TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
Department of Civil Engineering and Architecture

ANALYZING THE REGULATORY ENVIRONMENT FOR INDUSTRIAL SYMBIOSIS DEVELOPMENT IN ESTONIA: THE PERSPECTIVE OF THREE COMPANIES

TÖÖSTUSLIKU SÜMBIOOSI REGULATIIVSE KESKKONNA ANALÜÜS EESTIS: KOLME ETTEVÕTTE VAATENURK

MASTER THESIS

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Tallinn 2024

AUTHOR'S DECLARATION

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THESIS TASK

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Thesis topic:

In English: Analyzing the regulatory environment for industrial symbiosis development in Estonia: the perspective of three companies

In Estonian: Tööstusliku sümbioosi regulatiivse keskkonna analüüs Eestis: kolme ettevõtte vaatenurk

Thesis main objectives:

1. To make an overview of political measures in Estonia related to industrial symbiosis;
2. To examine if political measures support or undermine the development of industrial symbiosis in Estonia through qualitative interviews with selected Estonian companies.

Thesis tasks and time schedule:

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3.	Methodology, results, conclusion	20.12.23
4.	Summary and introduction	27.12.23

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PREFACE

The current thesis topic, which focuses on the development of industrial symbiosis in Estonia and the exploration of its regulatory environment, was chosen with the guidance of professor Wolfgang Dieter Gerstlberger from the Sustainable Value Chain Management Unit at the School of Business and Governance at TalTech. The author's deep interest in circular economy and sustainable development along with the relevance of these topics in our current global context, led the author to this subject. This thesis aims to analyze the practical perspectives on the regulatory environment related to industrial symbiosis, as perceived by Estonian companies actively involved in industrial symbiosis initiatives.

The author would like to thank professor Wolfgang Dieter Gerstlberger for his invaluable assistance in defining and shaping the topic, as well as for his guidance throughout this research. Author thanks thesis supervisor Margit Kull for her guidance, support, and extensive expertise in this field. Auhtor's gratitude also goes to the co-supervisor Viktoria Voronova, whose assistance was crucial in the process of writing this thesis.

A special note of gratitude goes to the representatives of the companies who were kindly willing to participate in the interviews and share their valuable insights. Their practical perspectives have been fundamental in shaping the qualitative analysis and conclusions of this thesis.

Finally, the autor would like to express deepest gratitude to her family, friends, and colleagues. This thesis wouldn't be completed without your continuous words of support and encouragement!

Keywords: industrial symbiosis, circular economy, qualitative interviews, regulatory environment, master thesis

INTRODUCTION

In the current realms of growing environmental concerns and the pressing need to shift to a more sustainable economic system, the idea of circular economy has emerged as a key concept to achieve this. The European Green Deal, adopted in 2019, is a fundamental strategy for transitioning to a climate-neutral European continent by 2050. This strategy outlines the shift from a linear to a circular economic model, emphasizing sustainability and the creation of a resilient environment for future generations (European Commission, 2019).

The current thesis explores industrial symbiosis, a critical element within the circular economy framework, in the context of Estonia. Industrial symbiosis, characterized by its collaborative approach of exchanging resources, such as energy, materials, and water among companies, aims to optimize resource use and reduce environmental impact (Chertow, 2000).

The relevance and urgency of this topic come from the growing global emphasis on sustainability, resource efficiency, materials circulation, and reduction of waste. Industrial symbiosis not only addresses environmental concerns, but also presents significant economic and social benefits helping to foster innovative business models as well as community development. Despite the growing global interest towards the idea of industrial symbiosis, it is not applied as widely as it could be expected. The implementation of industrial symbiosis is often a complex task with regulatory frameworks being a significant challenge.

This thesis aims to analyze the regulatory environment in Estonia concerning industrial symbiosis, investigating how it supports or hinders the development of such projects. A qualitative research approach is applied, involving interviews with representatives from three Estonian companies actively engaged in industrial symbiosis initiatives. These companies are Ragn-Sells OSA Service Project, Auvere Agropark, and PAKRI Science and Industrial Park. The research is designed around the triple helix model, highlighting the interaction and collaboration between academia, industry, and the government in promoting innovation.

The first main objective of the thesis is to make an overview of political measures in Estonia related to industrial symbiosis. The second objective is to examine if political measures support or undermine the development of industrial symbiosis in Estonia through qualitative interviews with selected Estonian companies. With these objectives, the thesis seeks to contribute to the development of industrial symbiosis projects in Estonia by collecting and analyzing practical inputs from industry representatives and potentially provide insights for policy-makers which could further support the advancement of the circular economy in Estonia.

The thesis is structured into 4 chapters. The first chapter is dedicated to the theoretical background where principles of circular economy and industrial symbiosis along with its benefits and challenges are discussed. This is followed by an exploration of the current regulatory environment concerning industrial symbiosis in Estonia. The second chapter is dedicated to the methodology where the triple helix model, qualitative interviewing and thematic analysis method are described as well as an introduction of the selected companies. The third chapter presents the results from the qualitative interviews. And finally, the fourth chapter concludes the findings.

1 LITERATURE REVIEW

1.1 Linear vs circular economy

The linear economy which traditionally dominates industrial practices, operates on a "take-make-dispose" principle. This model is characterized by a one-way flow of materials and energy through the economy. Starting from resource extraction, moving through product manufacturing, and finishing in waste disposal, the linear model pays little attention to resource efficiency and sustainable use of resources. As a result, this model generates a substantial amount of waste at every stage of the product lifecycle which has harmful effects on the environment when being landfilled. (Neves & Marques, 2022)

Landfilling, as a waste management practice, leads to multiple serious issues that intensify with the growth of human population and corresponding increases in production demands. These issues include groundwater contamination, the proliferation of microplastics, the emission of harmful gases, and others. Each of these factors poses significant risks to the environment and to human health (Nai et al, 2021). This accumulation of environmental and health concerns demonstrates the fundamental unsustainability of the linear economy model (Neves & Marques, 2022).

The circular economy model as opposed to linear, is distinguished by its closed-loop approach, where waste and by-products are reutilized. This model envisions a sustainable loop where resources are reused, and waste generation is thus minimized. While not all waste can be repurposed, the circular economy model significantly reduces the amount destined for landfilling. (Greissdoerfer et al., 2017; Lahti et al., 2018)

While there isn't one clear definition to circular economy (Metsaru, 2020), it can be described as "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Greissdoerfer et al., 2017). In the context of Estonia, a suitable definition can be taken from the European Commission definition: "An economy and mindset aimed at maintaining the value of products and materials for as long as possible. Waste generation and resource use are minimized, and when a product reaches the end of its lifecycle, it is utilized to create new value.” (Eljas-Taal et al., 2020).

The circular economy model is significantly supported by the European Commission, which promotes circular practices, including industrial symbiosis, through measures like strategies and action plans. Industrial symbiosis, as an instrument of circular economy, touches upon political, economic, social, and environmental spheres (European Commission, 2019; 2020a; 2020b).

1.2 Defining industrial symbiosis

Industrial symbiosis, a key component within the broader concept of industrial ecology, represents a transformative circular approach in industrial operations. The concept of industrial ecology was first discussed and defined by Robert Frosch and Nicholas E. Gallopoulos in 1989 in their article "Strategies for Manufacturing”. The concept of industrial ecology is defined as a systems-based approach that draws analogies from natural ecosystems. It seeks to understand the interactions between industrial systems as well as optimize resource usage, reduce waste, and minimize environmental impacts of industrial systems. This concept was proposed as a way to transform the traditional linear "take-make-waste" model of industrial systems into a more sustainable and circular model that mimics the cyclical processes of natural ecosystems. (Frosch et al, 1989)

Similarly to ecosystems in nature where no resources are wasted, by-products or waste from one industrial process serves as input material for other processes or is recycled for further production. Ideally, industrial ecology envisions creating industrial ecosystems where there is complete or nearly complete internal recycling of materials, waters and energy, aiming towards "zero discharges" production. (Frosch et al, 1989)

As industries within the industrial ecology approach are seen as interacting systems instead of separate entities with their own materials’ linear flows, the focus is shifted from evaluating separate impacts of processes or facilities to considering the impacts of the whole larger system. The ultimate goal is thus to switch from a linear production model to materials cycle approach. This approach offers a wide range of benefits including environmental, economic, and social, which altogether leads to a more sustainable and resilient industrial system. (Frosch et al., 1989; Gibbs et al., 2005)

1.2.1 Classic *vs* re-defined definition

As mentioned above, one of the concrete tools derived from the principles of industrial ecology is industrial symbiosis. The idea of it is aligned with the broader idea of industrial ecology – it seeks to connect different industrial entities in a way that mutually beneficial exchanges of materials, water and energy occur (Chertow et al., 2000). A classic definition of industrial symbiosis is to create a closed-loop system which results in a more sustainable and efficient use of resources. The goal of industrial symbiosis is therefore to reduce waste, improve energy and materials efficiency, and create synergies between companies (Chertow et al., 2000). This classic definition emphasizes physical resource sharing, primarily focusing on industrial waste, by-products, water, and energy exchanges to minimize environmental impact as well as to improve resource efficiency (Chertow et al., 2000).

Chertow (2000) proposed a taxonomy of 5 different material exchange types of industrial symbiosis projects:

1. physical exchange is a type of industrial symbiosis, in which waste materials or by-products from one company are used as inputs by another company, either directly or after some processing or treatment;
2. internal exchange type of industrial symbiosis refers to the practice of material exchange which occurs primarily within a single organization. It can be adopted by large organizations that often see themselves as separate entities and may therefore adopt a multi-firm approach in a similar way to industrial symbiosis. Larger organizations have the possibility to optimize resource utilization across their products, services and processes life cycles;
3. within eco-industrial park type includes businesses and organizations located close by and which engage in a collaborative network where they exchange energy, water, and materials and can extend their cooperation to sharing information and services;
4. between firms of not immediate proximity type focuses on linking existing businesses that are not co-located but situated within a close geographic area. This approach

leverages the existing industrial landscape, identifying and connecting separate firms to capitalize on the material, water, and energy streams they already generate. A well-known example of this type is seen in Kalundborg, where the primary partners are not situated in immediate proximity but are close enough to share resources;

5. the last type relies on virtual linkages rather than physical co-location, allowing businesses to participate without relocating. It facilitates wider regional collaborations, increasing the potential for by-product exchanges among a diverse range of industries.

Chertow laid a foundational groundwork for the concept of industrial symbiosis, and this classic definition has been widely used and cited for more than a decade. Lombardi and Laybourn in 2021 proposed a renewed, wider definition of IS which goes beyond physical resource exchange and includes a wider array of collaborations such shared services, logistics, knowledge transfer. Their perspective recognizes the importance of technological innovation, collaborative networks, and the role of policy and governance in encouraging industrial symbiosis (Lombardi & Laybourn, 2012). Unlike Chertow's emphasis on geographical proximity, Lombardi and Laybourn's approach allows for more flexible network collaborations that are not strictly linked to physical closeness, thus proposing a more dynamic and adaptable understanding of industrial symbiosis. This updated definition can be integrated into various industrial and regional contexts to promote sustainable growth (Lombardi & Laybourn, 2012).

1.2.2 Industrial symbiosis as a business model

Industrial symbiosis, a circular approach to enhance resource efficiency and lower environmental impacts, functions as a business model that, when implemented effectively, can yield significant economic benefits for the firms involved in the collaborative network (Albino & Fraccascia, 2015).

A classification of business models based on the industrial symbiosis approach proposed by Albino and Fraccascia includes 6 different types. The authors emphasize that these business models are not mutually exclusive and can be combined in various ways. It is also highlighted by the authors that IS can not only result in environmental improvements, but also lead to revenue generation, market expansion, and product/process innovation. (Albino & Fraccascia, 2015) The proposed classification is as followed (Albino & Fraccascia, 2015):

1. Waste exchange (Model A): This model involves the use of waste from one production process for another. It can occur within a single firm (internal exchange, A1) or between different firms (external exchange, A2). The economic benefits include reduced waste disposal costs for the producer and lower input costs for the receiver. In some cases, firms can also gain additional revenue through fees associated with the exchange;
2. co-product generation (Model B): companies transform their waste into new products that are sold in the market, effectively expanding their business. This model requires strategic planning as the new products can be different from the company's main offerings;
3. co-product generation for internal consumption (Model A1∩B): in this model, companies use their waste to produce new products for their own use reflecting the resource efficiency and closed-loop principles of industrial symbiosis within a single firm;
4. co-product generation from external wastes (Model A2∩B): companies create and sell new products using waste materials sourced from other firms. This model is subject to the availability and consistency of external waste supplies;
5. online waste exchange platform (Model A2∩C-(A2∩C∩B)): this model involves creating an online marketplace for waste exchange, where companies can find offers for their waste products or needs. The platforms can generate revenue through transaction fees;
6. IS-based business oriented to product generation (Model A2∩C∩B): In this model, companies base their entire business on creating products from waste materials. A risk associated with this model is the dependency on the consistent supply of specific types of waste.

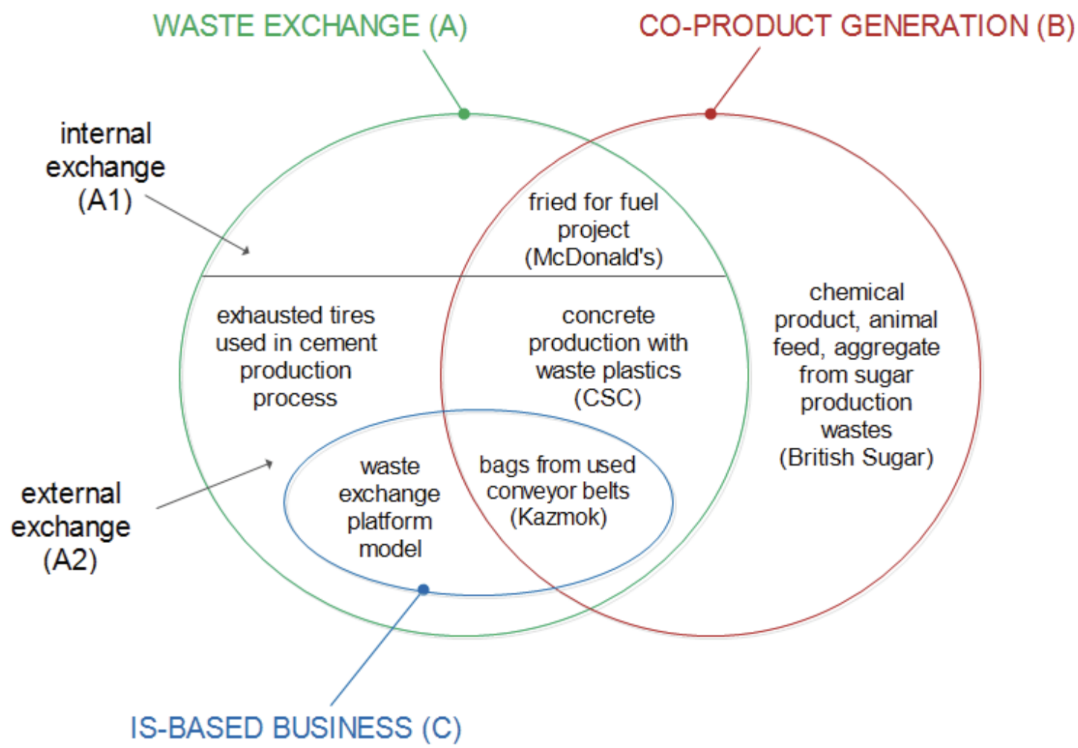

Figure 1.1. Classification of IS-based business models. Source: Albino & Fraccascia, 2015

While the implementation of industrial symbiosis offers a range of environmental, economic, and social benefits (Neves et al, 2020), putting industrial symbiosis and concrete eco-industrial parks into practice can be complex and challenging, presenting several recognized barriers (Hein et al., 2015).

Södergen and Palm (2021) analyzed the importance of local governments in fostering industrial symbiosis model and overcoming barriers to its development. The authors identified five distinct types of barriers (Södergen and Palm, 2021):

1. economic barriers include high substantial costs, difficulty in acquiring external capital, and uncertainties in dividing incomes and costs between organizations. Market volatility and regional differences in resource pricing add to this barrier, along with potential rises in operational expenses due to waste management;
2. operational and technical barriers involve difficulties in adapting production systems and storage to accommodate by-products, particularly due to extra processes and tracking. Imbalances between available materials and their demand, as well as rapid technological shifts, can disrupt established market dynamics. Logistical coordination

among partners and the challenge of relocating industries can also pose significant operational problems;

3. regulatory barriers are often related to restrictive or ambiguous laws and a lack of clear compliance guidelines. Conflicting regulations, particularly regarding waste management, complicate the approval process for waste reuse projects. Moreover, regulatory bodies themselves sometimes struggle with effectively planning and managing industrial symbiosis initiatives;
4. social barriers include a tendency for companies to operate in isolation, unwillingness to engage in collaboration, and a general lack of active involvement on higher management levels. Trust deficits among organizations, power imbalances, and insufficient support from institutions are also significant social barriers;
5. in information-related barriers concerns involve a lack of necessary information and training on the topic of industrial symbiosis. Awareness issues extend to understanding the concept itself and being informed about the resources available within neighboring businesses. Poor communication and information exchange, coupled with a lack of community awareness, further complicate the implementation of industrial symbiosis.

Industrial symbiotic systems can emerge in a bottom-up and top-down approach. Bottom-up industrial symbiosis is characterized by self-organization and spontaneous development – it arises naturally through initiatives and collaborative efforts of companies, possibly with the help of the government. In the case of top-down industrial symbiosis, the whole network (eco-industrial park) is planned and established through central authority; formation and development are thus largely driven by policy and strategic planning from a higher authority, often a government body. (Demartini et al, 2022, Scafà, 2018)

1.2.3 Benefits of industrial symbiosis

As a concept, inherently connected with the principles of circular economy and aimed at improving sustainability of the industrial sector, industrial symbiosis offers substantial environmental and economic benefits. These benefits are widely explored and discussed in the academic community (Cecchin, 2020).

Several studies have reported improved environmental performances of various industrial symbiotic systems (Daddi et al., 2017). For instance, Eckelman & Chertow (2013) analyzed Campbell Industrial Park; the cluster encompasses 11 facilities that engage in inter-firm exchanges of water, materials, and energy. The authors employed life cycle assessment methodology (LCA) to evaluate the advantages of such symbiotic relations in terms of energy consumption and environmental impact, while analyzing the benefits and costs of current system of flows. The results show that while using by-products may not always be environmentally beneficial, as they may require additional collection, processing, and treatment that could offset any benefits, it is clear that local exchanges of energy and materials between symbiotic industrial facilities can result in environmental savings over the entire lifecycle. (Eckelman & Chertow 2013)

More specific environmental improvements include reduction in the consumption of virgin materials and energy, significant decreases in waste generation and emissions, modest improvements in most environmental impact categories, notably in areas like acidification, climate change impacts, and particulate matter formation. These benefits are primarily achieved through efficient reuse and recycling within industrial systems and are further enhanced by upstream processes, earlier in the production chain, particularly in heat and electricity generation. (Sokka, 2011)

In addition to environmental advantages, IS offers significant economic advantages such as reduction in investment and pollution control expenses, improvements in resource use and production efficiency (Chen et al, 2022). Economic motives are often the primary drivers behind companies' initiatives to build industrial symbiosis relations (Neves et al, 2020).

Social impacts of IS are the least analyzed as they tend to be most challenging to measure in the context of IS (Neves et al, 2020). Yet it has been shown that industrial symbiosis networks and eco-industrial parks contribute significantly to job creation, reducing fuel poverty in rural areas, infrastructure improvement, and reduction of health risks for the community (e.g due to reduced emissions and exposure to particulate matter) (Neves et al, 2019).

1.2.4 Kalundborg symbiosis

Kalundborg symbiosis in Denmark, one of the most well-known and frequently referenced examples of successful industrial symbiosis (Neves et al, 2020), started in 1961 due to the scarcity of water in the region. This ecosystem began to form when local companies started to collaborate, using water from Lake Tissø for their production processes to minimize groundwater usage (Neves et al., 2020). The ecosystem consists of several firms, the primary companies being a power station, gypsum board facility, an oil refinery, pharmaceutical plant, and the City of Kalundborg - the Kalundborg symbiosis is the collaboration between public and private sectors. The involved parties share resources such as groundwater, surface water, and wastewater, along with steam and electricity. They also exchange various types of residues, which are repurposed as feedstocks in different processes (Chertow et al., 2000). Figure 2 below demonstrates participating companies' exchanges between each other.

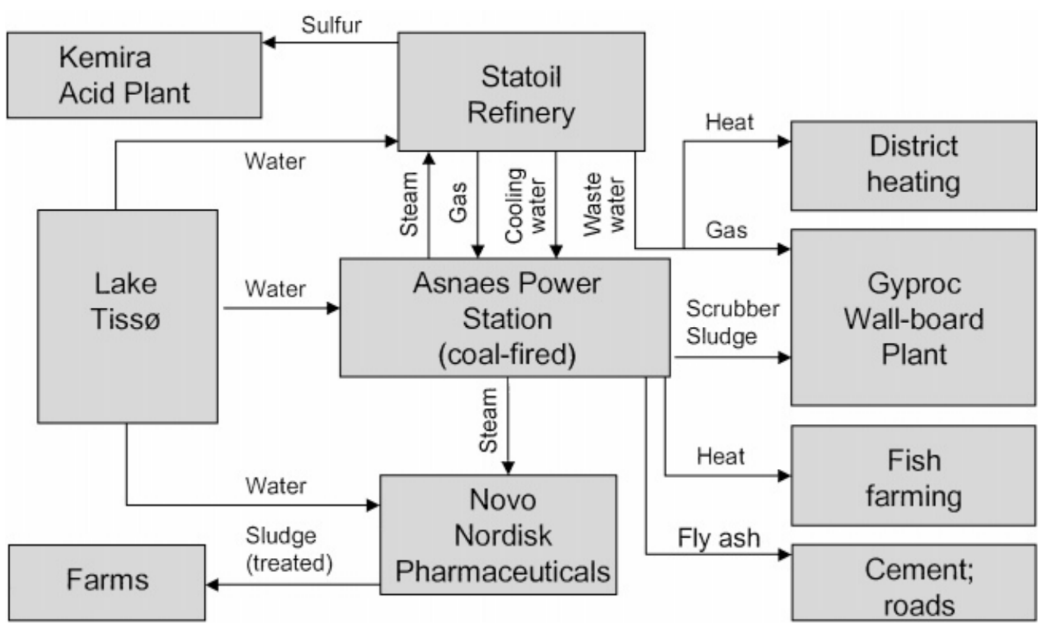

Figure 1.2. Kalundborg symbiosis' main firms and exchanges between them (Source: Chertow et al., 2000)

According to the industrial symbiosis classification proposed by Marian Chertow in 2000, Kalundborg is "Type 4" which is characterized by exchanges among local firms that are not colocated but are situated within close proximity to each other. The primary firms are located within about a two-mile radius, allowing them to take advantage of existing material, water, and energy streams, despite not being planned as an industrial park or colocated in the same facility in the first place. (Chertow, 2000)

Kalundborg symbiosis emerged spontaneously because of the physical proximity of the firms and it developed into a functioning eco-industrial park, thus being an example of a bottom-up approach symbiotic network (Neves et al., 2020).

1.3 Barriers to implementation of industrial symbiosis

While industrial symbiosis offers considerable environmental, economic, and social advantages (Neves et al., 2020), making it a highly effective approach for the industrial sector, its actual practical implementation often poses challenges and faces various barriers (Neves et al., 2020, Taqi et al., 2022).

Based on various studies conducted on this matter, the following barriers were consistently identified (Neves et al., 2019):

- inadequate legislative frameworks and policy support;
- limited awareness of industrial symbiosis concepts;
- insufficient knowledge about potential waste exchange partners;
- lack of trust among companies;
- unwillingness to disclose information about processes and waste;
- uncertain financial outcomes from participating in symbiotic networks;
- costs and risks linked to symbiotic partnerships;
- inconsistent availability and quality of waste materials;
- concerns about becoming dependent on other businesses;
- low prices of virgin materials and to waste economic value;
- minimal willingness of stakeholders cooperation;
- high initial investment in necessary infrastructure and equipment;
- scarcity of required technology;
- socioeconomic instability of a country/region.

Taqi et al in their 2022 article deployed DEMATEL (decision-making trial and evaluation laboratory) method which is used to analyze and understand the structure of complex systems, especially in terms of the causal relationships between various elements within these systems. Similarly to the triple helix model, DEMATEL is also extensively utilized in sustainable innovation studies. The 2022 study by Taqi and others aimed to identify and model the challenges in implementing industrial symbiosis within emerging economies. The study also aimed to review current research on industrial symbiosis, identifying knowledge and practical gaps, to help close the gap between theoretical understanding and practical implementation of industrial symbiosis. (Taqi et al., 2022)

The authors found that organizational challenges were the most significant ones. These include issues like lack of management support, financial constraints, unwillingness to transition to new systems, and cultural barriers within organizations. The article also highlighted the importance of economic and technological challenges, which include aspects such as market insecurities, lack of governmental policies, technical feasibility, safety concerns. Social barriers, while being less significant compared to others, were still noted – they include issues such as lack of customer awareness and stakeholder communication. (Taqi et al., 2022)

A study conducted by Tallinn University of Technology in 2021 aimed to identify circular economy business models suitable for existing small and medium-sized enterprises (SMEs) in Estonia, which mainly operate on linear economy principles or have applied circular economy principles to some extent, based on the specifics of their industrial sector. In addition, the objective was to identify barriers and drivers for transforming existing SME business models into circular economy models, and to highlight factors that require governmental intervention and support. The analysis was made based on 4 industrial sectors: the computer, electronics, and optical equipment industry; the chemical industry, excluding the plastics industry; the electrical equipment industry; and the metal industry. (Gerstlberger et al., 2021)

The primary barriers identified for each studied sector were (Gerstlberger et al., 2021):

1. For computer, electronics, and optical equipment industry:
    - limited implementation of technological innovations related to the circular economy;

- challenges in finding interested collaborators;
- challenges in securing necessary funding;
- low priority given to circular economy practices.

2. For chemical industry (excluding plastics):
    - some elements of circular economy business models were not applicable;
    - lack of funding;
    - lack of knowledge in specific areas of circular economy topics;
    - overall low prioritization given to circular economy activities.
3. For electrical equipment industry:
    - predominant lack of knowledge and interested collaborators;
    - lack of trust towards adopting certain practices;
4. For metal industry:
    - lack of related knowledge;
    - lack of interested collaborators;
    - lack of financial resources for future investments in technologies.

It can be seen that in summary, common barriers across these 4 sectors include challenges in adopting new technologies and practices, lack of necessary funding, knowledge gaps, and challenges in establishing collaborative partnerships. While this study concerns circular business models in general, the findings of the paper provide valuable insights for the context of this thesis as industrial symbiosis is inherently connected to the principles of circular economy. (Gerstlberger et al., 2021)

In the mixed-method research design of this study, qualitative interviews with focused groups, among others, were employed (Gerstlberger et al., 2021). Upon analyzing the study's findings, the interviews show to be an effective way for collecting valuable insights about the challenges and barriers the industries face when concerning circular economy approach.

1.3.1 Challenges between industry-academia collaboration

As circular economy topic and its related industrial symbiosis approach are complex matters that require involvement of different actors, effective collaboration among these actors is crucial for the success of sustainability innovations (Lerman et al., 2021).

Gandhi (2014) examined the challenges between the collaboration of academia and industry in the context of India (Gandhi, 2014). The key points brought out were the historical lack of collaboration between the two actors due to various barriers such as differences in approach and understanding – academia focusing on research and industry on applied research for primarily, short-term profits). The author also highlighted that there are changes happening due to global and economic trends which push for closer cooperation between these actors. (Gandhi, 2014)

A widely used framework for sustainability innovation studies, including circular economy innovations, is the triple helix model. It involves interaction and collaboration between academia, industry, and the government. It emphasizes the synergistic relationships between those actors since when addressing complex challenges of sustainability, interdisciplinary approach and multi-stakeholder cooperation are essential (Anttonen et al., 2018).

Liu and others (2022) deployed the triple helix model as a framework to understand and analyze the dynamic and interactive roles of universities, industries, and government in developing circular economy innovation through CoPs (communities of practice – a group of interest formed around a specific topic of interest) (Liu et al., 2022). The authors found that CoPs as vital for fostering regional circular economy innovation and that in initial stages, universities and government are cruicial for establishing the CoPs. The study demonstrates that the triple helix model is suitable for circular economy innovation studies as it captures the dynamic interaction between academia, industry, and the government (Liu et al., 2022).

1.3.2 Role of regulations/policies

The role of the regulatory environment or public sector in fostering successful and efficient symbiotic systems is a type of barrier/driver which is extensively discussed and acknowledged as highly significant (Neves et at., 2020).

Internationally, the concept of industrial ecology has been adopted by various countries, leading to active promotion and development of industrial symbiosis. Different countries approach it differently and have distinct strategies for its implementation. Some adopt strict polical instruments and regulated systems, while others encourage companies to participate in symbiotic systems voluntarily. Both strategies are effective and feasible. It can be generally said that in the majority of countries pracitcing industrial symbiosis, it functions with both policy-driven methods and based on voluntary participation. (Koov, 2021)

On the example of China the significant role of policies in fostering successful industrial symbiosis can be seen. China's rapid economic growth led to increased primary energy and resource consumption, and thus higher greenhouse gas emissions. Due to international pressure to decrease those emissions, the country implemented a range of political measures such policies, research incentives, and financial support which played the role in advancing industrial symbiosis across the country and making China a country with the largest number of industrial symbiosis case studies. (Neves et al., 2020)

Within European countries, the European Union has significantly influenced sustainable development practices. Since the 1970s, many EU countries have adopted the concept of circular economy which has been driven by various measures from the European Commission. These measures include strategic documents, policies, and programs supported by monetary incentives. Despite these efforts, the development of industrial symbiosis varies across EU countries. Northern and North-Western European countries, especially the United Kingdom, Sweden, Denmark, and the Netherlands, lead in implementing policies that align with a circular economy, thereby encouraging industrial symbiosis. The UK, in particular, has seen growth in industrial symbiosis cases due to policies like the Landfill Tax and the Waste Protocols Project, as well as programs like the National Industrial Symbiosis Programme. Industrial symbiosis however may arise spontaneously, as can be seen in Kalundborg, Denmark. (Neves et al., 2020)

A study 2019 by Domenech and others which aimed to provide an updated overview of industrial symbiosis in Europe, applied interviewing methods as part of their research design. Among interview participants were facilitators and coordinators of industrial symbiosis network, policy makers, government officials focused on IS and associated regulatory frameworks, and representatives from industry (Domenech et al., 2019). The in-depth interviews were designed to elaborate on key drivers and obstacles of IS networks and to explore various policy strategies for encouraging IS in Europe. Participants in these interviews had practical experience in the field of IS either from the facilitation or policy-making side (Domenech et al., 2019).

The interviews, along with other research methods used, allowed to gather valuable insights about IS key characteristics, drivers, barriers, and the potential of IS in the transition to circular economy. The findings include identified policy-related obstacles to IS such as (Domenech et al., 2019):

- complexity and inconsistency of regulations across different European countries. The study found that existing legislation sometimes hinder the development of IS due to the lack of clarity in defining what is a by-product and what is a waste;
- lack of standardized processes or systems for IS, i.e. logistical challenges. They included the comlexity of coordinating and managing the exchange of resources, especially when happening across different geographical areas;
- lack of funding, incentives or investment to support IS projects;
- administrative challenges when complying with different regional regulations and managing cross-border exchanges.

1.3.3 Related political measures in Estonia

The following subparagraph provides an overview of the regulations and policies that are currently in force in Estonia and which concern industrial circular economy projects and, indirectly, industrial symbiosis. Currently, there are no political measures in Estonia that directly address industrial symbiosis (Koov, 2021).

The Waste Act plays a central role in addressing topics related to circular economy, efficient use of resources, waste minimization, and sustainable development in general in Estonia. The Waste Act sets out general guidelines for preventing waste generation and resulting health and environmental hazards. The Waste Act also regulates the organization of waste management in order to reduce waste quantity and hazardousness. In addition, it establishes responsibility for non-compliance with the stipulated requirements. (JäätS, 2004)

The Estonian Waste Act mentions in several paragraphs that materials reuse, recycling and waste reduction are highly encouraged and supported by the law. However, when it comes to creating and developing industrial symbiosis, there is not enough specific and concrete information available. It would be beneficial to have more detailed guidelines and support for the development of industrial symbiosis, as it would promote its growth and development. (JäätS, 2004; Koov, 2021)

The concept of waste recycling and materials circulation, which are central activities in industrial symbiosis, encompasses several actions in the Waste Act. It involves using waste as secondary raw material or the preparation of waste for use as raw material. Recycling of waste is a process by which waste is processed into products, materials, or substances that can be used in their original form or in another form. The use of waste as a source of energy or fuels is not considered as recycling under the Waste Act. (JäätS, 2004, Koov, 2021)

The Waste Act contains a definition for the term "by-product," which refers to an item that is obtained as a result of a production process, but the primary purpose of the process was not its production. Instead, the item is a secondary output or a by-product of the process. However, it may still be considered a by-product instead of waste if certain conditions are met (JäätS, 2004):

“1. further use of the item is certain;
2. the item can be used directly without further processing, except for processing that is generally inherent to the relevant industry;
3. the item is generated as an integral part of the production process;
4. the item meets product, environmental, and health protection requirements for its specific use, and its use does not have a negative impact on the environment or human health."

The Minister of the Environment has the authority to issue regulations that further specify the conditions related to defining specific things generated in the production process as by-products (JäätS, 2004).

If a producer makes products using waste materials classified as by-products, they do not need to have a waste permit. However, if the recyclable materials are classified as waste under the law, the manufacturer using them must have a waste permit. A waste permit is necessary for waste disposal, recycling, collecting, or transporting hazardous waste, except for waste generated by the manufacturer's own activities, collecting and transporting other persons' metal waste for further trade or recycling, and some other cases. In order to obtain a waste permit, the manufacturer must submit an application to the Environmental Board. If a waste permit is not required, the manufacturer must register as a waste handler. Both holders of a waste permit as well as manufacturers registered as waste handlers are obliged to regularly submit waste reports. (JäätS, 2004)

The Waste Act also mentions waste hierarchy, where in waste prevention and in the development and implementation of waste management measures the following order of priority should be applied (JäätS, 2004):

1) “waste prevention;
2) preparation for reuse;
3) recycling;
4) other forms of recovery such as energy recovery;
5) disposal.”

All this information extracted from the Waste Act indirectly implies that industrial symbiosis, which by its classic definition assumes waste minimization, materials recycling, and more efficient use of energy and resources (Chertow et al., 2000), is favored by the law. However, more specific policies related to industrial symbiosis are currently lacking (JäätS, 2004). Similarly, the General Part of the Environmental Code addresses environmental protection, the possible reduction of environmental damage, the prevention of harm to the environment, and the promotion of sustainable development (KeÜS, 2011).

In addition to not directly addressing industrial symbiosis, which could pose a significant barrier to the deployment of industrial symbiosis projects in Estonia, the Waste Act includes certain aspects that might not be supportive enough for circular economy projects. For instance, products made from recycled materials must meet applicable product standards, quality control, self-control, and accreditation requirements. Furthermore, conformity assessment is required for such products. It is suggested that this could be the reason why some entrepreneurs would prefer to use virgin materials in their products instead. (Koov, 2021)

The White Book of the Circular Economy, created by the Ministry of Climate (formerly, Ministry of Environment) and the Environment Agency, serves as a guide towards more sustainable economic models and a more sustainable future. The main vision for the circular economy of Estonia, as outlined in the White Book is as follows: "Estonia has a functioning circular system of production and consumption, and we are a smart country leading the transition to circular economy". (Ministry of Environment, Environment Agency, 2022)

The action plan towards a circular economy released by the European Commission in 2019 also emphasizes the importance of adopting sustainable practices to reduce waste, promoting recycling and materials circulation, reducing landfilling, and mitigating environmental risks (Ministry of Environment, 2018) As a part of the Waste Package, changes were made to waste-related directives. The most important changes were (Ministry of Environment, 2018):

- "Obligations regarding separate collection and recycling of waste have been clarified. By 2025, the target level for preparation for reuse and recycling of municipal waste will rise to 55%, to 60% by 2030, and to 65% by 2035.
- The decision-making process on waste cessation has been specified.
- General minimum requirements have been established for extended producer responsibility systems.
- Waste prevention measures have been established, including a requirement for companies to add information about products containing highly hazardous substances to the European Chemicals Agency database.
- A limit has been set on landfilling - by 2035, no more than 10% of generated municipal waste may be landfilled.
- Reporting obligations of the member states have been harmonized."

Despite making progress in certain areas related to the environment and sustainable development, Estonia still has significant challenges to overcome. While the country has been ranked 10th in the global Sustainable Development Goals index in 2022, with the goal in the "Estonia 2035" strategy to be ranked 10th or higher by 2035, it is lagging behind in several important targets (Statistics Estonia: Tree of truth, 2023). For instance, one of the major issues that remains is the country's low circulating material rate. According to Statistics Estonia, the rate was 15.1% in 2020 and 15.6% in 2021, which is significantly below the target of being 30% by 2035 (Statistics Estonia: Tree of truth, 2023).

In addition, the amount of both common and hazardous waste as well as secondary waste generated by waste management facilities was 16,697 thousand in 2020; the number increased in 2021 and amounted to 19,362 thousand tons, which is a significant rise (Statistics Estonia: Tree of truth, 2023). This indicates that there has been insufficient progress made towards achieving the objective of reducing waste generation as stipulated in The Estonian National Strategy on Sustainable Development.

These statistics are an alarming sign that Estonia is not making enough progress in the transition to a circular economy, which is crucial for sustainable development. It is important to address the current situation and strive to keep abreast with relevant developments in the field.

2 MATERIALS AND METHODS

This section outlines the materials and methods used in the thesis. The central theoretical model for the methodological framework of this qualitative research is the triple helix model of innovation, focusing on the collaboration between industry, academia, and the government (Anttonen et al., 2018). The triple helix model rationalizes the selection of the research design, which is built around qualitative interviews with the industry representatives. A semi-structured interview method was chosen for data collection from the selected companies, and thematic analysis was used for data analysis.

2.1 Materials

For conducting the current thesis, three companies engaged in industrial symbiosis were selected. The companies are Ragn Sells OSA Service project, Auvere Agropark, and PAKRI Science and Industrial Park. From each company (project), one or two representatives were interviewed to provide input and perspectives for this qualitative research. A description of the selected companies, the relevance of each company to the thesis topic as well as the positions of the interviewed representatives are provided in the following paragraphs.

OSA Service project, a subsidiary of Ragn-Sells, is a large-scale, innovative project in Ida-Virumaa, Estonia. It focuses on the upcycling of oil shale ash – a significant waste product from electricity generation in Estonia. This project is a notable pioneering example of circular economy. The project involves converting oil shale ash into ultra-pure calcium carbonate while utilizing CO_2 from other industries, thus ensuring a climate-positive and emission-free production process. This process significantly reduces the need of natural resource extraction and minimizes environmental impact. (OSA Project, 2023)

The project aims to launch a demo plant in 2024 and a full-scale industrial plant in 2028. It is being developed in collaboration with Ragn-Sells, TalTech, University of Tartu, and various international labs. The operation will create new jobs in Ida-Viru county and stimulate the local economy through increased business opportunities and investments. It will also contribute to Estonia’s waste generation and recovery targets, reducing the carbon footprint and improving the overall living environment in the country. (OSA Project, 2023)

Calcium carbonate, the main product of the project, will be used in various industries, including food, pharmaceuticals, paint, plastic, and paper. This project also aims to explore the extraction of other critical elements like magnesium, aluminum, iron, zinc, and silicon from oil shale ash, thus aligning with industrial symbiosis approach. These efforts align with the global shift towards sustainable resource utilization and environmental conservation, giving Estonia a chance to stand out as a leader in innovative circular economy practices. (OSA Project, 2023)

This pioneering large-scale project has been chosen for this thesis because of its direct relevance to circular economy. It is believed that gaining insights into the challenges faced by this project, particularly those related to regulatory environments, will provide valuable understanding and perspective on this important topic. The interview for this research was conducted with Alar Saluste, the project manager of OSA Service project.

The second project selected, **Auvere Agropark**, is an industrial symbiosis project being developed in Ida-Virumaa. It is established by the Ida-Viru Investment Agency (IVIA). The agropark plans to utilze the reclaimed areas from the Narva quarry (approximately 1500 hectares), water from Narva River, heat energy from the Auvere station for heating, pool water, and irrigation. Other key features include utilization of CO_2 (e.g., for plant cultivation), using ash as a component in fertilizer production. The presence of a 330 kV substation nearby provides an opportunity for large-scale alternative energy projects. The large scale of the project allows for other circular economy solutions, where waste from one process becomes an input for another, creating a closed-loop system. (Auvere Agropark, 2020, Kuusmik, 2020)

Auvere Agropark plans to incorporate to the symbiotic network various sectors such as vegetable cultivation, algae farming, and potentially insect farming. By using thermal energy and direct electricity access from the power station, the project significantly reduces environmental impacts and operational costs. (Auvere Agropark, 2020, Kuusmik, 2020)

The project is at the moment in detailed planning stage. Building of the infrastructure is planned for the year 2023-2024. The project has gained support from the Narva-Jõesuu local government, reflecting its potential to create jobs and stimulate local economy. (Auvere Agropark, 2020, Kuusmik, 2020)

Auvere Agropark has been chosen for the current thesis because it represents a novel industrial symbiotic project, and thus being also directly linked to circular economy. The interviews for on this project were conducted with Teet Kuusmik, managing director of Ida-Viru Investment Agency (IVIA) - by which the project is being developed and with Nele Rogenbaum, development manager at IVIA.

The third project, **PAKRI Science and Industrial Park**, is a green technology and industrial symbiosis initiative located near Paldiski, Estonia. The project is a synergy between 3 pillars: smart industrial city, smart grid, and science and industrial park. Its vision is to become the largest smart industrial city and greentech competence center in Northern Europe. (PAKRI Science and Industrial Park, 2023)

PAKRI Science and Industrial Park focuses on renewable energy, energy efficiency, smart housing and cities, energy storage, and green fuels. The park's strategic location together with its developed infrastructure, including a 75MW renewable power network with smart grid capabilities, positions it as a leader in sustainable industrial development. The project owns 60 hectares of privately-owned space and has access to additional governmental land. (PAKRI Science and Industrial Park, 2023)

PAKRI was selected for this thesis as its approach indeed aligns with the principles of circular economy and industrial symbiosis as it focuses on the efficient use of resources and promotion of green technologies. It facilitates exchanges of energy and materials between participating companies which is aligned with the idea of industrial symbiosis. The interviews were conducted with two representatives: a partner on the PAKRI Energy side who wished to contribute to the research anonymously and a real estate broker at PAKRI - Jana Varimaa.

Table 2.1. Interviewed companies/projects and their representatives

Company (project) name	**OSA Service Project**	**Auvere Agropark**		**PAKRI Science and Industrial Park**	
Interviewed person position	Project manager	Development manager at IVIA	Managing director of IVIA	Partner at PAKRI energy	Real estate broker
Interviewed person name	Alar Saluste	Nele Rogenbaum	Teet Kuusmik	-	Jana Varimaa

2.2 Methods

This thesis was conducted in three phases. The first phase involved a literature analysis to establish a theoretical foundation, which resulted in the selection of the triple helix model as a suitable framework for this study. The second phase involved an assessment of the current situation regarding industrial symbiotic initiatives in Estonia which led to the selection of three companies actively engaged in industrial symbiosi. This phase also included conducting qualitative interviews with key representatives from these companies. In the final phase, the qualitative data gathered from these interviews was analyzed using thematic analysis, and subsequent conclusions were made. The following subparagraphs describe the applied methods more in-depth.

2.2.1 Triple helix model

The Triple Helix model, being a central concept in this thesis topic, conceptualizes innovation as a product of complex collaboration between industry, academia (the university) and the government spheres. This model is rooted in the understanding that significant improvements, especially in fields like circular economy innovation and sustainable practices, emerge from the collaborative efforts of these three key actors. The triple helix model suggests that successful innovation requires a 'consensus space' - an overlapping area where industry, universities, and government spheres share understanding and cooperate together. (Anttonen et al., 2018) This is relevant for the development of industrial symbiosis in Estonia, as it requires an aligned approach from industry (for practical implementation), government (for shaping policy and regulatory support), and academia (for research and spreading the knowledge).

In this research, the triple helix model is applied through qualitative approach. The focus is on understanding the experiences, perspectives, and insights of professionals (Quartey & Oguntoye, 2020) within the Estonian industrial symbiosis field. This qualitative framework is being applied in order to rationalize the selection of the research design, which employs qualitative interviews from the industry representatives. This approach, more broadly, aims to contribute to the transition towards a more sustainable industrial sector. The qualitative approach allows for a deeper exploration of how the interplay between academia, industry, and government supports or undermines the development of industrial symbiosis projects in Estonia, particularly from a regulatory and policy standpoint.

2.2.2 Semi-structured qualitative interviews and data analysis

For collecting inputs from the interviewed personas, a semi-structured interviews method was chosen. Semi-structured qualitative interviews allow the researcher to adapt during the interviewing process. Depending on the flow of the interviewing process, it can be chosen whether to stick to the prepared concrete questions or to follow the interviewee's responses and ask new questions outside the original questions scenario in order to go more in-depth with some topics. This flexible approach facilitates a deeper exploration of related topics as needed. (Kvale and Brinkmann, 2009)

The interview questions (full list is presented in Appencies 1-4) were chosen based on the research goal of the thesis which was to examine if political measures support or undermine the development of industrial symbiosis in Estonia through practical inputs from representatives of selected Estonian companies. The interview began with introductory questions to find out the current stage of the projects and how many companies have joined the symbiotic network. The primary focus of the interviews was on the challenges encountered by the representatives of the industrial symbiosis projects. General challenges were explored, but the main focus stayed on issues related to the regulatory environment. Representatives were also asked to share their perceptions of the regulatory environment — whether they find it supportive or problematic for their projects. It was asked in which way, in the opinion of the representatives, the state could be more supportive and which measures could be most effective. Additionally, it was asked to disclose the cost-effectiveness and future prospects of these projects in order to understand the viability of these industrial symbiosis projects in Estonia.

Moreover, interviewees were asked if they were aware of any other similar industrial symbiosis initiatives in Estonia, allowing the possibility that there might be more similar projects that are just starting and therefore might not be widely publicized. This approach was taken to potentially expand the scope of this research and to include more relevant cases. During the interviews, if any specific regulatory measures of particular relevance to this thesis were mentioned, the author tried to elaborate on them to gather more valuable data, aligning with the flexible nature of semi-structured interviews (Kvale and Brinkmann, 2009). A full list of the questions asked during the interviews is provided under the 'Appendices' section.

The interviews were carried out through face-to-face meetings, e-mail correspondence, and a phone call, in the period of time from 22.02 - 19.04.2023. Interviews conducted orally were transcribed manually into text, proofread, and translated into English. The transcribed data, along with the interpretations and conclusions drawn from them, were then sent back to the interviewees for their validation to ensure accurate understanding of the responses. If needed, necessary changes or improvements were made.

For analyzing the interviews' findings a thematic analysis, a well-known method in qualitative research for analyzing textual data (Wiltshire and Ronkainen, 2021), was applied. Thematic analysis was used to identify patterns or themes within the collected data to better structurize it and further interpret it. For creating the illustration for the thematic analysis, a graphical design platform, Canva, was used.

The following figures (Table 2.2 and Figure 2.1) present thematically structured findings from the conducted interviews. Firstly, the codes or significant relevant bits of information were identified. Subsequently, they were grouped into themes or broader topics (marked with different respective colours) within the gathered data.

Table 2.2. Thematic analysis: identified codes grouped by identified themes from interviewed companies

Company/ project	**Ragn Sells OSA Project**	**Auvere Agropark**	**PAKRI Science and Industrial Park**
Identified code	Stakeholder work pace variation; CO_2 supply challenges; Regulatory challenges in circular economy; Demand for climate-nautral product; Financial support from various funds; Estonia’s international opportunity; Goal to utilize ash mountains; International spreading of the technology.	Challenges in nature studies; Bureaucratic spatial planning; Regulatory obstacles; Local government's capacity with large projects; Balance of supply and demand in IS; Long project preparation.	Current situation in the world; Development stall; Interest is less that expected; Dependency on the tenants; Challenges in electricity market law interpretation; Possible increase in taxes; Need for governmental support; Profitability issues; Material flows between companies; Transmission capacity of electricity networks.

Theme 1: Regulatory environment and policy challenges

- Regulatory challenges in circular economy;
- CO2 supply challenges;
- Bureaucratic spatial planning;
- Regulatory obstacles;
- Local government's capacity with large projects;
- Challenges in electricity market law interpretation;
- Possible increase in taxes;
- Need for governmental support.

Theme 2: Market dynamics and project viability

- Financial support from various funds;
- Estonia's international opportunity;
- International spreading of the technology;
- Demand for climate-neutral product;
- Balance of supply and demand in IS;
- Long project preparation;
- Current situation in the world;
- Development stall;
- Interest is less than expected;
- Profitability issues.

Theme 3: Operational and strategic challenges

- Stakeholder work pace variation;
- Goal to utilize ash mountains;
- Challenges in nature studies;
- Dependency on the tenants;
- Transmission capacity of electricity networks;
- Material flows between companies.

Figure 2.1. Thematic analysis: identified themes along with grouped codes. Compiled by the author

3 RESULTS

This section of the thesis provides an overview of the qualitative interview findings. The interviews were conducted with representative(s) of the three selected companies: Ragn Sells OSA Project, Auvere Agropark, and PAKRI Science and Industrial Park. The results are presented within three identified themes: regulatory environment and policy challenges, market dynamics and project viability, and operational and strategic challenges.

3.1 Regulatory environment and policy challenges

The first theme identified, **"Regulatory environment and policy challenges"**, directly links to the core objective of the conducted interviews – assessing whether the regulatory environment for the development of circular economy projects, such as industrial symbiosis, is supportive or obstructive from the standpoint of industry professionals engaged in such projects in Estonia.

This theme emerged as a crucial and central aspect, highlighting the different aspects and nuances of current regulations that impact the progress of industrial symbiosis projects. Interviews with the companies' representatives revealed that regulatory challenges and their different aspects are a considerable concern, often acting as barriers to the successful implementation and growth of these projects. These challenges include bureaucratic spatial planning, regulatory obstacles, issues specifically related to captured or biogenic CO_2 supply and others.

Regarding the bureaucratic issues in spatial planning, Auvere Agropark's interviewees mentioned that one of the biggest challenges of implementing such new large-scale projects is spatial planning (detail planning) which is very time-consuming, complex, and costly.

> "*The biggest challenge in implementing new large-scale development projects in Estonia is the process of detailed spatial planning, including strategic environmental assessment and related studies. Today's Planning Act and Environmental Impact Assessment and Environmental Management System Act are overly bureaucratic - in practical terms, this means that every local or*

national structure involved in the process has the right to demand various time-consuming additional studies and analyses, many of which are of questionable value. Therefore, the preparation of detailed spatial planning together with strategic environmental assessment is extremely time-consuming and costly. Additionally, there is a tendency from state structures to demand various risk mitigation studies as a precaution. The process of preparing a detailed plan (DP) with environmental impact assessment (KSH) and amending the general plan is over-regulated. In addition to the described activities, it is also necessary to actually prepare technical work and constantly coordinate it. In this form, the length of the DP process from the submission of the initiation application to the establishment is about 5 years."

The interviewee from the OSA project brought up CO_2 supply challenges, indicating a shortfall in the required CO_2 amounts for their factories, which cannot be met domestically within Estonia. The interviewee pointed out that the problem here is that starting from 2030, the EU will implement regulations according to which if the project doesn't have biogenic or captured CO_2, then the product can't be called "sustainable"; there is enough of fossil CO_2, but using it won't make their product sustainable:

"*One of the biggest separate challenges is the CO_2 supply to our factories – making it possible to use emissions from the energy industry's chimneys, as we simply cannot obtain such quantities of CO_2 from other sources here in Estonia, and the CO_2 transport network is currently just a beautiful idea. We are in constant dialogue on this issue with both local and European Union institutions. Another challenge is to produce test products, calcium carbonate, in such large quantities as our customers need for their larger-scale tests. Of course, this is a positive challenge, and it is great that we have several large, international customers who are already so strongly associated with our project.*"

The representative also pointed out that this issue is closely linked to existing regulations, which were formulated rather in alignment with linear, not circular business model. The representative commented:

"*The challenge of CO_2 supply is clearly related to regulations that were created before the rise of the circular economy and thus favor a linear economic model.*

According to this, waste, including emissions, needs to be simply utilized or, if possible, maximally reduced. In terms of energy production, the latter option, however, means long-term development work, and so far, emissions could be used in production instead of burying them or releasing them into the air as taxed emissions. Hopefully, circular economy principles will also be modernized for CO_2 emissions and will view them as a material flow that innovative technologies allow us to utilize."

It has been also said that collaboration with the government is important and that the project hopes to provide their experience's input to contribute to the improvement of the existing regulations related to circular economy.

"*In our project, we have already experienced a great deal of interest and involvement from various institutions in the public sector. We hope to provide input for the modernization of existing measures and the creation of new measures that support the circular economy*."

A representative of Auvere Agropark also mentioned a challenge with local government's ability to handle/operate larger-scale projects:

"*It is directly related to regulations* (author: meaning the challenges with nature studies which are required)*, as well as to the local government's capacity and ability to carry out large-scale projects."*

Regarding developing policies, related to industrial development, Auvere Agropark representative mentioned that the state (government) doesn't have to intervene as "*...it is still a matter of finding the right balance between supply and demand*."

PAKRI Science and Industrial Park mentioned challenges with the interpretation of Electricity Market Act, specifically in relation to their unique network setup, which is built on providing network service as a closed distribution system operator (CDSO). This concept, being relatively new and not fully regulated, leads to different interpretations among various market participants, including distribution network operators (DSO), transmission system operators (TSO), the competition authority, and the Ministry of Economic Affairs and Communications.

"PAKRI Energy's medium voltage network is built on providing network service as a closed distribution system operator (CDSO), a new concept for several years, but all market participants understand it differently. Distribution network operators, system operators, Competition Authority (Konkurentsiamet), MKM (Ministry of Economic Affairs and Communications), and then us, a closed distribution system operator providing network services – it is not yet precisely regulated enough to use all the opportunities provided by the law. So, these obstacles will start to come from there on when we start implementing them. Each party starts to interpret them and has its understanding of what can and cannot be done. Very few parties try to find ways to work with it - who have such a mindset. Currently, there are multiple negotiations ongoing between MKM, DSO Elektrilevi, and TSO Elering. Since we own our network, where producers and consumers are added, and we act in some way as a distribution network company, just in simplified terms, then the goal (as I have understood from MKM) is to ensure the competitiveness of energy-intensive industry and security of supply, not by supporting it through any taxes or energy price benefits or whatever, but through some new legal possibilities that create accepted places where the network can be operated internally and the total energy price can be reduced lower than it would be in a traditional network. But in achieving this goal, it is currently the case that we are moving forward, things are getting clearer, but we have not yet found that final solution with different parties. Elektrilevi has been very open-minded as a DSO, focusing in finding solutions rather than being protective or passive in the process."

These differing interpretations create obstacles in fully utilizing the legal opportunities provided for operating such networks. The goal is to use new legal possibilities to operate the network internally, aiming to reduce the total energy price more effectively than traditional networks. Achieving this goal is, however, a complicated task since there is a lack of final clarity, specific application acts, or detailed regulation:

"*The laws and directives itself are easily understandable, but the interpretation of its implementation can vary greatly due to other nuances not stated in the law.*"

This situation puts PAKRI in a pioneering role, dealing with the challenges of figuring out and applying new laws in real-world practical situations:

> "*There could be more drawers and rules, some requirements and logic explained in more detail. But at the same time, I understand the state, they cannot predict all the details. They introduce a new concept, a new approach, and it needs to be resolved by the parties involved. So, those who do it first and try to work out all the details and nuances with all parties involved, they bear that pain. And if we solve it together, then we can transparently document it in cooperation with the Ministry of Economic Affairs and Communications. … we have simply ended up in such a pioneering role.*"

The representatives from PAKRI Science and Industrial Park also mentioned concerns regarding the potential impact of tax increases on their project:

> "*The current economic climate and the possible increase in taxes creates anxiety for everyone about what the future will bring. Every effort is being made to optimize costs or reduce them to remain profitable. Possible tax changes make companies think about whether to make short-term or long-term contracts. The same goes for energy - a company that wants to join the network must prepare the connection point and prepare the necessary construction work, which again requires money. It is possible to get some subsidies, but not always*."

It has been also pointed out that companies considering joining their park often expect government support:

> "*Of course it would be great if the government provided more support. For example, when a new foreign investor (client) wants to build a new building, they are naturally interested in what the country offers. They have their own project, they know exactly how to do it, but they would expect some help from the state. Unfortunately, we have to inform them that they might not qualify for support. Therefore, yes, of course, something is needed that would promote investments in Estonia and also assist local companies. Both foreign investors and local companies expect tax breaks and other forms of support.*"

3.2 Market dynamics and project viability

The second theme, **"Market dynamics and project viability**," although not directly related to the regulatory environment, is important for understanding the broader success factors of circular and industrial symbiotic projects. This theme encompasses market interest, financial support, and the impact of current global situations on project development.

The interviewee from the Ragn Sells OSA project highlighted that there is strong interest towards their main product – calcium carbonate produced in a climate-neutral way (produced using biogenic or captured CO_2).

> "*As mentioned earlier, we have several large international clients actively involved in our project. There is great interest both in Estonia and abroad. The more socially responsible an organization is, the more different innovative opportunities are sought. This is how our dialogue between the French flooring manufacturer Tarkett and the German window profile manufacturer Gealan came about very smoothly, and all parties see great potential for the project. So far, calcium carbonate has been produced with a very large CO_2 footprint, but there is a great deal of interest in a climate-neutral alternative.*"

It has been also mentioned that various governmental funds has been helpful for the development of the project:

> "*While the majority of investment so far has come from our parent company Ragn-Sells, which has already invested xx million here, various funds such as the EAS Applied Research Program or Archimedes are increasingly investing in the project's development; through this support is coming from Estonian state.*"

Moreover, the interviewee has mentioned that this large-scale circular project is a big opportunity for Estonia to stand out with circular practices internationally along with the potential to spread the technology further to other interested countries.

> "*From a circular economy perspective, this is a very innovative technology that could make Estonia stand out on the international stage, and why not take the*

lead in the CO_2 sequestration technology field. … One ambition is also the international sphere – there are more countries where oil shale has been used similarly and who may be interested in the technology."

Auvere Agropark's interview revealed that there are challenges with the lengthy preparation process for large-scale projects, particularly in detailed planning and conducting other necessary studies.

PAKRI Science and Industrial Park's interviews reveal how external factors, such as the COVID-19 pandemic and geopolitical situations like the war in Ukraine, directly affect the project:

"*If the general economic climate inhibits our clients (tenants) activities, then we also suffer damage. Covid was one thing, but the war in Ukraine also inhibits their activities because they are, after all, manufacturing companies. If some materials or parts of materials are connected to Russia or if the end products are sold there, then our activities are of course limited.*"

In addition, PAKRI has mentioned a development stall and lower-than-expected interest in the industrial park:

"*The development is stalled in the real estate part of the PAKRI peninsula, especially in the largest detailed planning area. Whether the location of the real estate is worthwhile or not depends on whether Paldiski attracts people or not. There are positive aspects, such as a port, a railway connection, and the fact that it is 45 minutes from Tallinn. There is also a center for the green sector, where there is a lot of renewable energy, such as PAKRI and other companies, including Eesti Energia's wind and solar power plants, etc. This could be the attraction, but yet there has not been a huge surge, as seen in areas like Kopli in Tallinn, to rediscover something similar to Paldiski. However, this is my interpretation of the situation as an energy expert. I am not a real estate specialist.*"

Moreover, profitability issues have been mentioned partly due to not receiving expected renewable energy subsidies:

"*Regarding PAKRI Energy, I can say that we have not yet reached positive cash flows. This is related to the previous topic – not enough energy consumers, and that we cannot use all the rights we see that we have. For example, we cannot receive support measures for a particular solar power plant, even though it is eligible for renewable energy feed-in tariff, because we produce the solar energy with the plant for our own grid, and what is left over from our consumers moves into the main grid. We do receive payment for the energy we produce, but we cannot receive the renewable energy support (aid) that was part of the business model for that power plant. There are legislative gray areas that are to be negotiated between the Ministry of Economic Affairs and Communications and Elering. I cannot say that I have any complaints about anyone. It is just an objective situation that we depend on and that needs to be addressed.*"

3.3 Operational and strategic challenges

The third theme, "**Operational and strategic challenges,**" while not directly linked to the regulatory environment, is still considered to be important as it helps shed light on broader challenges and factors contributing to the success of circular projects like industrial symbiosis. This theme encompasses a range of operational issues faced by companies in their implementations of circular economy projects.

Interview with Ragn Sells OSA Project revealed that a considerable common challenge they face is the fact that different stakeholders work with different paces:

"*One of the most common challenges in project management is that different stakeholders move at different paces because their activities are so varied. However, the results of these activities must eventually come together, and time planning and, if necessary, making changes in such a complex international endeavor requires great attention.*"

One of the ambitions of the OSA project is to finish the ash mountains and thus to reclaim back the natural environment. The project thus has the potential to, among others, improve natural environment in the local area:

> “*Even before the launch of this factory, the next step will be calculated to scale up production further. Of course, there will still be plenty of ash mountains left for decades, but the ambition is to fully utilize these mountains and reclaim the natural environment. … It is clear that this project is more important than a typical business project. In addition to the circular economy aspect, it has tremendous potential to improve the natural and living environment of Ida-Virumaa.*“

One of the operational/strategic challenges, mentioned by the representatives of Auvere Agropark was challenges with the required nature studies including wildlife survey, bird survey, study of protected species and a green network survey.

> “*The biggest challenge so far has been to understand what exactly we need to study during the nature studies on the 1500 hectares. We had six months of negotiations and discussions with the Environmental Board and local government. Subsequently, the slow action of the local government in drafting the procurement specifications for tenders became a hindrance to the project, causing it to stall for a year*.”

For PAKRI Science and Industrial Park the challenges within this theme include dependency on the tenants and the fact that tenants themselves depend on the external conditions and factors such as the COVID-19 pandemic implications, the war in Ukraine, possible tax increase and its implications.

Additionally, in the interview with PAKRI Science and Industrial Park issue with transmission capacity of electricity networks was mentioned. Specifically, the project faces a strategic challenge in expanding renewable energy production due to the existing constraints in the national electricity transmission network. While there is potential for growth and there is interest from industrial consumers side, the issue of integrating large-scale renewable energy production into the existing grid presents a significant operational and strategic challenge.

> “*When I spoke earlier about our network's capacity of 10 MW, our medium-voltage network is ready to grow to at least 40 MW within our network.*

But now it depends on how much and at what cost we can connect to Elektrilevi or Elering networks to take in this power. Our consumption direction is relatively large and scalable. However, we have restrictions on production due to the transmission capacity of electricity networks, as is the case throughout Estonia. Networks are congested in the production direction, and this is a problem for everyone in Estonia today. This is understandable because these are very capital-intensive works that need to be done to accommodate all the desired renewable energy into the electricity networks. This will definitely take time. Our goal is not to let our produced energy out of our network but to use as much of it as possible within our network. We are negotiating with several very energy-intensive consumers who want to come to the PAKRI industrial park and use PAKRI's energy and infrastructure, which includes the electricity network, connections to the national grid, and connections to renewable energy power plants, both ours and those on the Paldiski peninsula, to bring these into their network. We also have access to two optical service providers to offer very fast and modern communication networks to our customers. Therefore, the interest is quite high among large production companies."

4 CONCLUSIONS

The qualitative analysis of the regulatory environment for industrial symbiosis development in Estonia, particularly from the perspective of three companies, has revealed several insights. The primary theme of regulatory environment and policy challenges aligns closely with the central objective of this research. The findings suggest that while the current regulatory framework is not necessarily obstructive, it might present significant challenges that can act as barriers to the successful implementation and growth of industrial symbiosis projects. These include bureaucratic issues in spatial planning, regulatory obstacles, and issues related to CO_2 biogenic or captured supply.

The complexity and time-consuming nature of detailed spatial planning, as highlighted by the Auvere Agropark representatives, illustrate the procedural barriers that large-scale circular projects face. The OSA project's challenges with CO_2 supply underscore the need for regulations that align with a circular rather than a linear economic model. The regulatory framework, as it stands, appears to favor established linear models, potentially hindering innovative circular approaches like industrial symbiosis.

The interviewees' perspectives also indicate a need for closer collaboration between industry and government. Such collaboration can provide valuable inputs for modernizing existing measures and creating new ones that support circular economy principles. However, the current state of the regulatory environment seems to suggest that only the most proactive and responsible organizations can navigate these challenges successfully. This situation indicates a gap where structured and concrete regulations could play a vital role in encouraging a broader adoption of circular and sustainable practices.

The research also dives into market dynamics and project viability, which, though not directly linked to the regulatory environment, provide a broader understanding of success factors for circular projects. The interest in Ragn Sells OSA Project's climate-neutral calcium carbonate and the potential for Estonia to stand out internationally in circular practices highlight the market opportunities for such innovative projects. However, challenges like lengthy preparation processes, global economic impacts, and issues with renewable energy subsidies reflect the operational and strategic complexities these projects face.

The case of PAKRI Science and Industrial Park further emphasizes the external dependencies and operational challenges, particularly with regards to the electricity transmission network's capacity. These operational and strategic challenges, while not directly regulatory, are integral to understanding the broader context within which circular economy projects operate.

In conclusion, while regulatory environment in Estonia concerning circular economy projects, including industrial symbiosis, is evolving, it currently presents a landscape where proactive and innovative companies can navigate and succeed. However, for a broader and more effective transition to circular practices, a more supportive and detailly defined regulatory framework is essential. The findings from this qualitative study suggest that ongoing changes in Estonian regulations are moving in a direction that may increasingly support industrial symbiosis and other projects related ro circular economy, and thus contribute significantly to Estonia's and the wider EU's sustainability goals.

Since this thesis did not delve deeply into the specific policy measures that present barriers or challenges to the interviewed companies, the author proposes that future research could explore this matter further. Such research might try to understand how the mentioned policies might be improved or adapted to better support industrial symbiotic projects and the broader circular economy.

SUMMARY

In today's world, achieving sustainability in various sectors is a global priority. The circular economy is increasingly recognized as an approach that can yield substantial results in reducing environmental impacts and enhancing sustainability of industrial operations. Industrial symbiosis, being inherently connected to the principles of circular economy, is a collaborative approach where companies share waste, by-products, energy, and water. This approach has demonstrated notable successes, showing significant environmental, economic, and social benefits. However, the practical implementation of industrial symbiosis often presents various challenges, regulatory environment being one of them.

This thesis investigates the development of industrial symbiosis Estonia, focusing on how regulatory environment in Estonia influence its development. Implementing a qualitative research approach, the study engages with three Estonian companies actively involved in industrial symbiosis projects within the framework of circular economy in order to find out their practical perspective on the topic. These companies (projects) are Ragn-Sells OSA Service Project, Auvere Agropark and PAKRI Science and Industrial park. The research is framed within the triple helix model, which emphasizes the interplay between academia, industry, and government. The first objective of the thesis is to make overview of political measures in Estonia related to industrial symbiosis. The second research goal is to examine if political measures support or undermine the development of industrial symbiosis in Estonia based on the findings of the interviews.

Findings from the overview of political measures in Estonia related to industrial symbiosis demonstrate that while the Waste Act and other policies support circular economy principles, they lack specific measures for industrial symbiosis. The Waste Act encourages material reuse and recycling, but does not provide detailed guidance for symbiotic initiatives. It defines by-product criteria, impacting waste handling permits and reporting requirements. Despite efforts towards circular economy, as outlined in the White Book of the Circular Economy and EU action plans, challenges like a low circulating material rate and increasing waste generation in Estonia indicate a need for bigger, more focused progress in this area.

To fulfill the second research goal of the thesis, the results of the conducted qualitative interviews were analyzed using thematic analysis. The first theme identified was "Regulatory

environment and policy challenges" which directly links to the research goal of the thesis. The findings of the theme highlight the regulatory environment in Estonia, while not explicitly obstructive, presents some significant challenges. These include bureaucratic issues in spatial planning, regulatory obstacles, and issues related to biogenic of captured CO_2 supply; the existing regulatory environment appears more aligned with linear economic models, potentially limiting innovative circular approaches.

The second and third theme, while not directly linked to the research goal, were still identified as they provide insights about broader challenges and factors which contribute to the success of industrial symbiotic projects. The second theme – market dynamics and project viability indicates that there is significant market interest in sustainable products and highlights the role of global situations (wars, pandemics) in project development. Financial support from governmental funds emerged as an important factor in project viability.

The third theme – operational and strategic challenges indicates that companies face various operational and strategic challenges, including stakeholder work pace variation, lengthy project preparation processes, and electricity network capacity limitations.

It can be concluded that Estonia's journey towards a supportive environment for circular economy projects, including industrial symbiosis, is evolving, but not without challenges. The research suggests that while innovative companies can find ways to succeed, a more detailed and supportive regulatory framework is needed for broader adoption of circular practices.

The objectives of this thesis were achieved. Initially, by making an overview of political measures in Estonia related to industrial symbiosis and subsequently by examining if political measures support or undermine the development of industrial symbiosis in Estonia through conducting qualitative interviews with selected Estonian companies.

While this thesis does not delve deeply into specific policy measures, it is proposed that future research could focus on detailed related policy analysis. This analysis could suggest modifications or improvements that better support industrial symbiosis and the broader circular economy in Estonia.

KOKKUVÕTE

Tänapäeva maailmas on eri sektorite jätkusuutlikkuse tagamine ülemaailmne prioriteet. Ringmajandust nähakse üha enam kui lähenemist, mis võimaldab alandada negatiivseid keskkonnamõjusid ning tagada tööstusprotsesside jätkusuutlikkuse suurenemist. Tööstussümbioos, mis on otseselt seotud ringmajanduse põhimõtetega, on koostööpõhine ettevõtete võrgustik, kus ettevõtted omavahel jagavad jäätmeid, kõrvalprodukte, energiat ja vett. Selline lähenemine on olnud väga edukas, demonstreerides märkimisväärset keskkonna-, majanduslikku ja sotsiaalset kasu. Siiski võib tööstussümbioosi praktiline rakendamine olla piisavalt keeruline, millest üheks oluliseks väljakutseks on regulatiivne keskkond.

Käesolev magistritöö uurib tööstussümbioosi arengut Eestis, keskendudes sellele, kuidas Eesti regulatiivne keskkond selle arengut mõjutab. Rakendades kvalitatiivset uurimismeetodit, kaasati uurimustöösse kolm Eesti ettevõtet, mis on aktiivselt seotud tööstussümbioosi projektidega, et välja uurida nende vaatenurgad antud teema suhtes. Nendeks ettevõteteks (projektideks) on Ragn-Sells OSA Service projekt, Auvere Agropark ja PAKRI Teadus- ja Tööstuspark. Uurimistöö kotseptuaalse raamistiku keskmeks on kolmik-heeliksi mudel, mis uurib akadeemia, tööstuse ja valitsuse (riigi) vahelisi seoseid. Magistritöö esimeseks eesmärgiks on teha ülevaade Eestis tööstussümbioosiga seotud poliitilistest meetmetest. Teiseks uurimiseesmärgiks on välja selgitada, kas poliitilised meetmed toetavad või takistavad tööstussümbioosi arengut Eestis, tuginedes läbiviidud intervjuude tulemustele.

Eesti tööstussümbioosiga seotud poliitiliste meetmete ülevaatest selgub, et kuigi Jäätmeseadus ja muud poliitikad toetavad ringmajanduse põhimõtteid, puuduvad neil konkreetsed meetmed tööstussümbioosi jaoks. Jäätmeseadus julgustab materjalide taaskasutamist ja ringlussevõttu, kuid ei paku üksikasjalikke juhiseid sümbiootiliste algatuste jaoks. Seaduses on määratletud kõrvalsaaduste kriteeriumid, mis mõjutavad jäätmete käitlemise lubasid ja aruandluskohustusi. Vaatamata pingutustele arendada edasi ringmajandust, mille olulisust on käsitletud näiteks Ringmajanduse Valges Raamatus ning Euroopa Komisjoni tegevuskavades, näitavad madal ringlussevõtu määr ja kasvav jäätmete hulk Eestis vajadust suurema progressi järele selles valdkonnas.

Magistritöö teise eesmärgi täitmiseks analüüsiti kvalitatiivsete intervjuude tulemusi temaatilise analüüsi abil. Esimeseks tuvastatud kategooriaks (teemaks) oli „Regulatiivne keskkond ja poliitilised väljakutsed", mis on otseselt seotud töö uurimiseesmärgiga. Tulemustest selgus, et Eesti regulatiivne keskkond, olles mitte otseselt takistav, põhjustab siiski olulisi väljakutseid. Nendeks on bürokraatlikud probleemid ruumilises detailplaneerimises, regulatiivsed takistused ja biogeense või kinnipüütud CO_2 varustamisega seotud probleemid; praegune regulatiivne keskkond näib olevat rohkem kooskõlas lineaarse majandusmudeliga, potentsiaalselt piirates innovaatilisi ringmajanduslikke lähenemisi.

Teine ja kolmas teema (kategooria) pole küll otseselt uurimiseesmärgiga seotud, kuid need olid siiski identifitseeritud ja kirjeldatud, kuna annavad ülevaate laiematest väljakutsetest ja teguritest, mis mõjutavad tööstussümbiootiliste projektide edukust. Teine teema (kategooria) – turudünaamika ja projektide elujõulisus näitab, et jätkusuutlike toodete vastu on turul kindel huvi. Lisaks toob kategooria esile ülemaailmsete olukordade (sõjad, pandeemiad) rolli taoliste projektide arengus. Riiklikest fondidest saadav rahaline toetus samuti osutus oluliseks teguriks.

Kolmanda kategooria (teema) – operatiivsete ja strateegiliste väljakutsete analüüs viitab sellele, et ettevõtetel tekivad erinevad operatiivsed ja strateegilised väljakutsed, nagu näiteks sidusrühmade töötempode erinevused, projektide pikaajalised ettevalmistusetapid ning elektrivõrkude tootmissuunalise läbilaskevõime piirangud.

Kokkuvõtvalt võib öelda, et Eesti teekond ringmajanduse projektide, sealhulgas tööstussümbioosi, toetava regulatiivse keskkonna loomiseni on kindlalt arenev, kuid samas on ka väljakutseid. Antud uuring näitab, et kuigi uuendusmeelsemad ja proaktiivsed ettevõtted võivad leida võimalusi edukaks tegutsemiseks, on laiema ringmajanduse praktikate omaksvõtmiseks vaja detailsemat ja toetavamat regulatiivset raamistikku.

Magistritöö eesmärgid said täidetud. Esmalt koostades Eestis tööstussümbioosi puudutavate poliitiliste meetmete ülevaate ning teisalt uurides, kas poliitilised meetmed toetavad või takistavad tööstussümbioosi arengut Eestis, tuginedes kolme Eesti ettevõttega läbiviidud kvalitatiivsete intervjuude tulemustele.

Kuna käesolev magistritöö ei keskendunud konkreetsete poliitikate põhjalikule analüüsile, tehakse ettepanek uurida neid tulevikus üksikasjalikult. Põhjalik analüüs võiks välja pakkuda muudatusi või täiendusi, et luua veelgi toetavam keskkond tööstussümbioosi ja, laiemat, muude ringmajanduslike algatuste arenguks Eestis.

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APPENDICES

Appendix 1

Interview questions with Ragn Sells OSA project's representative Alar Saluste (conducted via e-mail)

Initial introduction and aim of the interview.

Question 1: At which stage is the OSA project at the moment?

Question 2: What are the main challenges/difficulties you are facing?

Question 3: Are there any challenges that are due to non-supportive regulations?

Question 4: Do you believe the government should take a more active role in developing IS's? Why? What kind of measures would be the most effective?

Question 5: Is it rather hard or not to find companies who would want to use Ca-carbonate and others processes/"value-added" by-products? What kind of governmental measures could help the process of network formation among companies?

Question 6: Please tell about profitability/cost efficiency of the project.

Question 7: What are the future prospects? How much do you plan to grow? How big is it possible to grow?

Question 8: Are there any similar circular economy or industrial symbiosis related projects in Estonia?

Appendix 2

Interview questions with Auvere Agropark representatives Teet Kuusmik and Nele Rogenbaum (conducted via e-mail)

Initial introduction and aim of the interview.

Question 1: At which stage is the Auvere Agropark project at the moment?

Question 2: What are the main challenges/difficulties you are facing?

Question 3: Are there any challenges that are due to non-supportive regulations?

Question 4: Do you believe the government should take a more active role in developing IS's? Why? What kind of measures would be the most effective?

Question 5: Is it rather hard or not to find companies to join the agro park? What could be done on the governmental level to make it easier/faster?

Question 6: Please tell a about profitability/cost efficiency of the project.

Question 7: What are the future prospects? How much do you plan to grow? How big is it possible to grow?

Question 8: Are there more industrial symbiosis projects in Estonia?

Appendix 3.

Interview questions with PAKRI Science and Industrial Park anonymous representative (partner at PAKRI Energy) (conducted via face-to-face meeting)

Initial introduction and aim of the interview.

Question 1: At what stage is the PAKRI project currently?

Question 2: How many companies are currently consuming the renewable sources electricity produced in PAKRI?

Question 3: You mentioned that the development is currently on hold or stalled. What are the reasons for this besides the increase in energy prices?

Question 4: Should the state intervene more and support the creation and development of circular and symbiotic systems in Estonia through various measures?

Question 5: You mentioned a change in the Electricity Market Act. Is it understood differently by different parties?

Question 6: Should the state then better formulate this law or add more information to make its implementation better and unambiguously understandable?

Question 7: How cost-effective and profitable is PAKRI as a company?

Question 8: Who pays for the mentioned support (aid) for renewable energy?

Question 9: What are the future prospects for energy part of PAKRI? How big do you plan to grow or how big is it possible to grow?

Question 10: Are there any other major symbiotic projects in Estonia that deal with, for example, sharing renewable source electricity?

Appendix 4.

Interview questions with PAKRI Science and Industrial park representative Jana Varimaa (conducted via phone call)

Initial introduction and aim of the interview.

Question 1: At what stage is the PAKRI project currently?

Question 2: How many companies have currently joined?

Question 3: What are the current general difficulties or challenges?

Question 4: Is it difficult to find new customers?

Question 5: Are any difficulties/challenges related to the lack of supportive regulations/policies? For example, tax incentives could be provided for companies that connect to the renewable energy distribution grid.

Question 6: Please talk a little about the cost-effectiveness and profitability of the project.

Question 7: Please describe how the joined companies are interconnected, what material flows exist.

Question 8: What are the future prospects of the PAKRI Science and Industrial Park? How big do you plan to grow? How big is it possible to develop?

Question 9: Are there any industrial symbiosis projects in Estonia (that may be in the early stages and have not yet reached the media)?