra & Khanna, 2014; Islam, 2016; Haraguchi et al., 2019).

Furthermore, IS promotes resource recovery, recycling, and reuse, prolonging material life spans and reducing the need for virgin resource exploitation (Domenech et al., 2019; Mortensen & Kørnøv, 2019). IS reduces waste by transforming waste into valuable inputs for other businesses (Castellet-Viciano et al., 2022; Fraccascia, 2019). It encourages cleaner manufacturing practices, energy efficiency, and renewable energy use, reducing greenhouse gas emissions and other pollutants (Martin & Harris, 2018). Optimizing resource utilization and eliminating waste generation minimize

environmental impact (Eckelman & Chertow, 2013). IS improves energy efficiency through shared energy resources and energy-saving techniques, contributing to a more sustainable energy system (Fraccascia et al., 2021; Castro Oliveira et al., 2020). By reducing the environmental impact of industrial activities, IS minimizes habitat destruction and ecosystem deterioration, fostering biodiversity conservation (Castellet-Viciano et al., 2022; Martin & Harris, 2018).

Ultimately, IS facilitates greater job creation through innovative ventures and cooperative efforts (Crowe Pettersson & Rossouwa, 2024; Martin & Harris, 2018). IS encourages sharing innovative business concepts and technological know-how, expanding the knowledge base within the ecosystem (Kosmol, 2019). This circular approach promotes community involvement by uniting companies, governmental bodies, and neighbourhood associations, building trust and creating new partnerships (Neves et al., 2020). This shared ownership and responsibility strengthen social ties and collaborative action within the industrial ecosystem (Velenturf & Jensen, 2016).

Nevertheless, the industrial zone must be prepared for participation in such a circular collaborative approach. Accordingly, it is fundamental to address the readiness for Industrial Symbiosis implementation and determine the factors that influence this state of readiness.

2.3 Conceptualising the Readiness for Industrial Symbiosis

The concept of readiness for IS is multifaceted, as seen above within the literature on Industrial Ecology. Various scholars have articulated this readiness through different lenses. Some define it primarily as the willingness of industries to adopt IS practices (Agudo et al., 2024; Golev et al., 2015; Zhu et al., 2021). Another group of researchers interprets it as the potential for IS implementation (Azevedo et al., 2021; Neves et al., 2019). Furthermore, certain academics describe the concept in terms of the preparedness of companies to engage in local symbiotic relationships, particularly concerning the sharing of water, energy, waste and by-products (Agudo et al., 2022).

In this research, readiness for Industrial Symbiosis adoption is conceptualized as the capacity of industries or businesses to engage in resource exchanges. Specifically, it denotes a state wherein companies possess all requisite means and capacities to establish symbiotic relationships aimed at resource exchange with other co-located industries. This conceptualization is derived from the definition

proposed by Agudo et al. (2022), as this study employs and tests the framework of evaluating symbiotic readiness presented in that research article.

2.4 Introducing the Theoretical Lens

For this research, the framework from Agudo et al. (2022) was selected as the theoretical lens to be tested and employed. Originally developed as a quantitative assessment tool for evaluating symbiotic readiness, this framework aggregates insights from 85 research papers on Industrial Symbiosis (Ali et al., 2019; Chertow, 2004; Chertow & Lombardi, 2005; Kermani et al., 2019; Maya Sopha et al., 2010; Mirabella et al., 2014; Wahrlich & Simioni, 2019; Walls & Paquin, 2015; Yu et al., 2015). Due to the qualitative nature of this study, the tool cannot be utilized to its full quantitative extent. However, it serves as a theoretical anchor, enabling the development of knowledge on each sub-variable, which will be elaborated upon in later chapters.

The framework defines two primary dimensions of IS readiness: Exchange Resources and Exchange Capacity. The first dimension Exchange Resources consists of three variables and four sub-variables, focusing on a business's ability to exchange resources—such as water, energy, waste, and by-products—with other co-located industries (Agudo et al., 2022). The second dimension Exchange Capacity encompasses the factors that facilitate the adoption of Industrial Symbiosis, including four variables and eight sub-variables: New partnerships, Trust in doing business, Information sharing, Ease of obtaining information, Financing source, Subsidies, Environmental Policy, and Infrastructure (Agudo et al., 2022).

2.5 Summary of Key Insights

To summarise, Industrial Symbiosis represents a promising approach to resource management and collaboration among industries or businesses within a specific geographic area. There are several benefits IS brings across economic, environmental, and social dimensions. This circular approach encourages cost reduction, promotes resource efficiency, and fosters innovation and job creation. IS contributes to environmental conservation by reducing waste generation and minimizing resource exploitation.

The concept of readiness for IS emphasizes the fundamental requirement of possessing the requisite resources and capabilities for fostering symbiotic relationships. These prerequisites are crucial for facilitating effective participation in resource exchange within industrial ecosystems, thereby affirming the validity and significance of readiness for IS adoption.

To further explore the readiness for Industrial Symbiosis, Agudo et al.'s (2022) theoretical framework outlines the two dimensions of Exchange Resources and Exchange Capacity. This structure will serve as a theoretical lens employed in the qualitative research of this thesis, facilitating the examination of factors influencing IS adoption readiness. The study will determine inhibitors on each sub-variable level of Agudo et al.'s (2022) assessment tool, which needs to be overcome to successfully facilitate IS implementation. Similarly, the qualitative research will identify enablers for each sub-variable, providing insights into elements that could promote Industrial Symbiosis, both within the specific context of De Zwette and in a broader sense.

3 METHODOLOGY

3.1 Research Design

The research design for this thesis engages a qualitative study, employing an explorative and inductive approach to further investigate the state of compatibility for industrial symbiosis in the De Zwette industrial zone. Inductive analysis involves drawing broader conclusions from specific observations or data obtained through methods such as interviewing individuals to gather qualitative information (DeCarlo, 2018). The qualitative approach is the most appropriate method to test the theory, specifically the inductive method used in this research, which provides a structured way to analyze qualitative data, making it easier to derive significant conclusions when addressing specific research questions (Thomas, 2006). Qualitative research is particularly suitable for addressing how and why questions, allowing for an in-depth understanding of experiences, phenomena, and context (Collins & Stockton, 2018; Denzin, 2001).

3.2 Case Description: De Zwette Industrial Park

The research was conducted within the industrial park De Zwette, located on the outskirts of Leeuwarden, in the Fryslân province of the Netherlands. De Zwette industrial zone spans approximately 330 hectares and is residence to around 400 businesses of various sizes and focuses. This industrial park serves as an economic hub for Leeuwarden, employing a significant amount of Fryslân's population and offering advantageous features such as a harbour and direct highway connections for businesses (De Zwette, 2024b).

The businesses within De Zwette range from office spaces to large manufacturing companies producing various goods. The industrial park is divided into five distinct areas that were developed over different decades: the oldest sections date back to the 1960s and 1970s, with subsequent expansions in the 1980s, 1990s, and 2000s. A new section, De Zwette 6, is planned but has not yet been constructed (Personal Communication with Transition Manager of De Zwette, 2024).

The business landscape in De Zwette is highly diverse, particularly regarding sustainability practices. Some companies are in urgent need of adopting more sustainable actions, while others are already heavily engaged in sustainability and circular economy initiatives. The industrial park aims to

become more circular and contribute to the region's goal of achieving full circularity by 2050 (Personal Communication with Transition Manager of De Zwette, 2024). This ambition aligns with Friesland's broader environmental objectives and emphasises the relevance of examining the readiness for Industrial Symbiosis in De Zwette (Circulair Friesland, 2021).

3.3 Data Collection

Data was collected through semi-structured interviews with business representatives from De Zwette Industrial Park in Leeuwarden. Participants were selected for their relevance to the research question, which focused on the potential for Industrial Symbiosis implementation. Principally, manufacturing companies were contacted due to their high potential of engaging in sharing resources such as water, energy, waste streams, and by-products. The selection of participants was aiming to capture a diverse range of findings, insights, and opinions from businesses of varying sizes, industries, and levels of engagement with sustainability practices.

Initially, over 30 companies within De Zwette were contacted via email or telephone to participate in the research. Ultimately, eight interviews were conducted, each lasting 30 to 60 minutes. These interviews included discussions with seven business representatives from various companies and one Transition Manager of the industrial park to gain a broader perspective on readiness for Industrial Symbiosis implementation within the area. More detailed information about the participating companies and their representatives is provided in Table 1.

Interviews were conducted in person or online, depending on participants' availability and preferences. With participants' consent, interviews were audio-recorded to ensure accuracy in data capture. A pre-developed interview guide listing essential questions and topics was used to lead the interviews. However, the nature of semi-structured interviews fostered the flexibility to facilitate a natural flow and address significant themes that might not have been previously considered relevant.

The interview guide consisted of a brief introduction, explaining the research purpose and ethical considerations, followed by general questions about the company and its sustainability practices, its full version can be found in Appendix A. Furthermore, it focuses on conceptualising the term Industrial Symbiosis for interviewees, who were not familiar with the concept before the interview and

sharing its benefits. The guide helped to explore the company's readiness for Industrial Symbiosis, addressing potential benefits, challenges, and needs. It employed Agudo et al.'s (2022) framework, the two dimensions: Exchange Resources (Water, Energy, Waste, By-products) and Exchange Capacity (Partnerships, Trust, Information Sharing, Financing, Subsidies, Environmental policy, Infrastructure) aiming to capture unique insights from the participants. The interview was concluded by inviting additional remarks and questions from participants.

Table 1 - Overview of interview details

Interview	Industry	Establishment	Operations	Operating in De Zwette	Participant role	Duration
1	Manufacturing (Electronics Services)	An international company	Worldwide	16 years	QESH Manager	27 minutes
2	Manufacturing (Piping Systems)	One of Two Plants in the Netherlands	EU	25 years	Managing Director	57 minutes
3	-	-	-	2 years	Transition Manager of De Zwette Industrial Park	39 minutes
4	Production (Plant Based Meat Alternatives)	Part of a mother company	Worldwide	5 years	Plant Manager	35 minutes
5	Retail (Second-hand Goods)	Part of chain	Local	10 years	Plant Manager	25 minutes
6	Waste Management and Metal Recycling	One of two plants	Local	15 years	Operational director	27 minutes
7	Manufacturing (Packaging Solutions)	Part of a mother company	Worldwide	19 years	Sales Manager for the Netherlands & General Manager	35 minutes
8	Processing (Yarns and Fibres)	Individual Company	Local	-	Sales Manager	35 minutes

3.4 Ethical Considerations

Participation in this research was entirely voluntary, with rigid measures implemented to ensure confidentiality. All collected data were anonymized during transcription, and no personal information was disclosed. Before the interviews, each participant received an informed consent form for review and signature, guaranteeing full confidentiality. These signed consent forms are securely stored; the

anonymized consent form template is available in Appendix C. Data were securely stored in compliance with the ethical regulations of the University of Groningen, with access restricted to authorized personnel only. Ethical approval for the study was obtained from the Campus Fryslân Ethics Committee, ensuring strict adherence to ethical guidelines and the protection of participants' rights and well-being.

3.5 Data Analysis

Following data collection, a thorough analysis was conducted on all obtained data. As mentioned earlier, the interviews were recorded to capture relevant insights and subsequently transcribed using Otter.ai. These transcripts underwent detailed review and correction to address any inaccuracies and typographical errors missed by Otter.ai. The analysis was guided by Agudo et al.'s (2022) dimensions of readiness for the IS framework, which served as a foundational anchor throughout the research. This framework structured the analysis, providing a robust basis for interpreting the data within the context of Industrial Symbiosis readiness.

To ensure a thorough understanding, the researcher meticulously read through the transcripts multiple times. Pertinent components of the conversations were identified and labelled as significant based on their relevance to the research question, insights regarding Industrial Symbiosis readiness, and alignment with proposed theories. Microsoft Excel was utilized for the coding process, ensuring a detailed and concise approach that prevented any information from being overlooked. The insights from the participants were coded using sub-variables from Agudo et al.'s (2022) framework as categories. Relevant insights were coded into first-order codes, second-order codes, and finally into themes, which were categorized as either inhibiting or enabling factors of Industrial Symbiosis. A comprehensive list of codes is provided in Appendix D, offering a transparent overview of the data analysis process.

4 FINDINGS

Following the data analysis, several key themes emerged concerning the readiness for Industrial Symbiosis implementation in the De Zwette industrial zone structured along Agudo et al.'s (2022) framework as a theoretical lens. The analysis identified both the inhibiting factors currently hindering the implementation of industrial symbiosis and factors potentially stimulating the adoption of this circular solution on a larger scale. These insights deliver a comprehensive understanding of the current state of readiness and emphasize particular measures which would enhance readiness for industrial symbiosis in this particular context. A comprehensive summary of the findings can be found in Table 2 below, it proposes identified inhibitors and enablers for each one of the sub-variables of Agudo et al.'s (2022) readiness dimensions. The first three columns of Table 2 are part of Agudo et al.'s (2022) framework and the other two columns are uniquely identified research findings.

4.1 Exchange Resources

4.1.1 Water Resources

Water

Regarding the exchange of resources, the findings indicate that *water* is not considered a relevant element in the context of the De Zwette industrial zone. The Transition Manager of the industrial park explained in an interview that water has not been perceived as a scarce resource, which is why industries have not been focused on conserving it. He stated, "*…until now, water hasn't been perceived as a scarce resource, and that's probably why nobody's very busy looking at how they can save water. Because there's just enough of it*."

Therefore, no specific information about the readiness for IS adoption, nor inhibitors or enablers were identified which would either hinder or stimulate the readiness for IS concerning water resources.

4.1.2 Energy Resources

Energy

The most mentioned factor hindering the potential for IS implementation regarding energy is *policy regulations*, which encompass various challenges. For some businesses, policy regulations block the ability to share renewable energy since the law prohibits the direct exchange of energy between

co-located businesses and prevents some companies from purchasing renewable energy technologies. One business representative stated, *"I'm one of the biggest energy consumers in this industrial park. But I'm not allowed to buy a wind turbine. It's not even allowed to cooperate with my neighbour, who has one, to use his energy. It's not allowed to bring his electricity to my production plant"* (Int.2). Another company representative mentioned that they have excess solar energy to spare, but the regulatory framework prohibits them from sharing it, *"For example, we have this solar system, but we cannot provide the energy back to the network. So, of course, that's waste"* (Int.1). Lastly, financial challenges such as *high initial investments* to purchase suitable technological equipment to foster energy sharing among co-located industries were emphasized by one of the interviewees, *" (...) but someone has to pay for the battery, invest in it"* (Int.2).

Regarding the topic of energy, one enabler has emerged that could further stimulate the adoption of IS. More than half of the participants indicated that they perceive solutions such as *shared energy hubs* or stations as potential enablers for sharing energy within the industrial zone. As one participant noted, *"Energy hubs would be something we would probably need because it will take a lot of time until all the buildings have sufficient electrical connections"* (Int.8). Another participant mentioned, *"If you look at joint operations, that would be an idea, or maybe a production site where solar power functions as the hub"* (Int.7).

4.1.3 Material Resources

Waste

Regarding hindering factors for waste only one participant mentioned concerns about their waste-stream situation potentially affecting their readiness for IS participation. They emphasized that their company struggles to utilize waste streams from collocated industries due to the *low quality* of these residual materials. Further, national policy regulations prohibit the utilization of specific waste streams from other businesses within the De Zwette industrial park. When discussing potential transformations needed to facilitate future IS participation, two business representatives expressed a desire for comprehensive information or initiatives regarding the sharing or utilization of waste streams in the specific context of De Zwette. As the Transition Manager noted, *"(...) companies know that they*

[actors informing about what to do with particular waste-streams] exist and they can use these materials, the bigger the possibility that can be cycled up to more value products. So, I think that's for materials that's a very important factor that there is something like that on a terrain like De Zwette" (Int.3).

By-products

Regarding by-products, the interviewees did not provide any specific insights, nor did they mention it as a relevant element in their operations concerning resource exchange.

Table 2 - Summary of research findings

Dimensions	Variables	Sub-variables	Identified Inhibitors	Identified Enablers
Exchange Resources	**Water Resources**	Water	-	-
	Energy Resource	Energy	• Policy regulations concerning energy sharing (4) [1] • High investments in shared energy (1)	Shared energy storage/hub (5)
	Material Resource	Waste	• Regulatory restrictions (1) • Low quality of waste-streams (1)	Spreading awareness about possibilities (2)
		By-products	-	-
Exchange Capacity	**Trust**	New partnerships	• Insufficient awareness of IS (6) • Lack of information about companies within De Zwette (4) • Operational differences (2) • Organisational resistance to change (1)	• Proactive engagement (8) • Policy push (4)
		Trust in doing business	-	• Willingness to trust (6) • Commitment to consistent actions (1)
	Information sharing	Information sharing	Lack of Information Sharing (3)	Willingness to share information (7)
		Ease of obtaining information	Lack of Information Obtaining (6)	-
	Access conditions	Financial Resources	Lack of Financial Support Available (2)	External financial investments (1)
		Subsidies	Uncertainty in Subsidy Acquisition (3)	Enhancement of funding possibilities (5)
		Environmental Policy	Lack of Environmental Policies and Regulations connected to IS (3)	Stricter environmental policies and regulations (3)
	Infrastructure	Infrastructure	-	-

[1] Indication of the number of interviews in which the factor was mentioned

4.2 Exchange Capacity

4.2.1 Trust

New partnerships

Forming new partnerships emerged as the most debated topic during the interviews. Although some connections already exist among businesses in De Zwette, interviewees did not indicate that there is any symbiotic partnership currently in place. Therefore, exploring both the inhibitors and enablers in regard to forming new partnerships for IS implementation is a highly relevant topic at this moment to assist in facilitating the readiness for IS adoption.

However, several factors hinder the ability to form new partnerships. Firstly, there is *insufficient awareness of IS*, including a lack of familiarity with the concept and the potential benefits it could bring to companies and the industrial zone as a whole, *"Well, I think at this time, companies are still struggling very much with this idea to see what the potential of Industrial Symbiosis is"* (Int.3). Only two out of seven business representatives were familiar with the term.

Secondly, there is a *lack of information about companies within De Zwette*, resulting in a low level of awareness among companies about the operations of other businesses. As one participant noted, *"(...) I don't know what is exactly happening next door,"* (Int.8) and another stated, "*Except for renewable energy topics,* w*e don't have specific information about what our neighbours do*" (Int.7). A further comment highlighted the issue, *"(…) I know maybe what my, neighbours do, but I do not know what the neighbours of my neighbours actually doing"* (Int.8). Some businesses, due to their international focus, admitted to overlooking the local context because they operate on a broader level. One representative remarked, "*We primarily focus on potential customers outside the Netherlands, which sometimes means we overlook what's happening right before our eyes"* (Int. 8).

The third challenge that emerged from the interviews was the *operational differences* among companies in the industrial zone. This issue was noted by two business representatives, *"But it's very hard to do that. Every company has its own policy its own way of working, has its own its own clients, own network. So, it's very difficult to get within that"* (Int.6). Furthermore, another business representative shared that they are one of very few companies focusing on food processing in De Zwette industrial zone. Therefore, as a company, they do not have resources or capacities appropriate for sharing

with other businesses, which are mostly operating in industrial field. This sentiment was echoed by a couple of companies, which do not perceive the formation of new partnerships as necessary.

The fourth identified inhibitor is *organizational resistance to change*, as noted by Transition Manager of De Zwette, *"(...) companies in De Zwette are very used to doing things in a certain specific way, (...) and they want to spend as little time as possible, changing that"* (Int.3).

Regarding forming new partnerships, the interviews also identified several factors that could stimulate readiness for IS. All eight respondents highlighted the need for *proactive engagement* to facilitate IS readiness. Several business representatives stressed that bringing together the business representatives of companies within the De Zwette industrial zone for conversations and discussions would be hugely beneficial in exploring potential symbiotic relationships. One interviewee emphasized, *"They want to bring all the companies together. There are a lot of images already there that they are bringing the managing directors, and companies together. But not everyone is really cooperating there or is not aware of those meetings"* (Int.2). Another respondent shared his opinion, *"(...) maybe a proactive, get people together, investigate the needs and ideas and put them together"* (Int.1). Third participant appointed, *"The most important would be the information sharing at the beginning and just getting the businesses together to have a conversation or do you have to see something different"* (Int.3).

Furthermore, a demand emerged for a comprehensive summary of the needs and requirements of businesses in De Zwette willing to engage in symbiotic relationships, "*I think it makes sense to bring the companies together and maybe make it easy to list what we have from these companies"* (Int.2). Another interviewee emphasized, *"When there's a reason to connect further, it's of course, nice to have, that you have a list. Knowing what people are doing now and what companies are doing. And thinking for yourself, hey, that's interesting. Maybe it is interesting to connect with each other. A kind of overview of all the companies and what they are doing"* (Int.5). Additional propositions include promoting successful business cases of symbiotic relationships and hiring a professional expert to facilitate connections and foster the transformation to IS in De Zwette.

Moreover, there are several prominently mentioned stimulating factors, such as *governmental support*. Four interviewees emphasized the need for stronger governmental backing, which would

significantly facilitate companies' engagement in circular solutions, such as IS, *"But I think we need a little bit more help with the law"* (Int.2). Another interview added, *"(...) there are a lot of things that need to be arranged (...) with the government to say we can make those steps and make it better eventually"* (Int.6).

Additionally, there is a notable emphasis on stimulating factors such as *policy push*. Four interviews indicated a desire for stricter policy regulations, which would facilitate companies' involvement in circular solutions. For instance, one interviewee stated, *"Another thing that would help as well is that the municipality is starting to become ever stricter and demanding in how much circular material has to be used and how it has to be certified"* (Int.3).

Trust in doing business

Regarding trust in doing business, no particular inhibitors hampering the readiness for Industrial Symbiosis were identified. However, two enabling factors were distinguished, which might foster the readiness for IS. Firstly, six out of seven business representatives expressed a willingness to trust other businesses in De Zwette, no significant obstacles related to trust in conducting business within the industrial park. One interviewee attributed this to the absence of direct competitors in De Zwette, stating, "*We don't have competition here; we would be very interested. Now, of course, if everything starts with trust, we don't have a lot of secrets"* (Int.7), while another remarked, *"that's for me now competition or something. So, you have competition on your own at the same industry Park? It will be difficult. We don't have*" (Int.2).

An additional stimulating factor mentioned by the Transition Manager is the *commitment to consistent actions*. He stated, "*I think that's also good that in De Zwette the companies are now very clear, and the board is very clear about the sustainability transition is coming. We have to focus on that we have to be very consistent in building up a new, new way of doing business. And that also builds trust for companies that there are people who are actually spending time on this and working for the greater good"* (Int.3).

4.2.2 Information sharing

Information sharing

Three business representatives revealed that they perceive a *lack of information sharing* among businesses in the De Zwette industrial zone, which significantly hinders the readiness to implement IS. This issue is closely linked to the challenge of forming new partnerships, as several participants emphasized their limited awareness of activities within De Zwette. One participant aptly noted, *"I guess when no one is collaborating, they also don't share information"* (Int.3). Consequently, no interviewee indicated that their company is currently capable of sharing production information with other businesses in De Zwette.

Willingness to share information was emphasized by all business representatives as a critical enabler. The Transition Manager accurately summarized this sentiment, stating, *"I've experienced that companies are pretty open, except when it's their product, you know, if it's really, their core business, of course they're not going to disclose secret information, but the general information most things they are pretty open"* (Int.3).

Ease of obtaining information

Regarding achieving clear and structured production data from co-located industries, a prominent inhibitor identified was the general *lack of information obtained*. Six out of seven business representatives indicated a perceived deficiency in obtaining information from other companies within the De Zwette industrial area. Accordingly, none of the interviewees reported having access to production-related information from other businesses. No specific stimulating factor was identified for this particular sub-variable.

4.2.3 Access conditions

Financial resources

Two business representatives identified a key inhibiting factor in obtaining funding from private or public organizations: l*ack of available financial support*. They emphasized that for the implementation of IS, they would need to make investments themselves. This necessity arises from

contextual factors such as the size or focus of their operations, which make it challenging to secure external investments. As one representative articulated, *"The issue is we have shareholders above this company. And they have a lot of companies. So together we are big. We are too big for any funds. It's not, we are a little bit too big "* (Int.2). Another representative added, *"(...) and you also have to invest yourself"* (Int.6.).

External financial investments were the sole stimulating factor mentioned. One interviewee mentioned that they have been offered investment from a private actor for the implementation of IS. The interviewee expressed, *"*(...) *that we can have an investor, luckily, we have some investors who want to make that happen"* (Int.6) indicating that this opportunity would facilitate their participation in IS.

Subsidies

Three respondents identified the *uncertainty in subsidy acquisition* as an inhibiting factor. Furthermore, the requirement for prior investments in order to secure a subsidy for the formation of exchanging networks was mentioned as a challenge, with companies unsure of whether they will acquire the subsidy (Agudo et al., 2022). As one participant articulated, "*It is hard because you can get subsidies. But you have to make a plan, you have to make the investments before you get the subsidies"* (Int.6). Additionally, there was mention, "*Not for this [IS or other circular transformations]*, we *don't receive any subsidies from the government"* (Int.4).

The primary stimulating factor identified was the *enhancement of funding possibilities*. Five companies expressed a need for more accessible funding opportunities to facilitate their engagement in symbiotic relationships, particularly enabling their participation in projects like IS in De Zwette. One respondent remarked, *"Yeah, I think, of course, it would help, and it [subsidies] might be the final nudge"* (Int.3). Another stated, *"(…) if there are subsidies for free, we're always I'm here for it"* (Int.6).

Environmental Policies

Participants did not emphasize any specific environmental policies and regulations that would encourage participation in IS. Neither any particular factors inhibiting the capacity of environmental policies and regulations to facilitate IS were identified among the interviewees. Nevertheless, one

enabler for readiness for IS was emphasized. Three interviewees proposed that *stricter environmental policies and regulations* would push companies to be more prepared and potentially participate in circular initiatives. As one interviewee stated, "*Well, if you are being pushed. You need to react or act prior to being pushed. I think we already do some things but sure, we could step up. And if you are being pushed it is more likely that you are putting a little bit more effort in there"* (Int.8).

4.2.4 Infrastructure

Infrastructure

Concerning accessing the resource-sharing infrastructure, there has been no evidence of established synergetic relationships among research participants, indicating a gap in the knowledge infrastructure necessary for effective resource exchange. However, respondents have expressed that, in their view, the infrastructure at De Zwette is adequate and would meet their current needs for resource exchange. Nevertheless, as highlighted in the sub-variable new partnerships, participants were not fully acquainted with the concept of IS, indicating a lack of comprehensive understanding of its general scope and implications.

5 DISCUSSION

In this section, the findings from the empirical research conducted in the industrial zone De Zwette are aligned with theoretical insights to identify parallels and divergences regarding the inhibiting and enabling factors influencing readiness for IS. Through this reflection, the study positions itself within the existing literature, distinguishing whether the results introduce novel insights or align with prevailing scholarly perspectives. This examination serves to emphasise the actual relationships and underscore the contribution of this research to the broader academic discourse on readiness for Industrial Symbiosis.

5.1 Discussion of Factors Influencing Readiness for IS

Both empirical findings and academic literature emphasize *regulatory and policy challenges* as significant inhibitors to IS readiness. Specific examples include energy regulations that block the direct exchange of renewable energy between businesses and restrict the purchase of renewable energy technologies, as well as national policies that prohibit the utilization of specific waste streams within the industrial park (Golev et al., 2015; Henriques et al., 2021). *Financial constraints* are consistently highlighted across both sources. *The high initial investments* required for purchasing technological equipment necessary for IS activities and the difficulty in obtaining funding from private or public organizations to engage in IS are significant barriers. *The uncertainty around acquiring subsidies* and the financial risks associated with prior investments further deter businesses from pursuing IS projects Henriques et al., 2021; Sellitto et al., 2021). *A lack of awareness about IS* and i*nsufficient sharing of information* among businesses are significant themes in the findings and the academic literature. This shortcoming hampers the identification of potential synergies and reduces interest and engagement in IS initiatives (Golev et al., 2015; Henriques et al., 2021). Both sources identify *social and organizational barriers,* such as resistance to change and operational differences, as significant inhibitors. *Organizational inertia* and established logistics chains discourage businesses from exploring new partnerships and symbiotic relationships (Henriques et al., 2021). The importance of *proactive engagement* and *information sharing* is emphasized in the findings and the academic literature. Encouraging discussions among businesses and sharing general production information are perceived as critical enablers for IS (Henriques et al., 2021). *Government support* and *policy push through stricter*

environmental regulations are highlighted as crucial for driving businesses towards adopting IS solutions. *Stronger support from government* entities can significantly encourage businesses to engage in IS practices (Golev et al., 2015; Sellitto et al., 2021). *The willingness to trust other businesses* and *the commitment to sustainability* by industrial park management are recognized as important enabling factors. Trust is essential for fostering collaborative efforts necessary for IS (Henriques et al., 2021).

The research has indicated that respondents in the De Zwette industrial zone generally feel that the current infrastructure meets their needs for resource exchange, which shows that there is a lack of information about IS. Academic literature identifies significant emphasis on community awareness and the role of social factors, such as environmental awareness and the creation of internal and external networks, which enhance project development and readiness for IS (Henriques et al., 2021). Academic sources mention logistical costs and geographical distance as factors that can hinder the economic viability of symbiotic exchanges, which are not highlighted in the findings from De Zwette (Sellitto et al., 2021). The broader literature discusses management-related barriers, such as a lack of contacts and formal agreements, as significant challenges for IS implementation. This is less explicitly addressed in the De Zwette findings, which focus more on operational differences and organizational resistance to change (Henriques et al., 2021).

5.2 Practical Implications: Improving the Readiness for IS

To improve readiness for IS, multiple practical recommendations are emphasized. These suggestions could serve as a starting point for any initiator looking into facilitating the implementation of IS in the industrial park De Zwette. However, these propositions could also provide valuable insights for other industrial areas. Given the findings, that participating companies lack awareness about IS and their limited interactions with other businesses in De Zwette, their readiness for engaging in resource exchange within a symbiotic relationship appears to be quite low. Consequently, the recommendations focus primarily on the initial stages of IS adoption.

Facilitating collaboration and raising awareness about IS

According to the empirical findings, bringing companies together, initiating conversations and raising awareness about IS are the crucial first steps in improving the readiness for IS. The findings suggest that the initial step should be to organise events or meetings focused on fostering open discussions about the needs of businesses within the industrial park and exploring how they can mutually benefit from each other's resources. This implication should be combined with an emphasis on raising awareness and educating businesses about the relevance of Industrial Symbiosis to the industrial zone by presenting successful business cases. Such a strategy was pointed out in several interviews. These examples help companies acknowledge potential benefits and gains IS might foster in the industrial park, highlighting its social and economic desirability.

Proactive engagement

Following the establishment of initial conversations and the acquisition of some level of understanding regarding IS, an additional recommendation entails the development of an information system, database, or document. This resource should entail clear, comprehensive, and concise information, allowing companies to easily discern potential collaborators, their possibilities, and their needs. Such a system should be user-friendly, well-functioning to minimize the effort required by companies and available to all companies in the business park.

Moreover, it is advisable to establish focus groups based on shared needs or thematic topics within the industry. This approach has the potential to yield more valuable outcomes for specific industries or issues**.** Furthermore, engaging an expert to facilitate connections and guide the process could prove highly beneficial. This expert would dedicate their time to executing the collaboration process, alleviating the burden on participating companies or the board of De Zwette during the initial stages of IS engagement.

Fostering the creation of renewable energy hubs

In response to the inadequate availability of electricity in De Zwette and the growing energy demand, companies within the De Zwette industrial park are exploring renewable energy solutions.

Existing policy and regulatory constraints hinder the sharing of renewable energy among companies in the park. A couple of the interviewed companies, due to diverse reasons, cannot invest in renewable energy technology such as solar power or windmills. There is a pressing need to explore the feasibility of establishing an energy hub or storage facility where companies can collectively share renewable energy generated from sources such as wind turbines or solar panels. This solution would circumvent the policy inhibitor prohibiting companies from sharing renewable energy. Therefore, it would enable businesses to utilize excess renewable energy, thus reducing reliance on conventional energy sources and promoting sustainability.

Advocating change in governmental regulations

To address the inhibitors and enablers identified during the research process, the following recommendation focuses on enhancing policies and regulations at the regional level, with the potential to extend to the national level. This approach could significantly facilitate the implementation of IS in Fryslân, which is committed to becoming fully circular by 2050. Interviewed companies indicated a need for changes in regulatory frameworks and increased governmental support to encourage IS implementation.

The first sub-recommendation would be to *advocate for local policies* which support the implementation of IS. Therefore, promoting removing the regulatory barriers and encouraging incentives for IS implementation through local policies would be desirable. Lobby from De Zwette board or other entrepreneurs in the business park for changes in energy regulations is essential to facilitate the transformation to collaborative sharing of renewable energy resources. Specifically, it is important to lobby for changes in energy regulations to enable the sharing of renewable energy resources and encourage the establishment of subsidies or funding opportunities specifically designed to support IS initiatives.

Secondly, *enhancing funding opportunities for IS projects* is essential. This involves creating more attractive funding and subsidy opportunities for small and medium-sized enterprises by simplifying and supporting the process. Collaboration with government agencies, financial institutions, and private investors can lead to the development of specialized funding schemes or investment vehicles aimed at

supporting circular economy initiatives in industrial zones such as De Zwette. Additionally, providing assistance to businesses in navigating the application processes for subsidies and grants will ensure that these opportunities are accessible.

Lastly, *supporting the implementation of stricter environmental policies* is necessary. Promoting the adoption of stringent environmental policies and regulations can incentivize sustainable business practices, including participation in IS. Several business representatives proposed that as a driver to participate in IS. This suggestion shows the importance of regulatory compliance and highlights the long-term business benefits of proactive environmental stewardship, which might further motivate businesses to adopt sustainable practices.

5.3 Limitations

Despite efforts to minimize potential inaccuracies, several elements may have influenced the research findings. This qualitative study involved conducting eight interviews out of nearly 400 businesses present in De Zwette. Consequently, there is limited saturation and findings are unique to De Zwette. They may not apply to other industrial parks due to differences in industry composition, geographical location, regulatory environment, and cultural factors. Additionally, response bias could have affected the data, as interviewees might have provided socially desirable responses. Time constraints also played a role; some interviewees had limited availability, which may have prevented in-depth discussions and led to incomplete findings. The fact that some interviews were conducted online may have affected the interview dynamics and contributed to response inaccuracies. The qualitative nature of this research introduces the possibility of subjective bias, both in interpreting the interviews and analyzing the data. Furthermore, the interviews were conducted in English, which was not the native language of the researcher or the interviewees. This language barrier may have resulted in misunderstandings or inaccuracies, with some insights potentially lost in translation.

5.4 Recommendations for future research

Based on this research, several potential recommendations for future research endeavours have emerged. Firstly, it would be valuable to conduct a longitudinal study examining the implementation of IS readiness over time. This study would track how readiness evolves with continuous efforts. However, such a study might be more appropriate during a more advanced phase of IS implementation, as it may be premature and unnecessary at the initial stage. Additionally, conducting a quantitative study with a larger sample of businesses in De Zwette would be highly beneficial. This approach would provide a broader understanding of IS readiness across the industrial park, facilitating targeted transformations and potentially accelerating IS adoption. Lastly, future research could focus on a detailed case study of the De Zwette industrial zone. The objective would be to connect the dots and map how IS could be practically fostered. This would offer novel and valuable insights, contributing to the development of a symbiotic ecosystem.

Ultimately, there is a need for additional case studies focused on assessing the readiness for industrial symbiosis, a highly beneficial circular economy solution. Given the current environmental challenges, its adoption is likely to become increasingly attractive among business parks. Thus, conducting further case study research within industrial parks is essential to identify the key factors influencing the implementation of industrial symbiosis. Such research might facilitate targeted improvements and accelerate the adoption process to meet specific needs effectively.

5.5 Conclusions

From the research conducted in the De Zwette industrial park, several conclusions can be drawn. The study focused on examining the readiness for Industrial Symbiosis implementation and identified several inhibiting and enabling factors influencing the adoption of IS. By doing so, the research contributes valuable insights and actionable strategies to enhance IS readiness, ultimately promoting a more sustainable and symbiotic industrial ecosystem. More specifically, to address the research question, the findings indicated that to facilitate the readiness for IS implementation, among members of an industrial park, it is fundamental to comprehend and address particular barriers and enablers of IS. Pivotal inhibitors identified in the findings include regulatory and policy challenges, such as restrictions

on renewable energy exchange and specific waste stream utilization, and financial constraints, including high initial investments and funding difficulties. Both empirical findings and literature highlight a lack of awareness and insufficient information sharing among businesses as significant barriers, along with organizational resistance to change. Furthermore, enablers recognised in the findings were the importance of proactive engagement and information sharing, government support through stricter environmental regulations, and fostering trust among businesses. The empirical findings emphasize the need for initiating discussions within the industrial park, sharing general production information, and highlighting successful IS business cases to encourage further participation. These results were crucial for proposing tailored strategies on how to improve the readiness for IS and facilitate the improvement of the readiness. Firstly, raising awareness and educating businesses within the industrial park about IS and its benefits can foster initial interest and engagement. Furthermore, sharing successful business cases and practical examples can motivate participation in such an approach. Facilitating collaboration through organizing events, the introduction of suitable information systems, and expert guidance might help overcome barriers. Additionally, creating strong business networks and conducting focus groups within a particular industry or based on shared needs can bring valuable outcomes. Advocating for policy changes and enhancing funding opportunities are critical steps to address regulatory and financial barriers. Additionally, governmental support through stricter environmental policies can drive businesses toward sustainable practices and IS adoption.

The research holds significant value in several aspects. Firstly, it contributes to the academic discourse on readiness for IS by aligning empirical findings with theoretical insights, thereby identifying parallels and divergences regarding the inhibiting and enabling factors influencing IS readiness. This contributes to the robustness and credibility of the theoretical framework, particularly by empirically validating Agudo et al.'s (2022) framework and developing each of its dimensions. Agudo et al.'s (2022) framework has proven successful as a theoretical lens for identifying the inhibiting and enabling factors in each dimension of IS readiness. As the framework delves into depth by proposing several highly relevant sub-variables which together build the state of readiness for IS. Moreover, the study provides particular insights and suggestions for the specific context of the Fryslân region in the north of the Netherlands, which may assist in achieving the regional objective of becoming fully circular by 2050.

Furthermore, the research offers valuable observations that might help to improve the readiness for IS adoption in industrial ecosystems globally. Lastly, by deepening the knowledge about IS readiness, this research provides practical guidance on facilitating this transition. Therefore, the research value lies in its academic contributions, practical insights, and potential global applicability in enhancing readiness for IS adoption, ultimately assisting companies to foster positive environmental influence and strive towards sustainability.

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LIST OF TABLES

APPENDIXES

Appendix A

Interview Guide

General information

- **General information about the company**
- Focus, Aims, Mission, Vision, Size, Branches, History
- **Basic demographic information about the participants** o Role in the company, years of experience etc.
- **Information about their operations in De Zwette**
  o How long are you operating in Industrial Park De Zwette? o How satisfied are you with how De Zwette functions?
    - What aspects of De Zwette industrial park do you consider positive?
    - On the other hand, are there any areas you believe could be improved or changed?

Sustainability and Circular Economy

1. Does your company engage with sustainable and circular practices in its operations?
2. Are there any specific sustainability goals or targets your company is working towards?
3. In what areas do you believe your company could improve its sustainability efforts?
4. Are there any challenges or barriers hindering your company's ability to become more sustainable?

INDUSTRIAL SYMBIOSIS

Context setting

- **Ask about Industrial Symbiosis, how much you know about it?**
- **Define what Industrial Symbiosis is**

o **Industrial symbiosis**

▪ Collaborative approach among industries within a geographical area (in this case De Zwette) where resources (including waste, by-products, energy, water) are exchanged, reused, or recycled with the result of keeping resources in productive use for longer

- **Mention benefits of Industrial Symbiosis**

General Readiness for Industrial Symbiosis Questions

1. What are your thoughts on the potential benefits of Industrial Symbiosis for your company and the industrial park as a whole?
2. Do you perceive any potential challenges or concerns associated with adopting industrial symbiosis practices?
3. What resources or support would your company need to successfully adopt industrial symbiosis practices?

Question based on Agudo et. al 's (2022) framework

Exchange Resources (ER):

- Does your company exchanges or shares any resources with other businesses in De Zwette – Water, Energy, Waste or By-products?
- What would you as a company need for this to happen?

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a) **Water Resource:**

- Can you discuss whether your company engages in water exchange with other businesses in De Zwette?
- If so, how frequently does this exchange occur, and what proportion of water is exchanged?

b) **Energy Resource:**

- Does your company participate in energy exchange with other businesses in De Zwette?
- How often does this exchange take place, and what is the proportion of energy exchanged?

c) **Waste:**

- Can you describe if your company exchanges waste materials with other businesses in De Zwette?
- What is the frequency and proportion of waste exchange, if any?

d) **By-products:**

- Does your company have arrangements to exchange by-products with other businesses in De Zwette?
- If yes, how often does this exchange occur, and what is the proportion of by-products exchanged?

Exchange Capacity (EC):

a) **New Partnerships:**

• Has your company formed new partnerships to share any resources with other businesses in De Zwette?

• If yes – Could you elaborate on these partnerships and their objectives?

b) **Trust in Doing Business:**

• Does your company develop and maintain trusting relationships with other businesses in De Zwette?

• If yes – how?

• Can you provide examples of successful collaborations based on trust?

c) **Information Sharing:**

• Does your company engage in sharing information with other businesses in De Zwette?

• If yes – How?

• What are the motivations and benefits behind this information sharing?

d) **Ease of Obtaining Information:**

• Does your company access data or information from other businesses in De Zwette?

• If yes – how?

• Are there any challenges or barriers in obtaining this information?

e) **Financing Source:**

• Does your company have access to funding sources or investments related to Industrial Symbiosis implementation?

• If yes – How does the availability of funding impact your company's participation in resource exchange networks?

f) **Subsidies:**

• Has your company benefited from subsidies or incentives aimed at promoting the formation of circular networks?

• If yes – Could you provide examples of how these subsidies have facilitated resource sharing initiatives?

g) **Environmental Policy:**

• How do environmental policies and regulations influence your company's participation in Industrial Symbiosis initiatives?

• Are there specific policies or regulations that either facilitate or hinder circular activities?

h) **Infrastructure:**

• Can you evaluate the accessibility of resource sharing infrastructure for your company?

• Are there any improvements or investments needed to enhance infrastructure support for Industrial Symbiosis?

Conclusion

- Is there anything else you would like to share or add?
- Do you have any questions for me about the research or the interview process?

Appendix B

Link to interview transcripts on Google Drive

https://docs.google.com/document/d/1I3QqrpI1YT7A1lEWNiSCqgx-80CWoyL/edit?usp=sharing&ouid=101042995912642742432&rtpof=true&sd=true

Appendix C

Consent form

INFORMED CONSENT FORM
Master Thesis Nela Votápková
Title study: Examining the Readiness for Industrial Symbiosis Implementation: The case of Industrial Park De Zwette

Name participant:
Assessment

- I have read the information sheet and was able to ask any additional question to the researcher.
- I understand I may ask questions about the study at any time.
- I understand I have the right to withdraw from the study at any time without giving a reason.
- I understand that at any time I can refuse to answer any question without any consequences.
- I understand that I will not benefit directly from participating in this research.

Confidentiality and Data Use

- I understand that none of my individual information will be disclosed to anyone outside the study team and my name will not be published.
- I understand that the information provided will be used only for this research and publications directly related to this research project.
- I understand that data (consent forms, recordings, interview transcripts) will be retained on the Y-drive of the University of Groningen server for 5 years, in correspondence with the university GDPR legislation.

Future involvement

- I wish to receive a copy of the scientific output of the project yes / no
- I consent to be re-contacted for participating in future studies yes / no

Having read and understood all the above, I agree to participate in the research study: yes / no

Date
Signature

To be filled in by the researcher

- I declare that I have thoroughly informed the research participant about the research study and answered any remaining questions to the best of my knowledge.
- I agree that this person participates in the research study.

Date
Signature

Appendix D

Coding table

CATEGORIES	1st ORDER CODES	2nd ORDER CODES	THEMES
Energy	Policy issues; unable to share solar energy	Policy regulations concerning energy sharing	Inhibitor of IS
	Policy barrier		
	Regulatory barrier		
Energy	The financial barrier of high investments	High investments in shared energy	Inhibitor of IS
Energy	Potential improvements energy hubs	Shared energy storage/hub	Enabler of IS
	Need of energy storage/hub		
Waste	Policy barrier regarding usage of PE	Regulatory restrictions	Inhibitor of IS
Waste	Barriers concerning the quality of waste streams	Low quality of waste streams	Inhibitor of IS
Waste	Improving information about possibilities	Spreading awareness about possibilities	Enabler of IS
New partnerships	Lack of knowledge about IS	Insufficient awareness of IS	Inhibitor of IS
	No familiarity of IS		
New partnerships	Not much contact with other companies	Lack of information about companies within De Zwette	Inhibitor of IS
	Individualistic operation in De Zwette		
	No information about what is happening in De Zwette		
New partnerships	Barrier operational differences	Operational differences	Inhibitor of IS
New partnerships	Barrier resistance to change	Organisational resistance to change	Inhibitor of IS
New partnerships	Need to explore the potential	Proactive engagement	Enabler of IS
	Need for having an initial conversation		
	Need for showing a business case		
	Need for connecting companies		
	Need to have a list/database of companies who want to collaborate		
	Need to learn about benefits		
	Need for hiring an expert		

New partnerships	Governmental push	Policy push	Enabler of IS
	Regulatory demand		
	Regulatory stability		
	Policy driver		
Trust in doing business	Ready to trust other companies in De Zwette	Willingness to trust	Enabler of IS
	Existence of trust within industrial zone		
Trust in doing business	Being consistent in doing business	Commitment to consistent actions	Enabler of IS
Information sharing	No information sharing	Lack of Information Sharing	Inhibitor of IS
Information sharing	Willingness to share general information	Willingness to share information	Enabler of IS
	Open to share information within De Zwette		
	Sharing information/being transparent would help		
Information obtaining	No information obtaining among business	Lack of Information Obtaining	Inhibitor of IS
Financial resources	No financial support due to size	Lack of Financial Support Available	Inhibitor of IS
	No financial support		
Financial resources	Available funding possibilities	External financial investments	Enabler of IS
Subsidies	Difficulties with obtaining subsidies	Uncertainty in Subsidy Acquisition	Inhibitor of IS
	Uncertain process		
Subsidies	Improving funding possibilities	Enhancement of funding possibilities	Enabler of IS
	Funding for business actions		
Environmental policies	No environmental policies in connection to IS	Lack of Environmental Policies and Regulations connected to IS	Inhibitor of IS
Environmental policies	Need for positive motivation to participate in IS	Stricter environmental policies and regulations	Enabler of IS
	Improve governmental regulations		