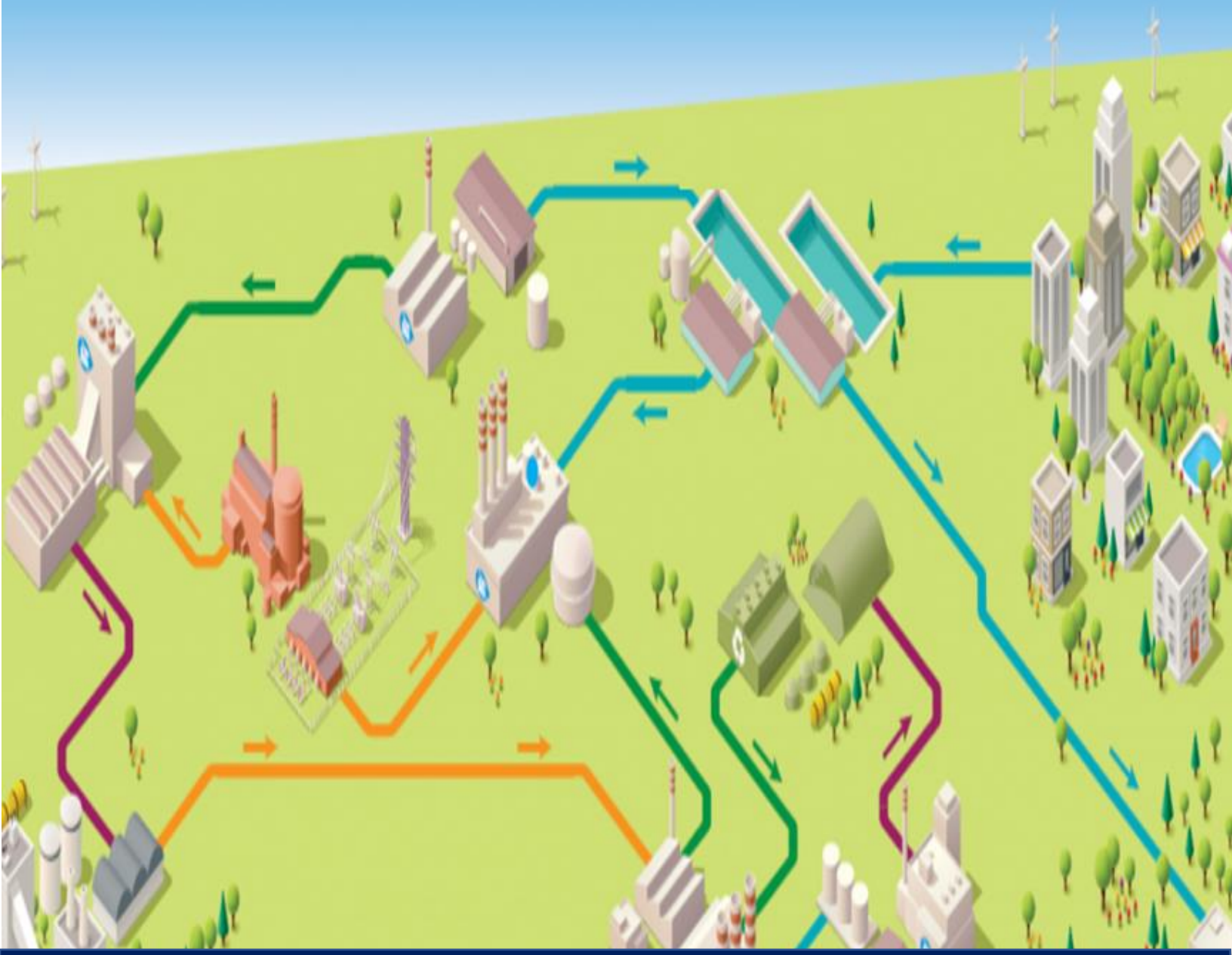
Creating Synergies in Eco-Industrial Parks in the Netherlands: A Refined Framework Through a Cross-Case Analysis



Carlos Enrique Valladolid Calderón

TU Delft

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Carlos Enrique Valladolid Calderón
Student Number: 4947401

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Graduation Committee

Chairperson : Dr. G. van de Kaa, Section Economics of Technology and Innovation
First Supervisor : Dr.ir. Jaco Quist, Section Energy and Industry
Second Supervisor : Dr.ir. Gijsbert Korevaar, Section Energy and Industry

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Executive summary

The Netherlands is aiming for a circular economy. To transition to a circular economy, eco-industrial parks (EIPs) are needed. The problem is that developing EIPs is not easy. Many industrial parks aiming to become more sustainable and transform into EIPs have failed.

In the Netherlands, industrial symbiosis, which is the most important aspect of EIPs, is not common. However, some EIPs in the country have successfully implemented industrial symbiosis and utility sharing activities. Studying what these successful EIPs have done to implement utility sharing and industrial symbiosis activities is relevant to understand what can be done in other EIP developments to increase their likelihood of success.

The literature revealed some gaps that need to be addressed regarding EIPs. There is little literature on EIPs in the Netherlands, and most of the existent literature regarding the success factors and barriers to creating synergies in the Netherlands is old. Besides, there is no literature on some EIPs. This study fills the gaps by updating what is happening at three front-running EIPs in the Netherlands and what are the success factors and barriers that played a role in the implementation of synergies.

Therefore, the main research question for this study is: *What are the main factors that influence the implementation of industrial symbiosis and utility sharing in front-running eco-industrial parks in the Netherlands?*

Three successful parks in terms of industrial symbiosis and utility sharing were studied using the framework of Eilering & Vermeulen (2004) to answer this question. The selected front-running EIPs were InnoFase in Duiven, Industrial Park Kleefse Waard in Arnhem, and Biopark Terneuzen in Zeeland. A cross-case analysis was made between the three EIPs.

In total, nine main factors and 64 sub-factors were found as relevant to implement industrial symbiosis and utility sharing when developing an EIP. The nine factors are:

1. Vision and ambition: What the park wants to achieve. The vision of sustainability guides the whole project.

2. Location-specific physical features: Refers to the park's physical characteristics where industrial symbiosis and utility sharing activities occur. Physical characteristics are defined by the type of companies, layout, and resources available at the park.

3. Location-specific social features: Refers to the social context of the park. A favorable social context includes awareness of neighbor activities, a sharing culture, easy communication, trust and knowledge sharing between companies.

4. Business-specific features: The characteristics of the companies inside the park. Companies should be entrepreneurial, with financial capacity, willing to commit and innovate, disposed to make long-term investments, big-sized and with a lot of residues.

5. Proposed measures: Measures chosen to implement at the park. Opportunities can be identified by companies, research institutions, government, or consultancies.

6. Policy instruments: Tools used to support the implementation of synergies such as regulations, subsidies, promotion, a facilitator and park policies.

7. Organisation of decision-making: The way in which the process to make decisions is organised.

8. Project economic features: Economic impact of the project on the company. A proposed synergy project must have beneficial economic features to move forward.

9. External context: Play an indirect effect on synergy implementation. External context includes the sustainability importance given by society, market conditions, public opinion and human capital.

Key findings also include the industrial symbiosis and utility sharing activities at InnoFase and IPKW. InnoFase is engaged in many industrial symbiosis activities by exchanging different types of flows such as biomass, biogas, water, electricity and heat with other synergies in development. IPKW has mainly utility sharing activities with Veolia supplying the necessary utilities to the entire park through their gas-fired powerplant and wastewater treatment plant. There are other smaller flow exchange activities that include plastic, biomass, and wood reuse by some companies at the park.

Finally, this study also allowed to give some recommendations to the developers of EIPs to have a more likely success in the implementation of utility sharing and industrial symbiosis activities.

Recommendations for EIP developers

- Develop a future map with all the possible stream connections to guide every actor involved.
- Visit a successful EIP to motivate involved actors to participate in synergy projects.
- Search for companies that complement each other's processes and have similar sustainability ambitions.
- Only locate companies with an entrepreneurial mindset, financial capacity, willingness to participate in synergy projects, and disposed to make long-term investments
- Only locate companies that support the concept of circularity.
- Only companies that generate/demand a huge amount of residues should participate in the exchanges.
- Keep in mind that companies will only participate in synergy projects that have a business case.
- Involve a facilitator that enables a social context and strengthens ties in the network with interactions between actors.
- Enable a supportive social context for synergies to occur with increased awareness of neighbor activities, a sharing culture, trust, easy communication, constant contact and knowledge sharing between companies.
- Involve a facilitator that supports with feasibility studies and technical implementation of synergies.
- Involve research institutions to find more opportunities for exchanges.
- Get a company or body that leads the EIP project in terms of vision and strategy.
- Bring all the decision-makers of companies or government to one table to discuss the projects and keep the momentum.
- Consider the interests of every stakeholder during the planning phase of the projects to avoid future problems.

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1. Introduction

1.1 Background

The concept of sustainable development was introduced in 1987, which refers to *"a development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission On Environment and Development, 1987; as cited in (Le Tellier, 2019). In other words, sustainable development aims to conserve and utilise material, water and energy resources as efficiently as possible (UNIDO, 2017).

The current socio-technical regime of production does not support sustainable development. The current regime consists of Industrial parks, which are industrial activities gathered in a specific area (Massard, Jacquat, & Zürcher, 2014).

Industrial parks demand a lot of energy and raw materials and generate industrial discharges for their production (Massard, Jacquat, & Zürcher, 2014). Hence, industrial parks bring environmental and economic risks, such as scarcity of non-renewable resources, emissions to the environment, climate change, and biodiversity loss (Erkman, 2001).

Today, the number of industrial parks in the world could be more than 20,000 (Sakr, Baas & Huisingh, 2011). In the Netherlands, there are around 130 (UNEP, 1996, as cited in Sakr, Baas & Huisingh, 2011). The Netherlands is a highly industrialised country and therefore generates considerable harm to the environment. The industrial park's occupation of the Netherlands is around 2% of the country's land (580 km^2 in 1994) and land occupation by industrial parks is expected to grow 1.5% every year (Lambert & Boons, 2002).

In many countries, industrial parks have not addressed the environmental issues accordingly (Sakr, Baas & Huisingh, 2011). However, The Netherlands is one of the countries with sustainability concerns brought by industrial parks and has transition ambitions for sustainable development (Smith, VoB, & Grin, 2010).

The Netherlands aims to establish a Circular Economy (CE) where the traditional linear economic system changes to a circular economic system with closed-loop production patterns (Le Tellier, Berrah, Stutz, Audy, & Barnabé, 2019).

Now the country has a programme called "*A circular economy in the Netherlands by 2050*". This programme is expected to accomplish goals such as reduced consumption of natural resources, sustainable resource extraction, less waste, fewer emissions, more natural capital, more earning power, and more jobs (Potting, Hekkert, Worrell, & Hanemaaijer, 2017).

Industrial Symbiosis (IS) and eco-industrial parks (EIPs) are needed to accomplish a transition to a CE (Saavedra et al., 2018) and to establish sustainable development (Heeres, Vermeulen, & De Walle, 2004). The relation between CE, IS and EIPs is shown in Figure 1.1.

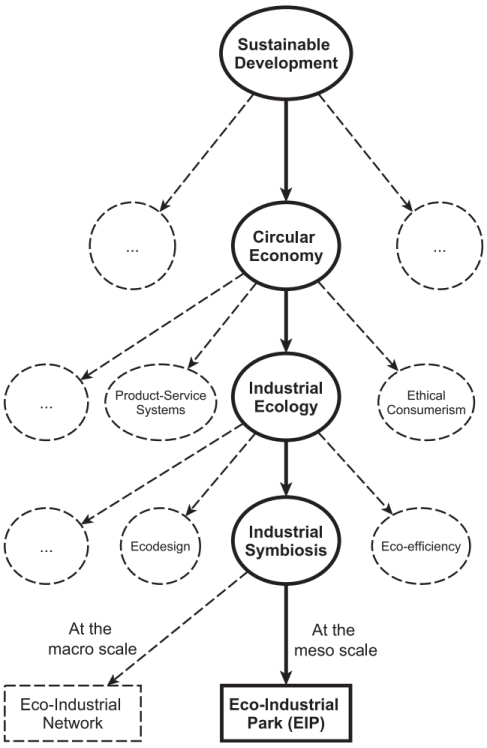

Figure 1.1: Position of the EIP concept (Le Tellier et al., 2019).

EIPs are industrial parks that considerably reduce companies' environmental footprint by reusing and recycling waste generated in production processes through collaboration. Besides, EIPs also bring economic and social benefits (UNIDO, 2017).

The implementation of EIPs is increasing due to the threats that industries cause to climate change (Sakr, Baas & Huisingh, 2011). The Netherlands is one of the countries in Europe that has put more emphasis on the development of EIP (Gibbs & Deutz, 2007). However, replicating the positive results of the EIPs such as the one in Kalundborg, Denmark, is not easy. Mostly because what was created organically is very difficult to replicate and accomplish with planning (Eilering & Vermeulen, 2004).

1.2 Problem statement

Numerous projects of developing EIPs have failed or have abandoned the objective of becoming an EIP (Sakr, Baas & Huisingh, 2011). Although the Netherlands has paid more attention to EIPs, there is a gap between sustainable principles in theory and practice in EIPs (Louw, 2017). Even though companies and authorities desire to implement sustainable activities in industrial parks, the implementation is slow and only has a marginal effect (Lambert & Boons, 2002).

In the Netherlands, industrial parks continue to be the mainstream strategy for development and the transition to eco-industrial parks is far. Even though the most important feature of EIPs is the exchange of flows and materials, the reality is that it does not frequently happen in the Netherlands (Gibbs & Deutz, 2007; Heeres et al., 2004; Louw, 2017).

Exchanges of flows are not frequent because it is difficult to convert abstract principles such as industrial symbiosis into operations (Louw, 2017). As explained by UNIDO (2017), practice in EIPs does not match the ambition.

Therefore, it is relevant to study the parks in the Netherlands where an exchange of flows has been successfully implemented. The best practices to achieve industrial symbiosis and utility sharing that led to the success of EIPs can be replicated to other parks.

1.3 Scope of the study

This research focuses on eco-industrial parks in the Netherlands. There are two main reasons for this. First, the Netherlands seeks a transition to a CE and the EIPs are necessary for it, which makes the topic particularly relevant. The second reason is accessibility to interviewees related to the parks because the researcher is living in the Netherlands.

The sustainable activities that are relevant for this study are industrial symbiosis and utility sharing, which need the collaboration of companies to happen. Utility sharing is the joint supply of resources (i.e. collective purchase or generation of energy) or waste processing (i.e. collective wastewater treatment plant). Industrial symbiosis refers to the exchange of residual flows between companies to be reused for another process. Utility sharing and industrial symbiosis are also known as synergies.

Three front-running EIPs that achieved industrial symbiosis and utility sharing activities in the Netherlands were selected to study (InnoFase, Industrial Park Kleefse Waard, and Biopark Terneuzen). The criteria for the selection of the cases can be seen in Chapter 3: Methodology.

1.4 Research objectives

This research aims to fill in the gaps found in the literature. Firstly, it expected to update and more clearly define the success factors and the barriers to implementing industrial symbiosis and utility sharing in EIPs in the Netherlands.

The second objective is to update and enlarge the literature available by finding the state-of-the-art of the selected EIPs in the Netherlands. An update is done by explaining what industrial symbiosis and utility sharing activities are happening today at each of the studied parks.

Thirdly, a cross-case analysis of the selected parks allows finding recommendations for the key developers of EIPs such as park managers, companies, and government. This study aims to facilitate the implementation of industrial symbiosis and utility sharing in other parks by understanding what led the selected cases to their success. With these recommendations, EIP developments may have a more likely success in becoming more sustainable and circular.

1.5 Research question and sub-research questions

- The main research question for this study is: *What are the main factors that influence the implementation of industrial symbiosis and utility sharing in front-running eco-industrial parks in the Netherlands?*

The sub-research questions to support finding the answer for the research question are:

- What factors influence the implementation of industrial symbiosis and utility sharing in eco-industrial parks according to the literature?

- What are the industrial symbiosis and utility sharing activities happening at front-running eco-industrial parks in the Netherlands?

- How can developers facilitate the implementation of industrial symbiosis and utility sharing activities in eco-industrial parks in the Netherlands?

1.6 Relevance of the study

1.6.1 Scientific relevance

Dutch EIPs have not been studied recently. This study gives empirical novelty about the state-of-the-art of the front-running eco-industrial parks in the Netherlands by finding what activities of industrial symbiosis and utility sharing are happening at these parks. This study contributes by studying three parks in the Netherlands, InnoFase, Industrial Park Kleefse Waard and Biopark Terneuzen.

Furthermore, the study finds what factors influenced the success of utility sharing and industrial symbiosis at these front-running parks and what barriers were found on the way to its success. Barriers to realising industrial symbiosis and utility sharing need to be more clearly defined. Most of the literature focuses on the success factors.

Besides, this study does a cross-case analysis. This allows for having more generalisable findings than a single case study and gives the possibility to apply the recommendations to other eco-industrial parks in the Netherlands. This study allows replicating some of these parks' practices to have a more likely success in developing other EIP projects.

1.6.2 Practical relevance

The implementation of innovative production processes such as industrial symbiosis and utility sharing is complex and, in many cases, fails. People involved in developing EIPs can benefit from this study by knowing what factors contributed to front-running parks' success.

This study gives a list of the relevant factors that EIP developers must consider and some recommendations to have a more likely success of synergy implementation. Therefore, developers can focus their efforts on the success factors and create the same conditions that have already worked in other cases. Besides, developers can pay attention to barriers faced by developers of the studied parks and try to find a solution before the implementation process starts.

This study has managerial relevance because implementing industrial symbiosis and utility sharing is a decision taken by managers of companies or managers of EIPs. These people are the ones that overview the entire innovation and implementation process, which is in most cases new for them.

People that benefit from this research directly include the developers of EIPs and the developers of synergies inside the park. These include managers of firms located at EIPs, managers of EIPs, facilitators such as consultancies, and governmental actors.

In other words, this study is helpful so developers have a more likely success in implementing industrial symbiosis and utility sharing activities in EIPs in the Netherlands.

1.7 Report content structure

Chapter 1: Introduction: problem statement, scope of the study, research objectives, research questions and relevance of the study

Chapter 2: Literature review: on eco-industrial parks, eco-industrial parks in the Netherlands, industrial symbiosis

Chapter 3: Methodology: research method and design

Chapter 4: Results: findings for each of the three cases

Chapter 5: Cross-case analysis: findings of the three cases are compared

Chapter 6: Discussion: interpretation and framework reflections, limitations, scientific contribution, practical relevance, future research

Chapter 7: Conclusion: an overview of the answers to the research questions and recommendations

2. Literature review

Relevant literature for this study is reviewed in this chapter. The literature review starts with the selection criteria for the sources. Then, relevant literature about eco-industrial parks, industrial symbiosis and the most important elements of an EIP are explained. The literature review continues with the relevant success factors and barriers to IS in EIPs. Finally, the literature review addresses EIPs in the Netherlands and success factors and barriers found specifically in Dutch EIPs. This section ends with an overview of the gaps found in the literature review.

2.1 Selection Criteria

Most of the literature sources were retrieved from Google Scholar and Scorpus, mostly from peer-reviewed journals. Sources mainly were obtained from English articles. The resulting papers were selected based on the title, abstract, and relevance to the research.

Three approaches were used for the selection of papers.

- Firstly, relevant papers were identified based on prior knowledge obtained from some recommended sources by an expert.
- Secondly, some papers were retrieved from the most relevant and cited papers about EIP found on Google Scholar and Scorpus, as shown in Appendix A.
- Thirdly, relevant sources mentioned in previously identified sources were also included

There are several terms used as synonyms for EIPs such as eco-industrial networks, eco-industrial development, networked eco-industrial parks, integrated eco-industrial parks, industrial ecosystems, and industrial symbiosis (Massard et al., 2014; Tudor et al., 2007).

Even though there are differences between the terms, some authors point out that other terms may be used as synonyms for EIP. Roberts (2004) says that green industrial parks are also used as a synonym for EIP. Massard et al. (2014) state that the term integrated eco-industrial parks and the term eco-innovation park may be considered as synonyms for EIP too.

Pellenbarg (2002) specifies that EIPs are also referred to as eco-industrial sites, eco-parks, or sustainable business sites. Baas (2008) states that industrial sites that are developed with industrial symbiosis may also be labeled as EIP.

Louw (2017) says that in the Netherlands, one rarely finds the term of EIP. Instead, the term sustainable business estate is more common.

Considering these synonyms for EIP and that the focus of this literature review is to find information about the development of EIP in the Netherlands, the different synonyms of EIP were used as keywords together with the words "Netherlands" or "Dutch" or "Holland".

The combination of keywords and results of the searches can be seen in Appendix A.

2.2 Industrial symbiosis

It is important to highlight that industrial symbiosis (IS) is the most important aspect of EIPs (Gibbs & Deutz, 2007). A very cited definition of IS is given by Chertow (2000): *"Industrial symbiosis engages*

traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products."

Sustainability with cleaner production and resource savings is achievable with two different approaches at the industrial parks:

1. Improving resource efficiency at individual companies.

2. Increasing efficiency at a park level by managing material, energy and water flows collectively through industrial symbiosis (UNIDO, 2016a; as cited in UNIDO, 2017).

According to Lambert & Boons (2002) and UNIDO (2017), there are three sustainable opportunities to collectively manage the park's physical flows.

1. Collective setting of utilities: pooled use and management of resources. Companies share utility infrastructures to collectively generate or purchase energy (e.g. steam, electricity, heat, gas, hydrogen).

2. Collective processing of waste streams: companies collectively recollect, process, recover or treat waste. An example is to recover water with a wastewater treatment plant (Chertow, 2008; Eilering & Vermeulen, 2004; Maes, 2011; Spekkink, 2013).

3. Mutual exchange of materials and energy: using disposed waste (solid, liquid, gas) from one company by another company to provide a product with value.

Other sustainable opportunities to manage flows collectively can also be found outside the boundaries of the park.

4. Applying residual products from remote companies.
5. Delivering residual products to remote companies.

The opportunities for flow exchanges inside and outside the park are shown in Figure 2.1.

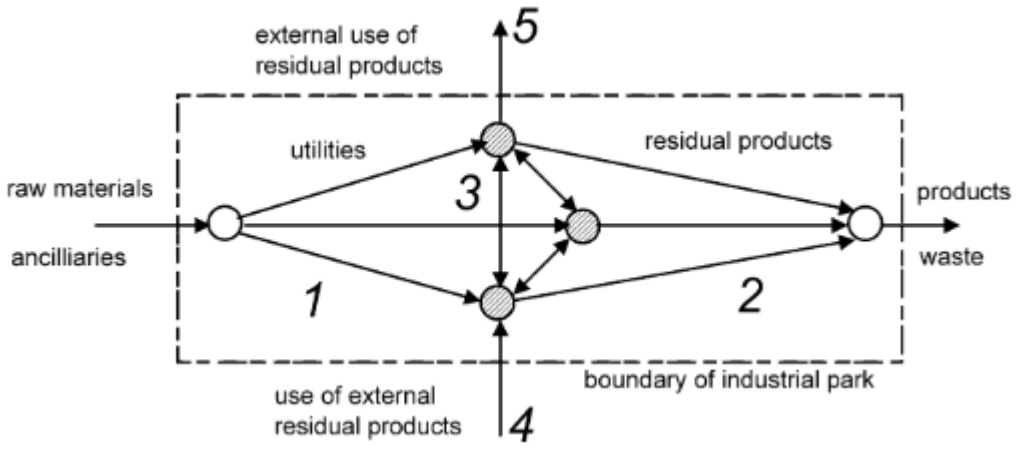

Figure 2.1 Industrial symbiosis (Lambert & Boons, 2002).

This study will focus on the first three points, collective setting available of utilities, collective processing of waste streams and mutual exchange of materials and energy.

2.3 Eco-industrial parks

A business park refers to designated areas by the local, regional and national governments to accommodate several companies that produce, transfer goods, store goods, or provide services (Snep, 2009). The business parks can be classified into industrial parks, mixed business parks, distribution areas, and seaport areas (IBIS 2001, as cited in Snep, 2009). Other words used for business parks are business sites, industrial sites, or industrial estates (Frej et al., 2001; as cited in Snep, 2009). Business parks should not be confused with office sites, where work is focused on administrative processing or commercial areas where companies sell products and services instead of producing, storing, or transferring goods (Snep, 2009).

An eco-industrial park is defined by Lowe (2001) (as cited in UNIDO 2017) as "*a community of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues.*"

EIP mainly refers to the exchange of resources between heavy industries in industrial complexes. However, the concept of EIP has extended to mixed industrial parks, which is another type of relevant industrial parks, but mainly formed by small and medium-sized enterprises and sometimes complemented by larger industries (Lambert & Boons, 2002).

Chertow (2007) says that an EIP is a manifestation of IS. EIPs seek a collective benefit greater than the sum of the individual benefits each company would get by performing individually (Chertow, 2007; Roberts, 2004). In other words, there needs to be a collective and collaborative behaviour between firms to be considered an EIP (Gibbs & Deutz, 2007). The term EIP should only apply to the parks where there are interactions between the companies (RTI, 2001; as cited in Gibbs, 2003).

Activities that do not require cooperation, such as pollution prevention measures, energy efficiency measures, green architecture and resource recovery, may be found in an EIP. However, an EIP needs inter-organisational networking, exchanges or resource partnerships among the tenants in the park (Adamides et al. 2009; as cited in Massard et al., 2014; Gibbs & Deutz, 2007).

Industrial parks need a transformation to manage their waste and resource consumption to become EIPs. Solutions include the exchange of waste materials, process integration with heat integration or water cascading (Lambert & Boons, 2002).

The exchange of energy and water between the companies or connecting material flows of production processes is not the only way to make a park more sustainable (Lambert & Boons, 2002; Pellenbarg, 2004). Other types of synergies and collaborations, such as utility sharing or joint provision of services, can occur (UNIDO, 2017).

It is important to highlight that due to the lack of methods to measure accomplishments, it is challenging to recognise when a park becomes an EIP (Massard et al., 2014).

Transforming industrial parks into EIP brings environmental, economic and social benefits, as shown in Table 2.1.

Table 2.1: Benefits of EIPs (Atwa, Ibrahim, & Saleh, 2017).

Environmental	Social	Economical
Reduce energy, raw materials and resoruce consumption	Show social and environmental commitment	Reduce operational, production, and disposal costs
Healthier working environment	Attract talent	Avoid environmental taxes and penalties
Incease energy independence	Promote local employment	Business efficiencies
Recycling, revalorization, elimination of waste products	Image of responsible and sustainable company	Innovative and sustainable investments can be financially supported
Reduction of emissions of greenhouse gases and other polluting gases and substances	Expand local business opportunities	For a large number of sustainable technologies, investments are paid back even in the short term
Protection of the local environment via site design	Partnership with businesses	Excess energy as export product
Efficient movement of people and goods	Good jobs, larger tax base	New initiatives possible
Efficient energy usage in operations and reduced emissions	Enhance quality of life in areas near the development	Income from sale of by-products
Efficient water usage and protection of freshwater resources	Positive impact on employee health	Positive impact on productivity
Provision of reserves, tracks, etc	Community pride	Enhance corporate image

2.4 Types of EIPs

According to Chertow (2007), an EIP can happen in two primary organisational forms:

- Planned EIP model (top-down): companies from different industries are deliberately identified to be located together to share resources between them. This model is mostly initiated and supported financially by the local or regional government.

- Self-organising model (bottom-up): emerges due to the motivation of private actors to exchange resources and accomplish cost reduction, revenue enhancement, or business expansion. The government may act as a facilitator and implement policies to try to encourage the uncovering of the IS. This model seems to be more successful than the planned EIP model.

Lambert & Boons (2002) categorise EIPs in new or existing developments:

- Greenfield projects: new park developments that follow specific pre-formulated requirements.

- Brownfield projects: refer to existing developments that address the restructuration of an already existing industrial park.

2.5 Key actors and stakeholders of an EIP

There are many participants and stakeholders involved in the development of industrial symbiosis and utility sharing in EIPs.

Research and education institutions: Critical for initiating an IS process (Behara et al., 2012; as cited in Mortensen and Kornov, 2019). They provide help with technical development or other assessments (UNIDO, 2017). They provide information and knowledge into the network and prevent misunderstandings caused by asymmetric information among stakeholders (Panyathanakun et al., 2013; as cited in Mortensen and Kornov, 2019). Research institutions also support knowledge capacity building (Costa & Ferrao, 2010).

Public bodies: Public bodies such as regional and local governments support the innovation process by helping companies, accessing knowledge, fostering engagement and promoting symbiotic thinking among actors (Valentine, 2016; as cited in Mortensen and Kornov, 2019). They set environmental standards and create policies for a supporting institutional framework (UNIDO, 2017). Public bodies can facilitate contact between different actors or even become a champion for forming collective synergies. The public bodies can also function as a bridge between companies and the national government (Costa & Ferrao, 2010).

Companies: Tenants of the park who operate and manufacture products and provide services in the park (UNIDO, 2017). These may innovate their production processes with IS. Companies that participate in the process should have a symbiotic mindset, proactive attitude, high motivation, and willingness to invest their resources and engage in new relations (Mortensen and Kornov, 2019).

Associations: Represent the interests of a group of stakeholders (e.g businesses, environmental organisations). The associations play an active role as a coordinator to foster interactions between the companies, government and community (Mortensen and Kornov, 2019).

Private organisations: Support the development of the park (e.g. management and technical consultancies). They advise implementing synergies in an EIP, such as calculating the new business models due to the synergies (Mortensen and Kornov, 2019).

Coordinator or a facilitator: This is the most mentioned actor in the literature. This role can be filled by an individual, an organisation, or a network of actors. The coordinator or facilitator activates the exchange of knowledge and relational resources among the actors by organising interaction. They are responsible for building the capacity (knowledge, relational, mobilisation) of actors, so industrial symbiosis or utility sharing occur (Mortensen and Kornov, 2019).

Park management: Maintain the parks' common facilities and functions as a coordinator (UNIDO, 2017).

Champions: Academic researchers, company managers, anchor organisations, company owners, or individuals may have a relevant role in acting as champions because they can connect different projects and actors (Mortensen and Kornov, 2019). They may engage in awareness-raising initiatives and influence EIP strategies' development by motivating industry partners from the network to participate in the project (UNIDO, 2017).

Financing institutions: Support companies and the park by providing funds to develop new projects (UNIDO, 2017).

Common service providers or park operators: Offer a joint infrastructure for companies inside the park (e.g. waste management) (UNIDO, 2017).

Local community members: Care about the impact of the park in their community (UNIDO, 2017).

NGOs: May act as facilitators in the development process (e.g. providing technical assistance) (UNIDO, 2017).

2.6 Context of EIPs

Synergy initiatives depend on the context in which they occur (Costa & Ferrao, 2010). The context influences the actors' opportunities and actions (Spekkink, 2013). Therefore, It is important to understand the local and national context of EIPs, including regulations and policies (UNIDO, 2017).

Synergies are often formed spontaneously between industries; however, an enabling context favours the condition for creating synergies. Thus, it is necessary to influence contextual factors to give support and stimulate the creation of synergies among companies (Costa & Ferrao, 2010). EIPs and IS initiatives cannot be implemented without structural and regulatory support and proper local institutional structures (Opuku, 2004; as cited in Gibbs & Deutz, 2007).

The external context is formed by the opportunities and constraints caused by policies and regulations, economic factors, market factors, social practices, cultural norms, technical conditions and other actors' actions (e.g. competitors) embedded in a geographical setting that influence decisions made by firms (Costa & Ferrao, 2010; Yap 2017).

The framework by (Yap, 2017) shown in Figure 2.2 considers IS as the consequence of a network of different actors influenced by the external context.

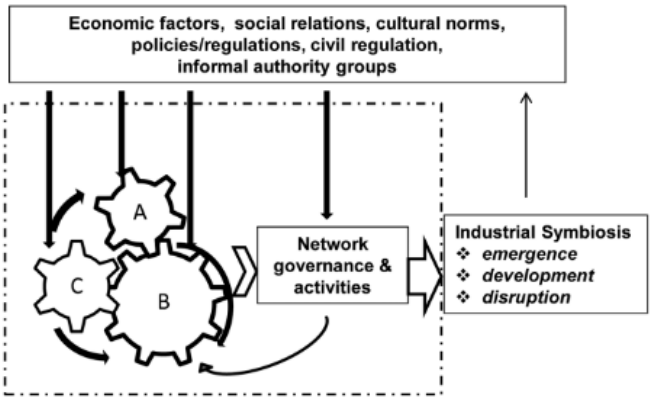

Figure 2.2: Framework by Yap (2017).

The involvement of the government is necessary to create the right institutional conditions for the creation of collaborative behaviour and inter-firm networking (Boons, 2012; Gibbs & Deutz, 2007). The government cannot force companies to cooperate with other companies, but they can create adequate market conditions, favorable regulations and policies, and foster knowledge so IS activities can occur (Le Tellier et al., 2019; UNIDO, 2017).

Laws and regulations such as waste management laws, policies to incentivise product exchanges, or lifting restrictions on how to process certain waste, can provide support for developing industrial symbiosis and utility sharing (Sun et al., 2017).

The government may also provide research funds to examine the feasibility of synergy projects and provide economic and financial incentives such as tax relief for material exchanges (Gibbs, 2003).

Policies and regulations may act as a driver for resource efficiency with regulatory pressure on companies (Boons, Spekkink, & Mouzakitis, 2011). Regulations may include placing a limit on end-of-pipe emissions, taxes on transport and fuel, or increasing prices of pollution and landfilling (Doménech & Davies, 2011; Walls & Paquin, 2015)

On the other hand, regulations can also act as a barrier to synergies. Regulations may make by-products be considered waste and hence have disposal restrictions (UNIDO, 2017). Therefore, the government must ensure that the legislation does not hamper the creation of industrial symbiosis and utility sharing (Gibbs, 2003).

Inside the park, policy instruments may be used to limit the companies' environmental limits to ensure that participants comply with the proposed sustainable measures. Also, tenants of the park that do not fit the company profile are rejected (Eilering & Vermeulen, 2004).

2.7 Location-specific features of EIPs

The location-specific features refer to the park's characteristics where industrial symbiosis and utility sharing activities take place (Eilering & Vermeulen, 2004).

It is not possible to implement all the designed sustainable measures in all parks. The park's specific features such as geographical location and availability of resources as water and energy, size, number of companies, type of industries contained, and social relations in the complex are decisive for the success of industrial symbiosis and utility sharing (Boons, Spekkink & Mouzakitis, 2011; Eilering & Vermeulen, 2004; Simboli, 2014; UNIDO, 2017).

A distinction can be made between the physical features and social features of the park. If either the physical features or the social features are missing, there will be no industrial symbiosis or utility sharing (Eilering & Vermeulen, 2004).

Location-specific physical features

A vital characteristic needed for industrial symbiosis is that firms need to have complementary needs for residual flows, energy, or water. A high diversity of firms increases the chance of achieving symbiosis. However, a very high diversity of companies may also lead to many different interests, strategies and preferences and hamper the creation of exchanges. Also, if the companies are very different and from other sectors, dependencies may form (Eilering & Vermeulen, 2004).

Simboli (2014) remarks that in some industries such as the chemical, homogeneity of companies has some advantages on developing industrial symbiosis. However, heterogeneity of companies increases the chance of finding suitable partners to exchange streams.

Diversity of companies is not an issue for utility sharing because companies have similar demands and supplies for resources (Eilering & Vermeulen, 2004).

Also, the distance between companies plays a role in the creation of synergies. The distance must be short (Eilering & Vermeulen, 2004).

Location-specific social features

Spekking (2013) says that social aspects such as trust and cooperation are key to the success of industrial symbiosis. Chertow (2007) says that collaboration is necessary for industrial symbiosis to emerge.

Industrial symbiosis emerges through interactions, exchange of information about processes, exchanging visions on problems and solutions, exchanging knowledge, and trusting. Through these activities, the awareness of possible cooperation occurs, improving motivation and ties between actors (Spekkink & Boons, 2016).

Social ties are important for network formation. Interactions foster social ties such as trust development, mutual understanding, and commitment (Spekkink & Boons, 2016). Besides, a common culture, a shared vision (Spekkink, 2013) and a short mental distance may be formed (Mortensen and Kornov, 2019). Strong social ties are characterised by trust, fine-grained information transfer, and joint problem-solving (Doménech & Davies, 2011). If actors influence other actors' behavior it means that the social ties are strong. Building strong ties among actors is a long-term process (Walls & Paquin, 2015).

According to Eilering and Vermeulen (2004), important social and relation features that must be present for a successful implementation of synergies include:

- Companies must trust each other
- There must be an "anchor" company that attracts other companies (e.g. a power plant).
- There must be a pioneer that has initiative and confidence in the project.
- The mental distance of companies must be short
- There must be a core group of companies with a distinct environmental profile
- Companies must have a high degree of organisation

2.8 Business-specific features

The specific features of the companies involved are also relevant (Simboli, 2014). The business-specific features refer to the characteristics of the companies located in the park (Eilering & Vermeulen, 2004).

Each firm inside the park has different characteristics and features that are decisive for developing synergies. These individual characteristics of the actors also influence the development of sustainable activities inside the park.

- Companies must have the same quantity of demand and supply for IS to work (Eilering & Vermeulen, 2004)
- The quality of demand and supply must also be the same (Eilering & Vermeulen, 2004)
- Companies must have money to invest in infrastructure and technology because IS requires huge investments (Corder, 2014; Massard et al., 2014).

2.9 Vision and ambition

Having a clear vision of what is expected of an EIP is important (Eilering & Vermeulen, 2004). Creating a shared vision to create a common identity among the participants is crucial for the development of IS (Walls & Paquin, 2015).

According to Jackzo et al. (2019), the vision does not need to be formally documented in the planning phase. It is enough if it is verbally agreed as long as the actors involved are guided. Formal procedures in an early stage may hurt companies' interest due to the unnecessary time and effort needed for its development. However, as the sustainable innovations diffuse and interventions scale up with a larger stake, actors must put a shared vision with a more formal procedure.

The level of ambition is influenced by the vision of sustainability that is sought. Ambition refers to the initial ideas and goals that developers aim to achieve and how sustainable the actors want to become.

Sustainable activities may be targeted at individual companies (low ambition), achieving utility sharing (average ambition) or realising utility sharing and IS (high ambition) (Eilering & Vermeulen, 2004). It is important to have a clear collective ambition that participants agree on in the planning phase (Jackzo et al., 2019).

2.10 Organisation of decision-making in EIPs

Several actors and stakeholders are involved in an EIP. Therefore, It is important to consider who takes the project's leadership and how the decision-making process is organised.

The decision-making process can be organised top-down or bottom-up. In a top-down approach, the government takes the leadership of the project and makes decisions without consulting the firms.

With a top-down approach, there is a risk that the companies do not support the sustainable development project of the park because companies are not consulted to make decisions. On the other hand, in a bottom-up approach, initiatives and leadership are taken by the firms. It seems that a bottom-up approach is more effective (Eilering & Vermeulen, 2004).

According to UNIDO (2017) there are different management models, which lead to different types of decision-making:

- *Government management model:* The government oversees the management of the EIP through a team designated by a national, regional or municipal authority (e.g trade ministry).
- *Mixed public-private management model:* The EIP is managed by the government with the help of a private contractor or an NGO. The partnership may be permanent or provisional.
- *Private company or individual management model:* Park management is made by a private operator. It is also possible that companies in the park organise themselves and create an association to manage the EIP. With this model, there is little or no intervention from the government.

2.11 Park management

In EIPs, the presence of park management is common. Park management performs different tasks in the park that vary from simple such as maintenance and cleaning services, to complex tasks such as coordinating the process for the creation of symbiosis (Pellenbarg, 2004).

Park management also translates the stakeholders' sustainable vision into actionable plans assuming a mediator's role between tenants and authorities (UNIDO, 2017). They are also responsible for promoting the park and convincing businesses to locate in the park (Maes, 2011). Park management can also determine the best location for newcomers considering the potential connections at the site (UNIDO, 2017) and assist newcomers with the settlement (Massard et al., 2014).

The park management participates in project development and new business models' development considering collaborations (Massard et al., 2014). The park management also fosters knowledge sharing, collaboration, and trust between actors and raises awareness of potential connections between tenants (Masasrd et al., 2014).

Furthermore, park management may also design the criteria to select new tenants (UNIDO, 2017). Maintenance of facilities and infrastructure and monitoring of the park to comply with standards may also be done by park management (UNIDO, 2017).

2.12 Facilitator

In literature, the need for a third party that coordinates, facilitates, supports, oversees, and encourages synergies development is constantly mentioned. The facilitator role may be taken by an individual, an organisation, or a network.

Facilitators may be industrial development authorities, municipalities (Gibbs, 2003), a pioneer firm of the park, a management body, an independent party, a consulting firm (Jackzo et al., 2019), a business association or a research institution (Mortensen and Kornov, 2019). Without a body that coordinates, it is hard to encourage sustainable innovations and develop industrial symbiosis and utility sharing in industrial parks (Jackzo et al., 2019; Lambert & Boons, 2002).

A facilitator is crucial to foster awareness, coordinating stakeholders, establish a social network, and monitor the outcomes. A facilitator contributes to acquiring knowledge, building relationships and mobilising actors. These are fostered with periodical meetings, events and workshops (Mortensen and Kornov, 2019).

Spekkink & Boons (2016) talk about bridging actors. There is a need for actors to realise that other actors are sharing a common ground with similar problems. Actors have a bridging position if they notice a shared common ground and access information from different stakeholder groups. These actors can assemble stakeholders into collaboration. Bridging actors are important for raising awareness of collective synergies (Mortensen and Kornov, 2019).

For IS to emerge, a space or platform for interactions and sharing of innovative ideas among actors is important (Mortensen and Kornov, 2019). These spaces foster the development of trust and joint-problem solving (Doménech & Davies, 2011; Jackzo et al., 2019).

At these platforms, potential participants can meet and share information. Here, participants can discuss and exchange thoughts about possible industrial symbiosis and utility sharing opportunities. Actors may become aware of IS opportunities by participating in these activities (Mortensen and Kornov, 2019). These interactions may also cause participants to spread the idea of engaging in industrial symbiosis and utility sharing activities to other actors (UNIDO, 2017).

2.13 Industrial symbiosis as a network

Companies are the ones who decide if the solutions for resource efficiency such as IS and utility sharing are implemented (Yap, 2017). However, the subject of analysis in an EIP is not a single company but a network of companies and actors (Gibbs, 2003).

Every industrial symbiosis system is a network of relationships and exchanges with constant interactions between actors (Walls & Paquin, 2015). Gibbs (2003) says it clearly "*The concept of eco-industrial parks has as its basis inter-firm collaboration and networking, based upon trust and reciprocal relations. Without these, an eco-industrial park does not exist* ".

In a network, new knowledge is produced, learning is shared and solutions to joint problems are found (Spekkink, 2013). Interactions also foster trust development, mutual understanding, and commitment (Spekkink & Boons, 2016).

Through collaboration, the network develops processes and products together, share costs, mitigate risks, and share information such as data of their resource utilisation, flow, and waste streams (Gibbs, 2003). Collaborations allow the actors to tackle more complex problems such as using resources more efficiently (Marques et al., 2011; Provan and Kenis, 2008; as cited in Wang, 2017). These interactions may result in finding new business opportunities such as industrial symbiosis and utility sharing.

2.14 Success factors for eco-industrial parks development

Some important elements in EIPs were mentioned already. However, there are several success factors mentioned in the literature.

Companies' primary motivation to develop EIP strategies is reducing expenses and increasing profits (Jacobsen 2006; Karlsson et al. 2008; as cited in Massard, 2014).

Support by the government with legislation that facilitates and supports EIP's development and operation is key (Gibbs & Deutz, 2007). Financial incentives also play a major role (Massard et al., 2014).

The involvement of economic players is one of the most important factors. Cooperation among the economic players and stakeholders and community support is also necessary (Heeres et al., 2004; Roberts, 2004).

A coordinator for the operation of the park is crucial. The coordinator must support stakeholders with different tasks such as risk analysis, information and training, marketing and communication, getting the required permits, monitoring, and maintaining infrastructures in good conditions (Massard, 2014).

There must also be expertise and know-how in cleaner production methodologies and industrial synergy concepts. For synergies to happen, knowledge is needed about the material and energy flows in the park and the information must be shared (Massard et al., 2014: UNIDO, 2017).

Expertise and know-how may be obtained in cooperation with research institutions (Massard et al., 2014: UNIDO, 2017). Cooperating with academia and research institutes is key to have access to knowledge (Costa & Ferrão, 2010).

Technologies are required to implement symbiotic exchanges. Technology is necessary to treat by-products to meet certain requirements to be converted and transported (UNIDO, 2017).

Issues like material and energy flow management or mobility and transportation should be considered since the planning phase. A geographical location that is close to a big city or has easy access to resource extraction or importation is an incentive for companies (Jensen et al. 2012; as cited in Massard, 2014). Being close to seaport, airport, highway, urban centers also make it more attractive for companies (UNIDO, 2017).

If the location houses several industrial sectors and economic activities, then the creation of symbiosis is more likely (Fiksel 2003; Korhonen et al. 2005; as cited in Massard, 2014). The diversity of economic activities in different sectors enables the opportunity to create large sets of feedback flows and more opportunities for industrial synergies (Massard et al., 2014).

The differentiation between an EIP to a regular industrial park has become a form of promoting the site. The name of EIP benefits the public image of the tenants of the park. Furthermore, the diffusion of successful EIPs and projects inside the EIPs stimulates private and public support for these developments (Massard et al., 2014). This may foster replication of best practices throughout cities and regions (Chertow 2007; Mathews et al. 2011; Park et al. 2008; Shi et al. 2012; as cited in Massard, 2014). Quantitative data about economic and environmental benefits may stimulate other companies to join EIP projects and exchange with other firms (Eilering & Vermeulen, 2004).

The implication of all stakeholders (including the local communities) during the planning process should be present (UNIDO, 2017).

Besides, feasible distances between the companies reduce transportation costs. Therefore, synergies occurring with companies outside the park are more affected and harder to achieve (UNIDO, 2017)

Access to financial resources is crucial because the implementation of synergies needs a high investment. This happens especially with shared utilities and shared infrastructure (UNIDO, 2017).

Finally, trust, openness and communication between the different actors are necessary to form collaborations (Baas & Boons, 2004; Chertow, 2007). The firms' culture is also important, because they may not be willing to participate in some activities. For example, a company may not be willing to cooperate with a consultancy firm (UNIDO, 2017).

A table summarising the factors mentioned by Massard et al. (2014) and UNIDO (2017) is shown below in Table 2.2.

Table 2.2: Description of success factors for EIPs (Massard et al., 2014; UNIDO, 2017).

Success factor	Description	Sources
Economic value added	The implementation of synergies needs a return on investment.	(Massard et al., 2014), (UNIDO, 2017)
Policy & regulation	Support by the government with legislations, policies and regulatory instruments is key. Example of policies include tax reduction and/or financial support.	(Massard et al., 2014), (UNIDO, 2017)
Coordinators	Setting up a coordinating body to act as a facilitator is important to support the implementation of opportunities. They are in charge of the coordination of stakeholders (e.g. risk analysis, information and training, marketing and communication, help for getting permits, maintenance).	(Massard et al., 2014),
Cooperation with Science and Technology institutions	Cooperation with universities, science and technology enterprises and research centers speeds up and facilitates the implementation of synergies by allowing access to new technologies and more knowledge.	(Massard et al., 2014),
Geographical factors and regional infrastructure	A location close to a big city or has easy access to resource extraction or importation is an incentive for companies. Benefitial locations include being close to seaport, airport, highway, urban centers, historical and natural conditions.	(Massard et al., 2014), (UNIDO, 2017)
Diversity of economic activities	Diversity of economic activities in different industrial sectors enables the opportunity to create large sets of feedback flows and more opportunities of symbiosis.	(Massard et al., 2014)
Clear designation of the park as eco-innovation park	The differentiation between an EIP to a normal industrial park has become a form of promoting the site. Being categorized as an EIP brings benefits the public image of the tenants in the park.	(Massard et al., 2014)
Implication of all stakeholders	The exclusion of stakeholders threatens the whole implementation process. Local commuities are often not considered, but should be included.	(UNIDO, 2017)
Viable technology and equipment	Technologies are required to implement industrial synergies. Technology helps to treat, process, convert and transport products.	(UNIDO, 2017)
Feasible distances	Low tansportation costs are key for establishing a synergy. Synergies outside the park are clearly more affected than internal ones.	(UNIDO, 2017)
Access to finance	Enough financial resources are crucial because cleaner production and industrial synergies need a high investment, especially the shared infrastructures and utilites.	(UNIDO, 2017)
Trust and enabling environment	Synergies and a cleaner production cannot be obtained without cooperation therefore, openness, communication and mutual trust is needed.	(UNIDO, 2017)

2.15 Barriers to the development of an EIP and IS

Walls & Paquin (2015) did a literature review on the barriers to IS and found the next ones:

- Power asymmetries
- Too much diversity
- Exit of a player
- Cost, risk
- Too restrictive environmental regulation
- Lack of trust
- Dependency
- Unaligned interests or goals
- Inadequate monitoring

Walls & Paquin (2015) concluded that the barriers for IS were often discussed in vague terms and were addressed only briefly. They found that barriers were described as too little or too much of a success factor in various sources. They also highlighted that barriers were too speculative with little empirical work.

Chertow (2000) says that projects that aim for exchanges may not happen because of risk or finance issues (Chertow, 2007).

Heeres et al. (2004) point out that according to the literature, the main challenge for the development of an EIP is the establishment of symbiotic exchange relationships between participant companies. Five barriers difficult the establishment of an exchange:

- Technical: An exchange is not technically feasible
- Economic: An exchange is economically risky or unsound
- Informational: Right people do not have the necessary information at the right time
- Organisational: The exchange may not fit the corporate organisational structure
- Regulatory/legal: Caused by the complexity of laws and regulations

Gibbs (2003) adds another barrier category:

- Motivational: Firms, public sectors, or other actors are not willing to cooperate and commit to the process

Corder (2014) identifies another type of barrier:

- Cooperation and trust: There is a lack of trust and therefore, parties do not cooperate

Companies normally do not have a prior relationship with the other firms in the parks. They only share geographical proximity and consequently have a lack of trust. In order to build links and cooperation among companies, trust needs to be present (Lambert & Boons, 2002).

Gibbs and Deutz (2007) say that a poor consideration of the companies' motivations and interests by the project leader conducts a lack of participation and hence, a failure of the EIP initiative.

Also, if companies are not interested in sustainability, then cooperation between companies to make exchanges will not occur. Small companies are less interested in sustainability and cooperating with other than large firms (Lambert & Boons, 2002; Jackzo et al., 2019)

Limited knowledge about the potential benefits is also a constrainer to the implementation of EIP projects (Massard et al., 2014).

The long time needed to build the infrastructure for an exchange, high investment costs, and uncertainties in the market may also hamper the development of IS (Lambert & Boons, 2002).

The lack of a facilitator is one of the biggest barriers to a sustainable business park transition. Collaborations between companies can still happen but are harder to develop (Jackzo et al., 2019).

Mapping and monitoring the flows and materials and energy between different companies are key for developing EIPs. If there is not enough data available for the physical flows, it is impossible to propose materials and energy exchanges (Lambert & Boons, 2002).

Besides, laws and regulations may also hinder the development of exchanges in an EIP (Bontje, 2004).

Also, if the park has a few material and energy flows there are fewer options to make by-product exchanges (Chertow, 2008; Jackzo et al., 2019). This problem is more common in small companies (Lambert & Boons, 2002).

Smaller businesses are mainly affected by financial, time, resource, and know-how constraints to engaging in industrial symbiosis and utility sharing. The lack of physical space is also a critical barrier for handling outgoing and ingoing waste material (Corder, 2014).

Bacudio (2016) listed the barriers to the implementation of IS in an industrial park, as shown in Table 2.3. Other authors such as Heeres et al. (2004), Gibbs (2003), and Corder (2014) also mentioned some of the barriers mentioned by Bacudio (2016). Barriers mentioned by other authors were also included.

Table 2.3: Barriers in implementing industrial symbiosis in an industrial park (Adapted from Bacudio et al., 2016).

Barriers	Description	Sources
Lack of trust among locators	Trust is a prerequisite of collaboration since most locators have minimal or no prior cooperative mechanism.	(Bacudio et al., 2016), (Corder, 2014), (Lambert & Boons, 2002)
Lack of information sharing among locators	Different stakeholder objectives can create conflicts between locators which results in limited sharing of inofrmation.	(Bacudio et al., 2016), (Heeres et al., 2004)
Lack of top management support	Current management practice of industrial plants have yet to include IS approach as part of their policy. Due to the large investments needed and the uncertainties in the market, EIP projects may be seen as risky.	(Bacudio et al., 2016), (Chertow, 2000), (Heeres et al., 2004), (Lambert & Boons, 2002)
Lack of training	Adopting IS requires knowledge in several aspects such as technical and organizational expertise.	(Bacudio et al., 2016)
Lack of policy to incentivize initiative of industrial symbiosis	Government policies (e.g., tax relief) should be put in place to stimulate as well as to regulate IS.	(Bacudio et al., 2016), (Heeres et al., 2004)
Lack of funds	There is lack of financial resources to cope with the high investment costs.	(Bacudio et al., 2016), (Chertow, 2000), (Heeres et al., 2004), (Lambert & Boons, 2002), (Gibbs & Deutz, 2007), (Corder, 2014)
Lack of technology and infrastructure readiness.	Sustainable by-product exchange requires well-built infrastructures.	(Bacudio et al., 2016), (Heeres et al., 2004)
Lack of an institutional support for integration, coordination and communication	Improper management of an IS network may inhibit its development. A lack of a coordinator difficult the development of IS and utility sharing.	(Bacudio et al., 2016), (Heeres et al., 2004), (Jackzo et al., 2019), (Walls & Paquin, 2015)
Lack of willingness to collaborate	Industrial plants must be open to form synergies and to adapt to structural changes.	(Bacudio et al., 2016), (Gibbs, 2003), (Louw, 2017), (Lambert & Boons, 2002), (Jackzo et al., 2019)
Lack of awareness of industrial symbiosis concepts and benefits	Insufficient understanding of IS or unawareness of its benfits is a reason for non-implementation.	(Bacudio et al., 2016), (Massard et al., 2014)

2.16 Eco-industrial parks in the Netherlands

2.16.1 Processes for EIP development in the Netherlands

In the Netherlands, the owner of the land is often the government. However, a company or a property developer may also be the owner of the land (Eilering & Vermeulen, 2004). This means that EIPs may be developed with a top-down or a bottom-up approach. Successful EIPs in the Netherlands have been developed with different approaches such as Moerdijk (top-down approach and later bottom-up) or INES in Rotterdam (bottom-up) (Susur et al., 2019a).

A top-down approach is mainly organised by the local government because they are in charge of most land development (Lambert & Boons, 2002 ;Louw, 2017; Pellenbarg, 2004). The local

government is involved in the development of greenfields and redevelopment of brownfields (Van Leeuwen et al., 2003).

In the Netherlands, consultancy agencies play an important role in the development because they support municipalities by transforming theoretical knowledge of the functionality of the EIP into practice. Consultancies also act as a mediator between the government, which initialises the idea and the EIP's potential participant companies (Van Leeuwen et al., 2003).

Since local governments act as land developers, it is usual that local governments also do the park management. Since the late 1990s, park management has become a common organisation model for developing industrial and services business sites in the Netherlands (Pellenbarg, 2004). However, they can give the park management to the companies in the park, the association of companies, or an external specialised company. It is habitual that the Dutch government put their interests as a priority and take over park management to have an extra policy instrument and force companies to comply with the park rules (Pellenbarg, 2004).

On the other hand, Heeres et al. (2004) talk about a bottom-up process. They say that in the Netherlands, EIP projects are mainly initiated and guided by private companies with financial and advisory support from the government.

Business associations are often the ones that initiate EIP projects on behalf of their companies. They coordinate actions closely with the local or regional government. The business association and entrepreneurs are actively participating in the process during the whole project.

The local community and NGOs are basically not present in the development process of EIP in the Netherlands. The whole process is made by the companies that participate in the EIP project and the direct stakeholders involved. Consulting agencies and education institutions may also be involved (Heeres et al., 2004).

According to Heeres et al. (2004) in the Netherlands, EIP projects are pursued due to economic and environmental reasons, which seem to be equally important.

Financially, participation in the planning costs, is apparently equally divided between companies and government, each paying for 50%. However, the costs for the realisation of the developments are paid by the companies. Subsidies may cover part of these costs.

Finally, Heeres et al. (2004) say that in the three cases they studied in the Netherlands, there were no champions involved. Instead, the business associations took the role of a champion.

2.16.2 IS in the Netherlands

In theory, the exchange of energy, water, by-products, and materials seems to be the most important feature of an initial EIP development. However, in practice, in the Netherlands, the exchange is not as important in the initial development (Heeres et al., 2004). This claim is supported by Louw (2017) who says that even though the exchange of flows is the most important aspect of EIP, it is not frequent in the Netherlands.

In the EIPs studied by Heeres (2004), the focus was put on preventing pollution by sharing utilities instead of focusing on exchanges. This is mainly because utility sharing is expected to bring economic and environmental benefits and are not as risky as investing in exchange-focused projects.

If projects with low risk such as this are proven to be successful, then companies are willing to invest in projects with a higher economic risk and more benefits such as waste exchange (Heeres et al., 2004).

2.16.3 Success factors to IS and EIP in the Netherlands

Pellenbarg (2002) summarised the important factors and recommendations for the success of EIP in the Netherlands found in the literature. According to Dekker (1997), Van der Veeken (1998) and Kolpron Consultants (1998) (as cited in Pellenbarg, 2002) factors for success are:

- Trust among participants
- Make the ideas of stakeholders central to the project
- Respect for the interests of participants
- Making cooperation voluntary
- Creation of an association of the participant firms
- Avoid starting the implementation of the project too soon
- Support by government and policies
- Monitoring of the ecology goals

Recommendations to successful EIPs include:

- Have a chance of success in the short term
- Have enough financial means
- Use existing management means
- Have a close location between firms
- Big diversity of firms with complementary needs
- Establish good public relations

Chamber of Commerce of Molise (2017) came with the next recommendations after studying two EIPs in the Netherlands.

- Local social circumstances should not be ignored because they may stimulate trust between firms and therefore foster cooperation.
- IS should tackle the need of more than one firm or actor
- Firms participating in IS should be autonomous
- Participation in IS should be voluntary and in cooperation with the government
- Short distances between firms support IS
- Management, understanding, commitment, cooperation, and communication are necessary between participants

According to Pellenbarg (2002), the most important factor for success is the cooperation between firms, and between firms and government. It also seems crucial that the initiatives for cooperation come from the firms, not the government. The government contributes more to a partner that enables the conditions and delivers the required services.

Other factors that contribute to the success of EIP in the Netherlands are the importance of the interest of firms, and the presence of heterogeneous firms for the creation of exchange possibilities.

The presence of a large firm that leads the initiatives and not having direct competitors in the network are also relevant factors (Pellenbarg, 2002).

Heeres et al. (2004) say the most important factor for success is the active participation of companies in the project and their willingness to invest time, money among other resources. A lack of interest by the companies is deadly for the project. The second most important factor is the business association which has an important role in communicating the benefits for companies of the development of an EIP, and functioning as a communication platform among companies.

Heeres et al. (2004) add that other relevant other factors for the success of Dutch EIP are the existence of previous networks between firms. Eilering & Vermeulen (2004) also confirm that in successful EIP cases, companies knew each other and had a shared history which helped with the creation of trust.

Eilering and Vermeulen (2004) remark that physical and social features play a key role in achieving symbiosis and/or utility sharing. If one of the two is missing, then there will be no symbiosis. The most important physical feature is that there has to be complementarity in the needs of companies for energy, water or residual substance flows for symbiosis or utility sharing to happen. Social features include mutual trust, the presence of an anchor company, the presence of a pioneer, and a short mental distance between partner companies are also relevant for IS formation.

Policy instruments such as financial incentives or legislations play a role in the success or failure of an EIP, however, it is less important than physical and social features or the decision-making process (Eilering & Vermeulen, 2004).

Baas and Korevaar (2010) say that commitment, a shared vision, trust, enough resources, and a long-term program are vital to make IS occur.

Voogd and Bunnik (2003) identified the success factors of the EIP de Trompet:

- The physical environment of the park (the possibility of using aquifers)
- The period of the development (attention to sustainability, growth of energy market)
- Creation of an agreement between the municipality and official organisation (a clear division of responsibilities)
- Decision-making made by the organisation (establishing ambitions, objectives, conditions)
- The enthusiasm of people and organisations involved
- Effective communication

Table 2.4 shows the enabling factors specifically for the success of Dutch EIPs that were found in the literature. Factors that have the "*" symbol were described explicitly as crucial by authors.

Table 2.4: Factors for the success synergies in the Netherlands.

Success factors in the Netherlands	Sources
Cooperation between firms and government *	(Pellenbarg, 2002)
Create an association of participant firms that functions as a communication platform *	(Pellenbarg, 2002), (Heeres et al., 2004)
Interest of firms and willingness to invest time, money among other resources *	(Pellenbarg, 2002), (Heeres et al., 2004), (Chamber of Commerce of Molise, 2017), (Baas & Korevaar,
Presence of heterogenous firms for the complementarity in the needs of companies for energy, water or residual substance flows *	(Pellenbarg, 2002), (Eilering & Vermeulen, 2004)
Absence of direct competitors in the network	(Pellenbarg, 2002)
Presence of trust among participants	(Pellenbarg, 2002), (Eilering & Vermeulen ,2004), (Baas & Korevaar, 2010)
Give relevance to every stakeholder's interests and involve them in the process	(Chamber of Commerce of Molise, 2017), (Eilering & Vermeulen, 2004), (Pellenbarg, 2002), (Voogd &
Cooperation must be voluntary	(Pellenbarg, 2002), (Chamber of Commerce of Molise, 2017)
Initiatives coming from firms not from the government. The government should take an enabling position as a partner to create favorable conditions.	(Pellenbarg, 2002), (Eilering & Vermeulen, 2004)
Avoid a too early implementation of the project	(Pellenbarg, 2002)
Support by policies	(Pellenbarg, 2002), (Eilering & Vermeulen, 2004)
Continous monitoring of the ecological goals	(Pellenbarg, 2002)
Existence of previous networks between firms	(Heeres et al., 2004), (Eilering & Vermeulen, 2004)
Presence of a large firm that leads the initiatives	(Pellenbarg, 2002), (Eilering & Vermeulen, 2004), (Van Leeuwen et al., 2003)
Short physical distance between firms	(Chamber of Commerce of Molise, 2017), (Van Leeuwen et al., 2003)
Shared vision/small mental distance among partners	(Baas & Korevaar, 2010), (Chamber of Commerce of Molise, 2017), (Eilering & Vermeulen, 2004),
Favorable park location for collective synergies	(Van Leeuwen et al., 2003), (Voogd & Bunnik, 2003)
Effective communication	(Chamber of Commerce of Molise, 2017), (Voogd & Bunnik, 2003)
Favorable period of development (e.g attention to sustainability or growth of the market)	(Voogd & Bunnik, 2003)

Pellenbarg (2002) says that the literature is not specific about the factors that lead to the failure of EIPs. Heeres et al. (2004) also highlight that the reasons causing problems in the development of EIPs are less uniform than factors that lead to their success.

Pellenbarg (2002) and Eilering and Vermeulen (2004) say that success and failure factors are very closely related, therefore, the absence of a success factor may be considered as a failure factor and the absence of a failure factor may be considered a success factor.

Eilering & Vermeulen (2004) say that a top-down approach in the decision-making process may lead to failure of the project because companies are not consulted, which leads to a lack of support for the development of the EIP. On the other hand, a bottom-up or a joint process involves the participant companies and avoids future problems that harm EIP development. They add that companies' reluctance to provide information about the environmental gains is a problem for the diffusion of EIP practices.

Pellenbarg (2002) says that the complexity of agreements may also become an obstacle. The high complexity of an agreement increases the fear of not being free to adapt to whatever changes are needed for companies in the future. Besides, a lack of waste suitable for exchanges and not enough financial resources may be a reason for IS failure.

Having a few large financially strong companies, a difference of opinions among participants, or a relatively large distance between companies may also lead to an EIP development failure (Heeres et al., 2004). An overview of the barriers is shown in Table 2.5.

Table 2.5: Barriers to synergies in the Netherlands.

Barriers in the Netherlands	Source
Top down approach	(Eilering & Vermeulen, 2004)
Lack of information sharing	(Eilering & Vermeulen, 2004)
Complexity of agreements	(Pelenbarg, 2002)
Not suitable waste	(Pelenbarg, 2002)
Lack of financial resources	(Pelenbarg, 2002)
Difference of opinion among participants	(Heeres et al., 2004)
Large distance between companies	(Heeres et al., 2004)
Few large and financially strong companies	(Heeres et al., 2004)

2.16.5 Studied EIPs in the Netherlands

Bakker et al. (1999) (as cited in Pellenbarg, 2002) did an inventory of 62 EIPs in different phases of development in the Netherlands since 1990. The map of EIPs made by Bakker et al. (1999) can be found in Appendix C.

Pellenbarg (2002) managed to contact 43 of those 62 EIPs to get more key data such as year of founding, size of the site, goals of the EIP, factors for success, and what kind of sustainable processes or sustainable site arrangements they followed. However, only 5 of the 43 EIP that Pellenbarg (2002) studied can be identified in his paper.

In 1999, a total of 233 projects received a subsidy as part of a stimulation program called “Duurzame Bedrijventerrein” (Boons & Spekkink, 2012; Costa & Ferrão, 2010; Eilering & Vermeulen, 2004). The results until 2003 were 85 completed and 130 in development. Subsidies stopped on October 1, 2003. What happened to all of those parks afterward is not clear.

Massard et al. (2014) identified 16 EIP developments in the Netherlands, from which only 7 have detailed information on the case studies. Massard et al. (2014) highlights that by the time of their study there was no relevant literature about Agropark Noordoostpolder, Agro Industrial Complex Dinteloord, De Binckhorst site, Ecofactorij, Ladonk, Kleefse Waard Industrial Park, VAM Mera industrial park, Chemelot, Wavin site EIP.

A list of the studied EIP in the Netherlands that are mentioned in the literature and where some literature was found is shown in Table 2.6.

Table 2.6: Conclusion of the literature review and knowledge gaps

Eco-industrial park	Authors that studied the EIP
INdustrial EcoSystem project in the Rotterdam harbour and industry complex	(Massard et al., 2014), (Baas & Boons, 2007), (Baas & Korevaar, 2010), (Baas, 2008), (Chertow & Ehrenfeld, 2012), (Farel, Charrière, Thevenet, & Yune, 2016), (Gibbs & Deutz, 2007), (Heeres et al., 2004), (Chamber of Commerce of Molise, 2017)
Biopark Terneuzen in Zeeland	(Massard et al., 2014), (Chamber of Commerce of Molise, 2017), (Farel et al., 2016), (Spekkink & Boons, 2016)
Rietvelden/Vutter (RiVu) in Den Bosch	(Massard et al., 2014), (Heeres et al., 2004) and (P. Pellenbarg, 2002)
Moerdijkse Hoek in Moerdijk	(Massard et al., 2014),(Farel et al., 2016), (Heeres et al., 2004), (P. Pellenbarg, 2002) and (Spekkink & Boons, 2016)
Ecofactorij Eco-Industrial Park in Apeldoorn	(Eilering & Vermeulen, 2004) and (Pellenbarg, 2002)
Emmtec Industry & Business Park in Emmen	(Massard et al., 2014) and (Eilering & Vermeulen, 2004)
Business Park South Groningen in Ter Apelkanaal	(Massard et al., 2014) and (Eilering & Vermeulen, 2004)
Chemiepark in Delfzijl	(Massard et al., 2014)
De Krogten in Breda	(Pellenbarg, 2002)
IJmond Business Park in IJmuiden	(Pellenbarg, 2002)
Agro Industrial Complex in Dinteloord	(Eilering & Vermeulen, 2004)
The Kleefse Waard Eco-Industrial Park in Arnhem	(Eilering & Vermeulen, 2004)
The Trompet Eco-Industrial Park in Heemskerk	(Eilering & Vermeulen, 2004) and (Voogd & Bunnik, 2003)
Wavin Eco-Industrial Park in Hardenberg	(Eilering & Vermeulen, 2004)
VAM MERA Eco-Industrial Park in Wijster	(Eilering & Vermeulen, 2004)

2.17 Conclusion of the literature review and knowledge gaps

The literature review guided the reader through the definition of EIPs, the importance of industrial symbiosis and utility sharing in EIPs. Other relevant elements to EIPs such as the context, park management, facilitator, location-specific features, vision, and decision-making were also briefly explained. Them, the success factors and barriers for the implementation of EIPs and synergies found in the literature were presented.

Afterwards, literature specifically about EIPs the Netherlands was shown. Success factors and barriers that were found specifically at Dutch EIPs were displayed. Finally, a table with the previously studied EIPs and the time of the studies in the Netherlands was displayed.

The main problem found in the literature review is that even though the exchange of energy, water, by-products, and materials seems to be the most important feature of an EIP, in the Netherlands, the exchanges of flows are not encountered frequently at the parks. Utility sharing is a more common practice. However, it is essential to understand how other parks have achieved industrial symbiosis, so other parks to do the same. Heeres et al. (2004) and Louw (2017) clearly say that the exchange of flows is not common in Dutch EIPs.

"The exchange of flows, which is the most important aspect of EIPs, is much less frequently encountered in the Netherlands" (Louw, 2017).

Although, from theory one could easily get the impression that the establishment of such ''physical'' energy, water and material and by-product exchanges are an essential element of the initial EIP development process. In practice, the initial EIP development of the Dutch cases discussed focused on the establishment of pollution prevention projects with utility sharing characteristics." (Heeres et al., 2004).

Two knowledge gaps were found with this literature review.

Knowledge gap 1: The literature that addresses EIPs in the Netherlands is old. Hence, the literature about success factors and barriers to implement IS is outdated. Most of the relevant papers were published around 15 years ago. Especially, barriers for EIP development in the Netherlands have only a few empirical studies. In other words, an update on the success factors and barriers to industrial symbiosis is needed.

The following quotes support the need for a study that addresses the barriers to the formation of EIPs and IS. However, considering that the literature is too old, the success factors to the formation of IS in EIPs in the Netherlands also need to be addressed.

Pellenbarg (2002) says that *"The literature is less specific about factors which determine the failure of eco-parks."*

Walls et al. (2015) say that in the literature, the limiters for IS "*are discussed in vague terms…and tended to be speculative and with little supporting empirical work".*

Heeres et al. (2004) say that *"Although the reasons for project success seem to be fairly uniform, the reasons causing problems or failure in project development seem to be more diverse in nature."*

Knowledge gap 2: Literature that addresses specifically EIPs in the Netherlands is limited. There are many parks that need to be studied because there is currently not enough information about them. There is no literature about what happened to the 233 EIPs that were in development supported by the "Duurzame Bedrijventerrein" stimulation program in 1999.

Also there is no literature that explains if the 60 EIPs studied by Bakker et al. (1999) (as cited in Pellenbarg, 2002) prospered or failed. Massard et al. (2014) remark there is no detailed literature on certain EIPs (Agropark Noordoostpolder, Agro-Industrial Complex Dinteloord, De Binckhorst site, Ecofactorij, Ladonk, Industrial park Kleefse Waard, VAM Mera industrial park, Chemelot, Wavin site).

Besides, the studies of Eilering & Vermeulen (2004) mention that some EIPs in the Netherlands were in development, but no literature explains what happened to those EIPs and if they prospered or failed.

The literature review also allowed to answer the first sub-research question: *What factors influence the implementation of industrial symbiosis and utility sharing in eco-industrial parks according to literature?*

An explanation of the factors can be found in the literature review in sections 2.14, 2.15, 2.16.3 and 2.16.4. However, an overview of all the success factors and barriers to the development of industrial symbiosis and utility sharing found in the literature is shown in Table 2.7.

Table 2.7: Success factors and barriers that influence synergies.

Success factors	Success factors in the Netherlands
Policy & regulation	Cooperation between firms and government
Coordinators	Create an association of participant firms
Expertise and know-how	Interest of firms and willingness to invest time, money among other resources
Access to finance	Heterogenous firms for the complementarity in the needs for energy, water or residual substance flows
Viable technology and equipment	Absence of direct competitors in the network
Cooperation with Science and Technology institutions	Presence of trust among participants
Economic value added	Give relevance to every stakeholder's interests and involve them in the process
Trust and enabling environment	Cooperation must be voluntary
Diversity of economic activities	Initiatives coming from firms
Optimal park location and adequate industrial sectors	Avoid a too early implementation of the project
Continuous monitoring of environmental and social compliance	Support by policies
Feasible distances	Continous monitoring of the ecological goals
Clear designation of the park as eco-innovation park	Existence of previous networks between firms
Implication of all stakeholders	Presence of a large firm that leads the initiatives
	Short physical distance between firms
	Shared vision/small mental distance among partners
	Favorable park location for collective synergies
	Effective communication
	Favorable period of development (e.g attention to sustainability or growth of the market)
Barriers	**Barriers in the Netherlands**
Lack of policy to incentivize initiative of industrial symbiosis	Top down approach
Lack of an institutional support for integration, coordination and communication	Lack of information sharing
Lack of knowledge	Complexity of agreements
Lack of financal resources	Not suitable waste
Lack of technology and infrastructure readiness	Lack of financial resources
Lack of awareness of IS	Difference of opinion among participants
Lack of top management support	Large distance between companies
Lack of trust among locators	Few large and financially strong companies
Lack of willingness to collaborate	
Lack of information sharing among locators	

3. Methodology

In this chapter, the methodology followed is explained. It contains the research design, the conceptual framework used for analysis, the criteria to select the cases, and the data collection protocol.

It is important to remark that depending on the purpose of the research, the projects can be exploratory, descriptive, or explanatory. Based on the research question, this study is exploratory. Exploratory research is often made for new areas of inquiry (Bhattacherjee, 2012). Exploratory research is preferred when not much is known about a particular phenomenon when existing results are unclear or suffer limitations, when the topic is highly complex, or when there is not enough theory available for the development of a framework (Sekaran & Bougie, 2016).

A case study strategy was chosen for this research. According to Yin (1994) (as cited in Rowley, 2002) a case study research strategy is useful when *"a how or why question is being asked about a contemporary set of events over which the investigator has little or no control".* Therefore, this strategy suits our main research question: *How to facilitate the implementation of industrial symbiosis and utility sharing activities in eco-industrial parks in the Netherlands?*

3.1 Research design

A research design refers to the blueprint for collecting, measuring, and analyzing data created to answer the research question (Sekaran & Bougie, 2016).

The research design was based on Yin (2003) case study method as shown in Figure 3.1.

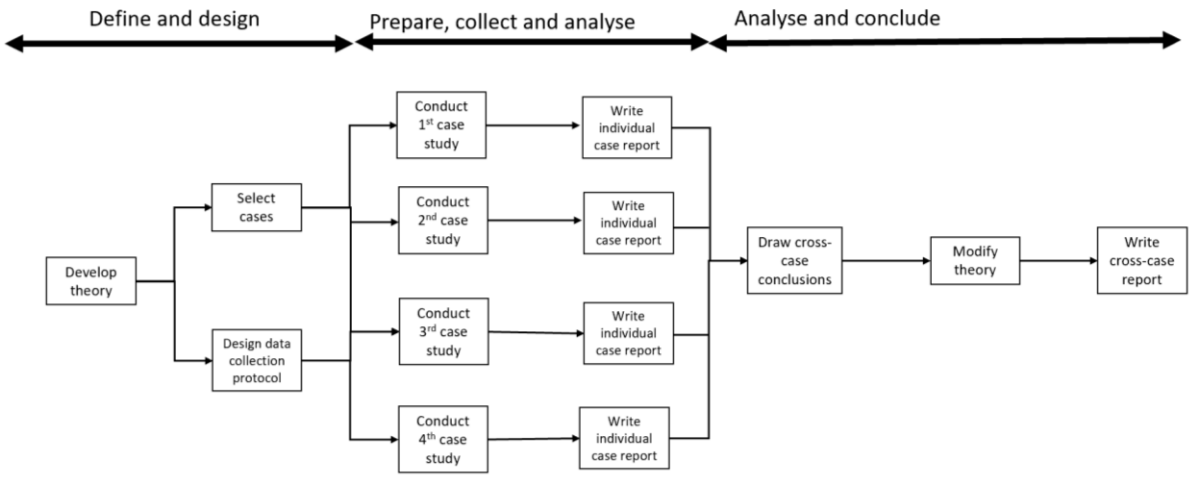

Figure 3.1: Case study method (Yin, 2003).

The first step of this design requires a framework based on the theory. The next step is to define the selection of cases and data collection process. Afterwards, case studies take place. Each case is reported individually. Then the different cases are compared to reach cross-case conclusions.

Important discoveries during the case studies could lead to a modification of the theory. Finally, the report is made (Yin, 2003).

3.2 Conceptual framework

A framework is needed to analyse the different park cases and answer what factors influence the success of industrial symbiosis and utility sharing in Dutch EIPs. As shown in Chapter 2, the literature pointed out several factors that have an impact on the performance of eco-industrial parks.

Elements mentioned in the literature review that are relevant to develop IS and EIPs include a vision, the external context, the context of the park (social and physical), the characteristics of the companies, the organisation of decision-making, a facilitator,

The framework developed by Eilering & Vermeulen (2004) in Figure 3.2 considers several of these factors already. This framework analyses the factors that influence the process from ambition to performance of the plans aiming for utility sharing and industrial symbiosis. It is important to highlight that Eilering & Vermeulen (2004) applied this framework to Dutch EIP cases.

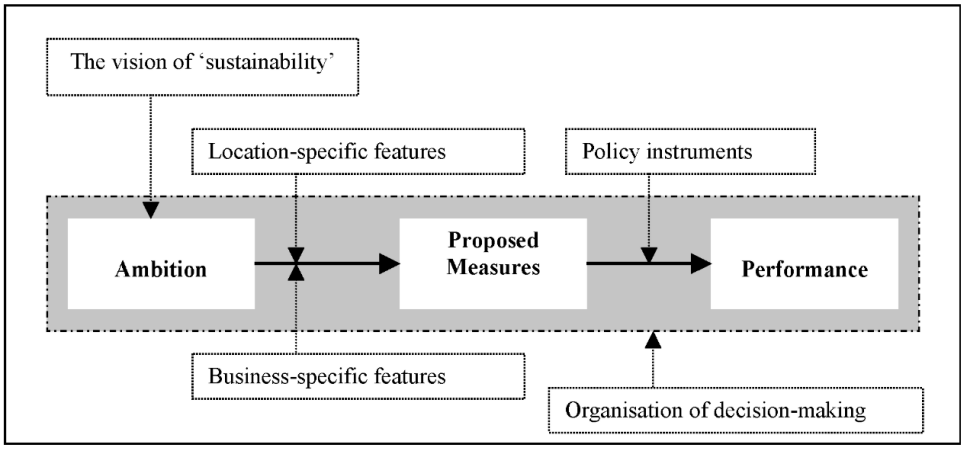

Figure 3.2: Framework of Eilering & Vermeulen (2004).

Considering that this framework contains several of the factors found in the literature, it was considered as an appropriate framework to use in this study.

This framework considers mainly seven factors that influence the performance and successful implementation of industrial symbiosis and utility sharing.

Vision: What the park wants to achieve. The vision of sustainability guides the whole project.

Ambition: The vision defines the ambition and how sustainable the park is looking to become.

Location-specific features

- Location-specific physical features: Refers to the park's physical characteristics where industrial symbiosis and utility sharing activities occur. Physical characteristics are defined by the type of companies, layout, and resources available at the park.
- Location-specific social features: Refers to the social context of the park.

Business-specific features: The characteristics of the companies inside the park.

Proposed measures: Measures chosen to implement at the park.

Policy instruments: Tools used to support the implementation of synergies such as regulations, subsidies, promotion, a facilitator and park policies.

Organisation of decision-making: The way in which the process to make decisions is organized.

Performance: Whether the proposed synergies are successful or not.

3.3 Selection of case studies

The framework for the case study selection can be seen in Figure 3.3.

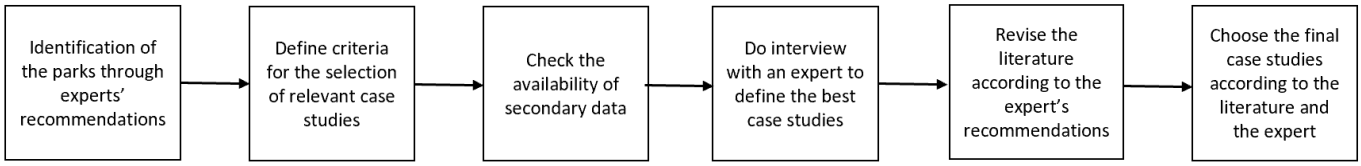

Figure 3.3: Framework for case study selection

3.3.1 Identification of relevant industrial parks through experts' recommendations

The first step was to ask some experts through an email what parks in the Netherlands could be interesting to study. According to the experts, thirteen cases were relevant to the study:

- Biopark Terneuzen in Zeeland
- Moerdijk
- Ecofactorij in Apeldoorn
- Industrial Park Kleefse Waard in Arnhem (IPKW)
- Chemelot (Former DSM site)
- Greenpark Venlo
- M4H in Rotterdam
- Buiksloterham in Amsterdam
- Waarderpolder in Haarlem
- Lage Weide in Utrecht
- Brainport Industries Campus in Eindhoven
- Oosterhout
- Zwolle

3.3.2 Criteria to select the case studies

The following points have been considered important for an EIP to be relevant for the research.

1. Presence of production facilities that allow by-product synergies and waste exchanges.

2. Some companies at the park must be involved in an exchange of flows.

3. There must be utility sharing activities at the park.

4. The size of the park and the number of companies in the park are significant. Parks can be huge such as Waarderpolder in Haarlem and Lage Weide in Utrecht, which has around 1000 companies or it can be small such as Ecofactorij with around 15 companies. It was decided that the park should have at the most 150 companies to make the information and development of the parks easier to track and study

5. The park needs to be a front-runner and interesting to study, according to experts.

3.3.3 Applying the criteria to possible cases

Information about the thirteen EIPs suggested by the experts was searched in secondary literature, mainly websites and papers. The information found on discarded EIPs can be seen in Appendix D.

Afterwards, an interview with an expert was held to define the selection of cases. The expert provided three extra possible cases that were not among the thirteen suggested by the other experts: De Trompet, Suiker Unie, and Rietvelden.

Another park called InnoFase was suggested by one interviewee when data was already being collected for one case. Therefore, a literature review of this park was also made and it was selected as another case because it complied with the most relevant criteria.

The criteria applied to the different suggested cases can be found in Table 3.1.

Table 3.1: Criteria for the selection of cases.

Eco-industrial park	Criterion 1: Presence of production facilities	Crtierion 2: Exchange of materials and flows	Criterion 3: Utility sharing	Crtierion 4: Joint provision of services	Criterion 5: Less than 150 companies	Criterion 6: Mentioned by expert
Biopark Terneuzen in Zeeland	Yes	Yes	Yes	Yes	Yes	Yes
Moerdijk	Yes	Yes	Yes	Not found	No	No
Ecofactorij in Apeldoorn	Yes	Not found	Yes	Yes	Yes	Yes
Industrial Park Kleefse Waard in Arnhem (IPKW)	Yes	Yes	Yes	Yes	Yes	Yes
Chemelot (Former DSM site)	Yes	Yes	Yes	Not found	No	Yes
Greenpark Venlo	No	Not found	Not found	Not found	Not found	no
M4H in Rotterdam	Yes	Not found	Not found	Not found	Not found	No
Buiksloterham in Amsterdam	No	No	No	Yes	Not found	No
Waarderpolder in Haarlem	Yes	Not found	Not found	Yes	No	Yes
Lage Weide in Utrecht	Yes	Not found	Not found	Not found	No	No
Brainport Industries Campus in Eindhoven	Yes	Not found	Not found	Yes	Not found	No
Oosterhout	Not found	Not found	Not found	Not found	Not found	No
Zwolle	Not found	Not found	Not found	Not found	Not found	No
De Trompet in Heemskerk	Yes	No	Yes	Yes	Yes	Yes
De Rietvelden in den Bosch	Yes	Yes	Yes	Not found	No	Yes
InnoFase	Yes	Yes	No	No	Yes	Yes

In the end, three parks were selected for the research:

1. InnoFase Synergie Park in Duiven

2. Industrial Park Kleefse Waard in Arnhem
3. Biopark Terneuzen in Zeeland

The location of the parks is shown in Figure 3.4.

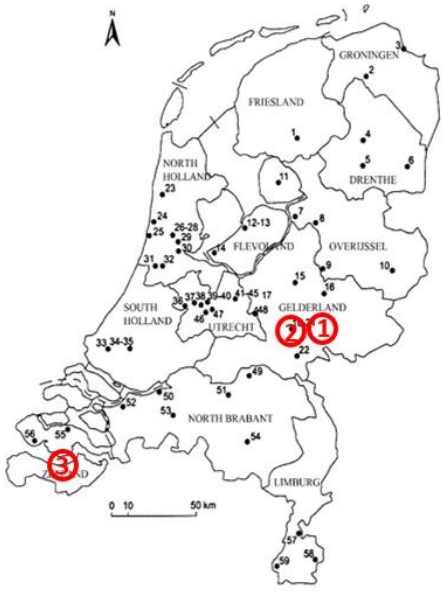

Figure 3.4: Location of the selected park cases.

The criteria for the selected cases can be found in more detail in Table 3.2. A table with more detailed criteria for the non-selected cases can be seen in Appendix D11.

Table 3.2: More detailed criteria for the selected cases.

Eco-industrial park	Presence of production facilities	Exchange of materials and flows	Utility sharing	Joint provision of services	Size (hectares)	Number of companies	Implementation year	Front-runner?	Available contact to interview	Sources
Biopark Terneuzen in Zeeland	Yes	Yes (Re use of waste streams including residual heat, CO_2, biomass, electricity, water, steam and starch and by-products used as feedstock).	Yes (Shared installations for water treatment)	Yes (collective gathering of waste)	45	27	2007	Yes	Yes	(Massard et al., 2014) (Chamber of Commerce of Molisse, 2017) www.bioparkterneuzen.com
Ecofactorij in Apeldoorn	Yes	There was an ambition in 2004 for industrial symbiosis but is not specified if they accomplished the goals	Yes (smart grid). Plans (in 2002) to use an incineration plant as a source of biogas	Yes (shared bycicles for internal mobility)	75	15	1998	Yes	No	(Eilering & Vermeulen, 2004), (Pellenbarg, 2002) www.ecofactorij.nl
Industrial Park Kleefse Waard (IPKW) in Arnhem	Yes	Not yet but there are experiments ongoing and plans for using waste flows of energy production or waste flows of one company as raw materials for another company.	Yes (There is a power plant and a waste water treatment station inside the park. Other utilities present at the park include heating, power, steam, natural gas, power grid management, water processing and treatment, compressed air.)	Yes (The park shares several facilities such as a testing ground, parking, a boot camp, meeting rooms, EV charging stations. Besides they share maintenance, park management, waste collection, security, and mobility services (electric cars and e-bikes))	90	25	1998	Yes	Yes	(Eilering & Vermeulen, 2004), (Pellenbarg, 2002) www.ipkw.nl
De Trompet in Heemskerk	Yes	Not known but there is presense of production companies which makes it possible.	All buildings are heated and cooled using individual heat pumps connected to a collective source.	It is planned to purchase resources collectively.	18	120	1992	Yes	No	(Eilering & Vermeulen, 2004), (Voogd & Bunnik, 2003)
innoFase	Yes	Yes (Exchanges of heat, electricity, wastewater, biomass, and residual waste)	No	No	Not found	12	2009	Yes	Yes	https://www.innofase.com/

3.3.4 Justification of the selected cases

1. Biopark Terneuzen in Zeeland

This park has already been studied because this is a successful case. Biopark Terneuzen has several exchanges of streams going on. However, the information about the park has to be updated. The last relevant paper about Biopark Terneuzen was published five years ago. Besides, the website seems abandoned and the last relevant document on their website dates on 2012. This makes it look as if the project stopped. An update is needed to determine if these exchanges remain the same or new exchanges have emerged or stopped. Besides, the park is relatively small, making sustainable activities in the park easy to track.

2. Industrial Park Kleefse Waard (IPKW) in Arnhem

First, Massard et al. (2014) remark that there is not enough information about this park, so they did not include IPKW in their study. The last time it was studied was by Eilering & Vermeulen in 2004.

Besides, this park won the award of the most sustainable park in the Netherlands in 2019. It is important to know what synergy activities are happening and what led to the park to such success.

According to Eilering and Vermeulen (2004) when created, this park only had ambitions of pursuing utility sharing and not an exchange of residues or waste apparently because the companies did not have complementary needs for residual energy, water, or residues. However, now the park is experimenting with industrial symbiosis by exchanging residual heat.

3. InnoFase in Duiven

InnoFase is one of the newest parks. They won the Circular Economy Award in 2020, making it relevant to study what led to the park's success.

Besides, there is no literature about this park. According to the website, there are plenty of flow exchanges going on at the park. It is interesting to know how these exchanges emerged and what is happening inside the park.

Furthermore, a contact with an important position in the park was shared by one of the interviewees, which made it more accessible to study.

3.4 Design data collection protocol

The analysis for case research tends to be qualitative and the interpretation of the findings depends on the researcher's abilities. Data may be collected using interviews, personal observations, or internal and external documents. The generalizability of the findings is increased by replicating the analysis to various case studies in a multiple case design (Bhattacherjee, 2012).

Three case studies support this research. Data came from secondary sources and semi-structured, online interviews with key actors of EIP development. These key actors include park managers, managers of companies housed at the park, local government and research institutions involved in the park's development. The variety of roles in the interviewees' process can give different perspectives and hence a better understanding and better insights into the research.

3.4.1 Election of the participants

The main goal was to interview key actors involved in the park's development, such as park managers, managers of companies, and people from the government. However, people from

research institutions and consultancies were also interviewed due to accessibility to their contacts and their involvement in the park's development in some way.

The contacts were approached through email or Linkedin. An introductory email was sent to the participants with a brief description of the study and their willingness to participate.

If the person was willing to participate, a second email was sent with the questions and consent form. The date and time of the interview was also scheduled by email.

All of the interviews were conducted online using Microsoft Teams. The interviewees were cited for an hour. All the interviews were digitally recorded. This allowed the researcher to transcribe every interview and do a more detailed analysis of the information.

It is important to highlight that some previously chosen parks such as De Trompet and Ecofactorij had to be discarded due to the absence of respondents for the interviews. InnoFase was added to the study due to the accessibility to some contacts involved in the development of the park.

Invitations were sent to 36 people through email or Linkedin. In the end, 14 people agreed to participate. The table of interviewees can be seen in Table 3.3.

Table 3.3: Related case and position of the interviewees.

Position	Eco-industrial park
Program Manager at the municipality of Duiven	InnoFase
Municipality of Duiven and Corporate Contact Officer of InnoFase	InnoFase
Plant Manager at AVR	InnoFase
Process Manager at the Rijn & Ijssel Water board	InnoFase
Plant Manager at Primco	InnoFase
Director of IPKW	Industrial Park Kleefse Waard
Communications & Marketing Officer and Project Manager at Veolia	Industrial Park Kleefse Waard
Project manager at Save Plastics	Industrial Park Kleefse Waard
Operational manager at the Mobility Innovation Center	Industrial Park Kleefse Waard
Economics program in the line of Hotspot Energy in Arnhem's municipality	Industrial Park Kleefse Waard
Partner at Van de Bunt Consultancy	Biopark Terneuzen
Partner at Van de Bunt Consultancy	Biopark Terneuzen
Assistant Professor and Researcher	Biopark Terneuzen
CEO of TransForum (Innovation Program)	Biopark Terneuzen

3.4.2 Interview structure

A list of questions was made for each interviewee. The questions addressed all the main points of the framework shown in Figure 3.2. The structure followed can be seen next:

First section. Researcher introduction: During the first section of the interview, the researcher introduced himself shortly at the beginning of every interview and confirmed that the consent form was read carefully.

Second section. Introductory questions: The interviewee was asked for a short introduction and to explain how the formation of the park or the start of the relationship with the park. This allowed identifying key actors in the development.

Third section. Vision and ambition: Questions were asked related to their vision of sustainability and ambition.

Fourth section. Decision making: The fourth section was related to the decision-making structure of the park.

Fifth section. The situation at the park. The fifth section is related to the situation at the park today. Respondents were asked to explain which successful synergies and sustainable projects are taking place at the park and also which projects failed. Also, respondents were asked about how the projects were identified and implemented. Important elements that influenced the implementation of the projects were also asked such as the context of the park and policy instruments.

An open question of what were the most important success factors and biggest barriers to the successful development of synergies was also asked.

Sixth section. Closing questions: Respondents what changes they would make to implement synergies and sustainable projects easier. At the very end, respondents were asked for contacts that could be useful for the research.

Some extra questions were formulated during the interview if a particular topic mentioned in the answers was considered relevant by the researcher.

The order of the questions was also modified in some interviews depending on the answers of the respondent. Some questions had to be left out in some interviews due to time constraints. However, the most important questions were answered by everyone.

Since respondents had different roles (park management, municipality, companies, consultancy, research institutions) and were involved differently with the eco-industrial parks, some questions were slightly modified to match each role. However, the general structure of the interview was the same. The questions asked can be found in Appendix G.

3.5 Data Analysis

Data transcription

A software called Otter ai was used to transcribe all of the interviews. This software automatically makes a transcript of the uploaded audio. However, the transcript is not entirely accurate. Therefore, each transcript was reviewed while listening to the recordings to fix the software's mistakes. This allowed having accurate transcripts of every interview.

Data reduction

Data reduction refers to the process of selecting, coding and categorizing the data. Coding refers to the analytics process through which the qualitative data that has been collected is reduced and integrated to form theory (Sekaran & Bougie, 2016).

For this study, the software ATLAS TI.9 was used to analyse the qualitative data. All the transcripts of the interviews were uploaded to ATLAS TI to be analysed. This software allows giving labels to relevant quotations in the interviews. These labels are known as codes. There were eight predefined codes defined by the framework by Eilering & Vermeulen (2004), making it a deductive approach. However, an inductive, exploratory approach followed to define in more detail the eight predefined

categories of Eilering and Vermeulen's framework. In other words, the basics are deductive, but within the predefined categories, the results are inductive and exploratory, making it a mixed approach.

The vision and ambition were categorized as only one factor because both are heavily linked to facilitate coding. A distinction is also made in location-specific features, dividing them into physical and social features.

The final eight predefined codes are seen below. Numbers 1-7 influence number 8, which describes the performance or current state of the park.

1. Vision and ambition
2. Location-specific physical features
3. Location-specific social features
4. Business-specific features
5. Proposed measures
6. Organisation of decision making
7. Policy Instruments
8. Performance/current state

All the quotes that referred to one of these eight predefined categories either as success factors or barriers were categorized accordingly. Several rounds of reviewing were made for the coding and categorization. In each review, codes were categorized into more detailed and accurate sub-factors. Connections were made between codes and notes were used to help the researcher on this task.

In total, there were 815 quotations considered relevant and a total of 121 codes was used. However, some codes could not be fitted into the existing predefined eight codes. Therefore new categories were made for these remaining codes. A total of 10 categories was used for the codes in the end. The added factors were:

9. Economic features
10. External context

Data display

Data display refers to how the data is presented (Sekaran & Bougie, 2016). For the three cases, each one of the factors and subfactors is explained. A table with the subfactors and the number of codes is shown for each factor.

4. Case Studies

In this chapter, the data collected in the case studies is analysed. Sources for this information include websites, news, and interviews. The information is structured according to the previously defined factors found in the framework of Eilering & Vermeulen (2004).

The factors considered are:

- Vision and ambition
- Location-specific physical features
- Location-specific social features
- Business-specific features
- Proposed measures
- Organisation of decision-making
- Policy instruments
- Performance/current state

Some factors could not be categorized into any of the other factors considered by the framework and were added as extra factors. The new factors are economic features and external context.

Performance/current state refers to the industrial symbiosis and utility sharing activities at the park. The performance results from the vision and ambition, location-specific physical features, location-specific social features, business-specific features, proposed measures, organisation of decision-making, policy instruments, economic features, and external context. For a better understanding of each case, the analysis will start with the performance. However, it is important to remember that the performance results from the combination of all the other factors mentioned in the framework.

4.1 Case 1: InnoFase Synergy Park in Duiven

The information collected for the eco-industrial park of InnoFase is compiled here. For this case, five people were interviewed. The code for the interviewees can be seen in Table 4.1.

Table 4.1: Table of interviewees for InnoFase.

Eco-industrial park	Position	Participant ID
InnoFase	Program Manager at the municipality of Duiven	MA1
InnoFase	Municipality of Duiven and Corporate Contact Officer of InnoFase	MA2
InnoFase	Process Manager at the Rijn & Ijssel Water board	CA1
InnoFase	Plant Manager at AVR	CA2
InnoFase	Director at Primco	CA3

Participants IDs will be used for simplicity. MA refers to municipality actor, and CA to company actor.

4.1.1 Introduction

InnoFase is a park located in the Province of Gelderland in the city of Duiven. This park contributes to a circular economy by saving raw materials and reducing environmental pressure by implementing circular technologies and innovations (InnoFase, 2020a).

The park is located far from residential areas, which allows InnoFase to accept companies up to environmental category 5. The park contains around 12 big-sized companies (InnoFase, 2020b).

InnoFase is a brownfield development built in an area that used to be called Roelofshoeve. This area was called “the sewage drain of Gelderland”. This area contained a lot of waste and recycling-related companies (MA1, 2020).

Around 2009, the municipality of Duiven wanted to do a project related to sustainability. They realized that at the Roelofshoeve zone, the Rijn & Ijssel water treatment plant was providing water effluent to AVR apparently since 40 years ago (MA1, 2020). Noticing the exchange of water gave the municipality the idea of closing residual loops at other companies (MA1, 2020).

The municipality gathered all the plant managers to explain a park's new project idea focusing on exchanging streams. Plant managers supported the new project (MA1, 2020). Consequently, the name of the park was changed from Roelofshoeve to InnoFase (MA1, 2020).

Today, energy, water, and raw materials are used in a smart way to limit the resources used for production. Flows such as biomass, CO2, heat, water and biogas are exchanged between the park companies. Besides reducing the environmental impact, these exchanges provide the companies with considerable cost reductions and save on raw materials (InnoFase, 2020a).

Thanks to their great results, InnoFase has been the winner of the Circular Economy Award of 2020.

An overview of InnoFase can be seen in Figure 4.1.

Figure 4.1: Overview of InnoFase Synergy park (InnoFase, 2020a).

4.1.2 Key actors

Municipality of Duiven

The municipality is the starter and facilitator of the project. Their primary goal is to sell grounds to other companies. However, they have a key role in enabling the context, so cooperation occurs among companies. They started the task force, where companies from the park and the municipality meet to discuss ongoing and new projects (CA2, 2020). Without the municipality, maybe InnoFase would not have been successful (CA3, 2021).

Research institutions

Research institutes are key at InnoFase because they provide scientific knowledge and information (CA1, 2020). in the early years, the University of Wageningen, the University of Radboud and the HAN helped companies find synergies opportunities. The suggestions from the University and their students functioned as an eye-opener for the companies inside the park and was the start of discussions for new projects (MA1, 2020).

Since the creation of the task force, universities contribute at a lower scale, but they are still working together with InnoFase to develop ideas for new projects (MA1, 2020).

4PET

The inclusion of 4PET in the park was a real breakthrough. The role of 4PET in the network needs to be highlighted. One of the respondents describes 4PET as "*the spider in the web*" because they are engaged in several exchanges and function as a central node. Without 4PET, InnoFase would be different (MA1, 2020). An interviewee explained the relevance of 4PET.

"I think the coming of 4PET was a real breakthrough. Because they are almost like a spider in the web. Things going in going out with other companies" (MA1, 2020).

Besides 4PET, every actor involved in an exchange of flows is also a key actor. The role of these key actors is explained in the next section.

4.1.3 Performance/current state

The second sub-research question can be answered for InnoFase in this section: *What are the industrial symbiosis and utility sharing activities happening at front-running eco-industrial parks in the Netherlands?*

There are several examples of industrial symbiosis that are present at InnoFase. Exchanges that happen include heat, electricity, wastewater, biogas, sludge, and biomass. Not every company at the park is participating in a synergy. However, all of them are related to sustainability somehow. The map of the exchanges that are happening at InnoFase can be seen in Figure 4.2.

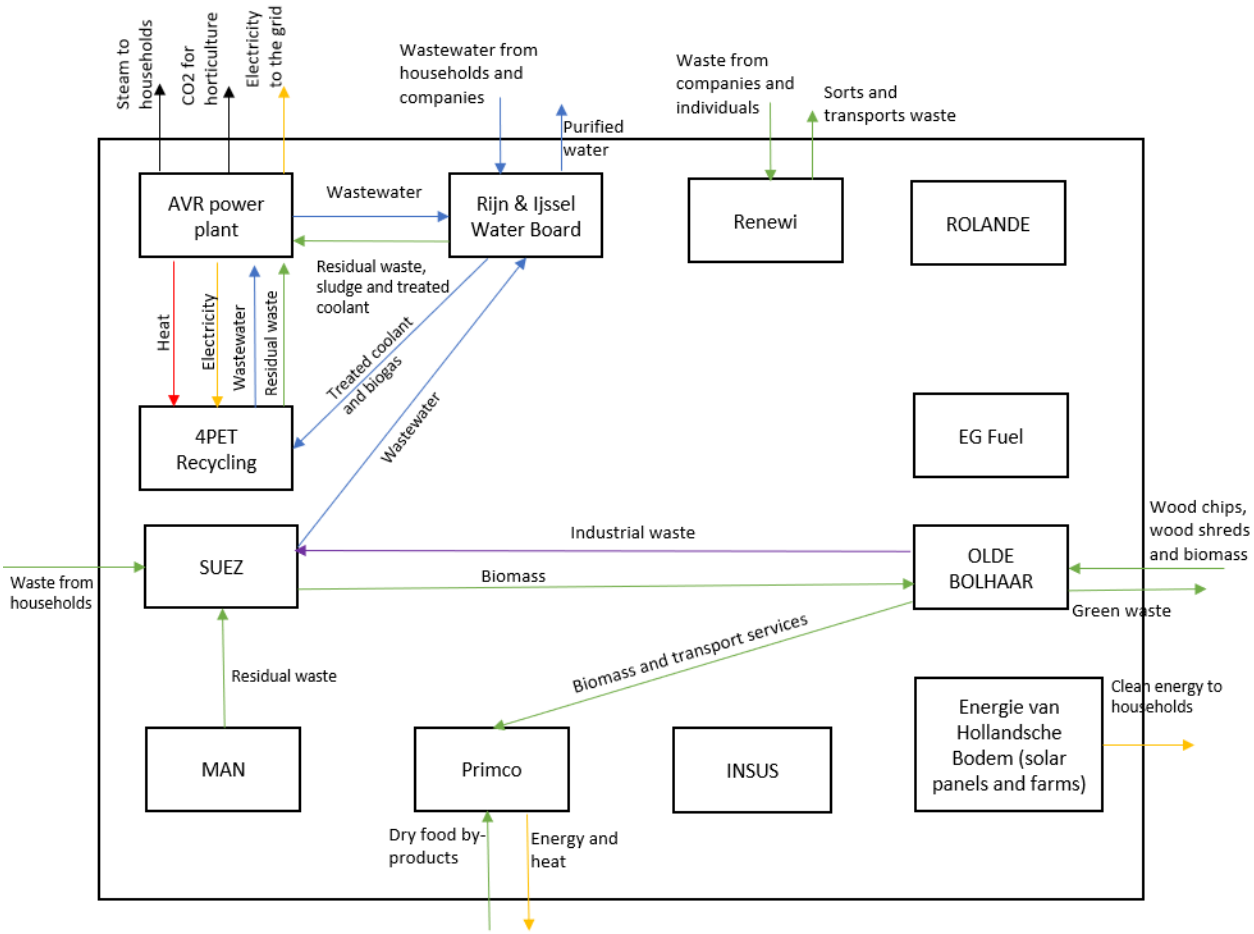

Figure 4.2: Map of exchanges at InnoFase (adapted from InnoFase, 2020a).

Explanation of the synergies:

AVR power plant: It is a waste to energy plant. Inside the park, AVR provides wastewater to Rijn & Ijssel Water Board, and electricity and heat to 4PET Recycling.

Outside the park, AVR burns municipal waste and delivers the remaining heat for warming houses and generates electricity that is re-supplied into the grid. The CO2 that is generated by burning waste Is given to greenhouses to be used in horticulture (InnoFase, 2020c).

Primco: They dry by-products from the food processing industry into new products with a higher added value (CA3, 2021). This company is developing a cogeneration plant that converts wood waste into energy and heat. The electricity generated will be supplied to the public grid, and the generated heat will be used on the site. Primco receives biomass and transport services from Olde Bolhaar (InnoFase, 2020c).

Rijn & Ijssel Water Board: The Water Board collects the wastewater in the sewers from around 400,00 people of households and companies (in and outside InnoFase) to get it purified in the wastewater treatment plant (CA1, 2020). A part of the purified water is used as coolant, and the rest flows to the Ijssel River (InnoFase, 2020c).

The Rijn & Ijssel Water Board provides residual waste, sludge, treated coolant and process water to AVR for their production. Also, they provide treated coolant and biogas to 4PET Recycling (InnoFase, 2020c).

4PET Recycling: This company processes PET into raw materials for different applications. At the park, the company provides wastewater and residual waste to AVR waste-to-energy plant (InnoFase, 2020c). 4PET receives biogas and cooling water from the wastewater plant and heat and electricity from AVR (MA1, 2020). They provide wastewater and residual waste to AVR. Besides, they have shared facilities with SUEZ. Research is being done so 4PET receives clean water from the wastewater treatment plant to wash their final product and stop using drinking water (MA1, 2020).

Olde Bolhaar: This company collects green waste and processes it into compost. Besides, they produce wood chips, wood shreds and biomass from pruning waste which can be used to generate heat and electricity in incinerators. Inside the park, they supply industrial waste to SUEZ and supply biomass and transport services to Primco (InnoFase, 2020c).

SUEZ: Collects waste from households and companies to make raw materials for new products. Inside the park, SUEZ provides biomass to Olde Bolhaar, and waste water to the Rijn & Ijssel Water Board (InnoFase, 2020c).

MAN: Their waste flow is delivered to SUEZ to get processed into raw materials for new products (InnoFase, 2020c).

Energie van Hollansche Bodem: This company makes solar roofs and solar farms. Together with the municipality of Duiven, they developed the solar farm Gansenwoirt, which supplies clean energy to households (InnoFase, 2020c).

EG Fuel: Develops and supplies alternative fuels such as electricity and liquid natural gas (InnoFase, 2020c).

ROLANDE: They supply liquid natural gas, which emits lower CO2 compared to diesel (InnoFase, 2020c).

Renewi: Collects waste from companies and individuals and transport it to processing sites so it can be used as energy or raw materials for new products. Renewi alsosorts the different types of waste for collection (InnoFase, 2020c).

4.1.4 Vision and ambition

InnoFase dates back to 2009 when the municipality wanted to do something related to sustainability and had the vision of transforming the area into an EIP.

After the program manager realized there was an existent exchange of water between AVR and the water board, he wanted to copy that idea and create something ambitious where streams were exchanged. Elements of the municipality visited the EIP of Kalundborg in Denmark to clarify the concept of industrial symbiosis that was on their mind (MA1, 2020).

As a result of becoming aware of an existing exchange and a visit to Kalundborg, the vision of the project was clear: to develop the concept of industrial symbiosis further where "*the output of one*

company is the input for another company" (MA2, 2020) and become a circular industrial park (MA1, 2020).

A meeting was held with all the companies where the park's concept, goals, and new name were discussed to align the vision. Since the beginning of the project, the municipality considered the companies' interests and opinions as explained by a respondent. *"They had a saying in the name change of the park and in the concept. So we put them really at the front of things. We made them participate at the front of the process. Of course, we had the idea of industrial symbiosis and they liked it"* (MA1, 2020).

Today, the program manager has a role in the vision and strategy for the development of the park. He has some ideas of which projects to develop in the coming years. However, it seems that there is not a well-defined road map of what are the next steps projects that are going to be developed at the park (MA2, 2021).

Table 4.2: Overview of ambition and vision in InnoFase.

Factor: Vision and ambition	Type of factor	Number of codes
Municipality's inititative	None	3
Visit an existing EIP	Success	2
Sustainable vision	Success	8
Develop vision collaboratively	Success	2

4.1.5 Location-specific physical features

At InnoFase, all the companies in the park are similar in that they are related to waste, energy, the environment and sustainability. Being in the same environment and location as the other companies is helpful because it helps to interact with other companies (CA1, 2020).

If companies are too different from each other, then exchanges of streams do not happen. Other types of companies, such as consultancies that do not have streams and do not allow relevant business cases are not present at the park (CA3, 2021). The type of companies housed in the park enables the creation of exchanges because they can offer by-products (CA3, 2021).

The short distance that companies have from each other also contributes to the success of the exchanges. Besides, a short distance to other companies is attractive for newcomers due to the considerable amount of money saved on transport. Besides, this also has benefits for the environment because materials travel meters instead of kilometers (CA3, 2021).

Table 4.3: Overview of location-specific features.in InnoFase.

Factor: Location-specific physical features	Type of factor	Number of codes
Complementary companies	Success	3
Short distance between companies	Success	1

4.1.6 Location-specific social features

One of the most highlighted barriers is that companies have their primary focus on their own business. It is not a priority for plant managers to look for business cases and synergies with the neighbour (CA3, 2021). Their priority is their main business. This was explained by a respondent.

Sharing things with my neighbor companies is not something that's high on my list. It's not good. But on typical, that's how every company works" (CA2, 2020). However, with the help of the municipality, companies now look beyond their own processes (MA1, 2020).

The problem of companies focusing only on their own processes was eliminated through the task force. The task force has played an important role in making companies interact, communicate, update each other about current processes, and share new project ideas (CA3, 2021). Thanks to the task force, companies inform the other companies and the municipality what the projects' status is (CA1, 2020). Therefore, companies are aware of what other companies are doing. It is not unknown anymore.

In the task force, problems are solved together by all the members. Members share their ideas and the best solution is discussed. This has contributed that actors in the network of InnoFase understand that to fulfill their ambition of a circular economy, there is a need for cooperation. As one respondent said *"I really think we need each other to fulfill the ambitions we have. We all have a certain role in the whole chain, and you need to find each other and you need each other. And then it's also to keep the whole cycle together" (CA1, 2020).*

At the task force, members share new ideas, knowledge, and information about the different projects in development (CA1, 2020). Also, new concepts, strategies, and projects are discussed (CA2, 2020). More detailed talks are arranged between the key actors involved in a project after the task force meetings to discuss the projects further and do feasibility studies (CA2, 2020).

Besides the task force, there is an innovation workspace at the wastewater treatment plant where the water authority, AVR, research institutions and the municipality of Duiven work together on new innovation projects (CA1, 2020).

Thanks to interactions and the task force, a collaborative culture has been formed at InnoFase. After the municipality's intervention and stimulation, companies are more bound together and strengthened social ties. The municipality has created a context where companies know each other and easily contact each other without any restriction.

Now, companies consider their neighbors' needs and capacities. There is an open culture where companies are trying to find synergies and couple resource streams (CA1, 2020; MA2, 2020). Companies look at their surroundings, checking with whom it is possible to collaborate (MA1, 2020).

This is explained by an interviewee. *"We are not willing to take all the benefits for ourselves. And that's also other companies' point of view in that" (CA2, 2020).*

New ideas can are easily shared with other companies (MA1, 2020). This makes companies work and cooperate together, as explained by another respondent.

"Companies are more bound together at the moment than they were at that time, now they know to find each other. When somebody has an idea they look at the neighbors and talk it through" (MA1, 2020).

Besides, the communication between companies and municipality is easy and efficient, as explained by an interviewee. *"When I need something from the municipality, I call the program manager or the mayor even and then it will be arranged in days instead of months"* (CA2, 2020).

At InnoFase, there is a good relationship between the companies and between the companies and the municipality. Thanks to the good relationship and easy contact, issues are solved quickly.

For synergy creation and collaboration, trust is crucial between actors (CA1, 2020 and CA2, 2020). Trust is not something that develops overnight and is basic for every cooperation (CA2, 2020).

As one respondent said "*You need trust in people and companies. Both of them. You have to trust the people you're working together with and you have to trust a company they're part of because you are going to do an investment of time and money*" (CA1, 2020).

Companies at InnoFase trust each other. The task force meetings have had an important role in the development of trust between participants (CA2, 2020). Trust has developed with the constant interactions between the members (CA2, 2020).

"Because we are in a kind of taskforce and we have been there for several years we trust each other and we have each other's telephone numbers and we are easy to contact. And that kind of trust is the basic for every good cooperation. And I think we put a lot of effort in that for the last few years. So I think that's another key success factor because you have to know each other" (CA2, 2020).

One of the constraining factors in the social features is that there is a lack of common understanding between knowledge institutes and companies. Universities are willing to help but provide fundamental research. Companies want practical and applicable research to create synergies (CA3, 2021).

Table 4.4: Overview of location-social specific features in InnoFase.

Factor: Location-specific social features	Type of factor	Number of codes
Companies focus on their core business	Constraining	6
Companies know what other companies do	Success	2
Joint problem solving	Success	2
Knowledge sharing	Success	2
Collaborative culture	Success	9
Easy communication	Success	3
Trust	Success	6
Lack of understanding between different actors	Constraining	1

4.1.7 Business-specific features

There are certain characteristics from the companies at InnoFase that have positively influenced the establishment of synergies. The employees at the companies of InnoFase also have specific characteristics that are key to the creation of synergies. One interviewee clarified, *"If you don't have the right persons at your table, it won't fly"* (MA1, 2020).

It is important to highlight that a characteristic of InnoFase is that every company is pursuing sustainability and has a strategy related to reusing and doing something with their waste (CA1, 2020 and H3). Besides, companies at InnoFase are willing and enthusiastic about making something better for the world. At InnoFase, all the plant managers want to make something for the environment (CA2, 2020).

The plant managers at InnoFase are all entrepreneurs and look for opportunities to make better and more sustainable businesses (CA3, 2021). People must think out of the box and be surrounded by entrepreneurial people to create synergies (MA1, 2020). This was explained by a respondent.

"*With people that are stuck in their own ideas and their own system and their own way of working you can't create new things and you can't go into transition. You have to let loose the old way of thinking and your structures, because otherwise, you're never going to get there"* (MA1, 2020).

Participant companies also have a long-term view and willing to have a return on investment in several years, not immediately (MA1, 2020). Synergy projects do not provide a return on investment shortly. However, most private companies are not willing to wait to have profits (CA3, 2021). At InnoFase, they do.

It has to be considered that the infrastructure such as pipes for exchanging flows is too expensive and small companies cannot pay them (CA1, 2020). Therefore companies need means to fund the project. If not, synergy projects cannot happen (MA1, 2020).

Furthermore, all companies at InnoFase have an environmental category 4 or 5 with a lot of processes and hence a high impact on the environment. This type of company generates more waste and therefore, more exchanges of streams are possible. For example, a logistics company does not allow to engage in synergies (MA1, 2020, H2, H3, and H4).

A considerable amount of residue that can compete with the normal grid is needed. A large amount of waste can only be generated by big-scaled companies. The amount of waste generated by small companies and cannot compete with a normal grid. Therefore, big-sized companies are needed for

exchanging flows. InnoFase has big-sized companies such as AVR, the Water Board and 4PET. These large companies also attract other companies to join the park (CA1, 2020).

If there is not enough waste flow, then an exchange cannot happen. At InnoFase, The Water Board talked about treating the water generated by Primco. However, their wastewater amount was not enough to make a feasible business case (CA1, 2020).

Besides, if two actors deliver the same residue, there may be some difficulties. AVR signed a contract to deliver heat to the district heating network. Another company generated heat with their processes and wanted to deliver heat to the network as well. However, there was an agreement already with AVR as the supplier. Therefore, only AVR was able to deliver residual heat to the grid (CA2, 2020).

It is important to remark the role of the company 4PET, which is considered a breakthrough. 4PET is a company that managed to exchange streams with several companies and has shared facilities with SUEZ. They are also looking to receive treated water from the water authority. In a nutshell, 4PET is a node in the network that is continuously looking for new exchanges.

A barrier to note is that companies that engage in synergy may have different industrial standards or more strict procedures. For example, a lower standardized company may not follow the accorded schedules. In a highly standardized company such as AVR, schedules are followed strictly. Cooperation still happens. However, the difference in procedures and standards are an obstacle to cooperation (CA2, 2020).

Table 4.5: Overview of business-specific features in InnoFase.

Factor: Bsuiness-specific features	Type of factor	Number of codes
Sustainability vision	Success	9
Willingness to commit	Success	2
Entrepreneurial mind	Success	3
Disposed to make long-term investments	Success	3
Financial capacity	Success	3
Industrial type companies	Success	4
Companies that produce/require a huge amount of waste	Success	2
Spider in the web	Success	6
Different industral standards	Constraining	1

4.1.8 Organisation of decision-making

At the park, there is not park management. However, the municipality takes mostly a coordinator role. The municipality is only in charge of choosing which companies join the park (MA1, 2020) and does outside management in the park's surroundings, such as fixing roads and taking care of trees (MA2, 2020). Besides, they started the task force (CA2, 2020).

Decisions, negotiations, and business cases are always by the companies (MA1, 2020). Each company makes its own decisions about which projects to pursue (CA2, 2020).

One of the most important success factors is to bring decision-makers together at the same table (CA3, 2021). This is done through the task force. The task force is formed by decision-makers of companies at InnoFase, some companies closeby to InnoFase, the province of Gelderland, a non-

profit organisation, the municipality of Duiven, and the mayor, who acts as a chairman. They meet around three times a year (MA1, 2020 and H3).

The decision-makers can decide at the meetings if they participate in new projects or not (CA3, 2021). If an idea is interesting for a certain company, then more personal meetings are arranged with the involved actors (CA2, 2020).

The task force is not a legal institution. It is an informal cooperation (MA2, 2020). There have been talks about making a legal cooperation; however, it has not been needed. The interviewees feel comfortable with informal cooperation (CA3, 2020). An informal cooperation has worked perfectly until now.

Two constraining factors were highlighted in the decision-making. First, different types of decision-making models may also slow the decision-making process. At InnoFase, the water board has a slow way of making decisions because it is a governmental institution. Private companies are more direct and decision processes are faster (CA2, 2020).

Second, it was remarked that in every project, there are many interests and stakeholders involved. Projects that involve neighbors and environmental organisations outside the park make decision-making and cooperation more difficult (MA2, 2020).

An example is the nature organisation Natura 2000, against the construction of new companies at the park. Also, the surrounding community of InnoFase does not want to implement a windmill at the park because it affects their sight (CA2, 2020). A respondent referred to this problem.

"Everybody stands up for their own interests. So you have to cooperate, and sometimes environmental organizations have success but the fact that there is a Natura 2000 area makes it more difficult for some companies to settle on InnoFase" (MA2, 2020).

Table 4.6: Overview of organisation of decision-making in InnoFase.

Factor: Organisation of decision-making	Type of factor	Number of codes
Companies decide what projects to pursue	Success	4
Have decision-makers together	Success	14
Informal cooperation	Success	3
Different decision-making models difficult cooperation	Constraining	1
Lots of interests	Constraining	2

4.1.9 Proposed measures

The initiative for synergies and new projects come from different actors. The municipality is continuously trying to find new project ideas. One of the most recent ones is to create an energy hub. The municipality also tries to identify new synergy opportunities with the newcomers to the park (CA2, 2020).

In the early years, Wageningen University helped with a scan of new synergy opportunities. Students came with some ideas, which made companies in the industrial area consider the new opportunities (MA1, 2020). Thanks to the students, the companies changed their mindset and paid more attention to circularity and the possibility of exchanging flows. One respondent explained the role of

universities in this. *"It was an eye opener for some companies. We didn't ever think about it, why didn't we think about it. That really helped*" (MA1, 2020).

An organisation called Kiemt also contributes to identifying opportunities for exchanges by providing knowledge on circular economy and sustainability (MA2, 2020).

Today, the concept of industrial symbiosis is already embraced by companies (MA1, 2020). Hence, most of the ideas for new synergies come from the technical experts at the companies (CA1, 2020; CA2, 2020). Opportunities may also be identified at the task force or through informal networking (CA3, 2021).

Opportunities can be identified before companies go to the park as well. The water board and 4PET or Primco and their neighbours were in conversations of synergy opportunities before they were established at the park due to the positive business cases (CA1, 2020).

Table 4.7: Overview of proposed measures in InnoFase.

Factor: Proposed measures	Type of factor	Number of codes
By government	Success	3
By research institutions	Success	3
By companies	Success	8

4.1.10 Policy instruments

Facilitator

The municipality of Duiven is the facilitator of InnoFase. According to an interviewee, the municipality of Duiven is unique and efficient, which is not common in the Netherlands. It is one of the success factors of InnoFase because It does different tasks that enable the creation of exchanges between companies. Without the municipality and its role as a facilitator, synergies would not have happened.

Respondents highlighted the importance of the municipality's help and guidance.

"In helping our companies achieving our goals they really are an exception. I think that's one of the key success factors of why InnoFase is working so good."(CA2, 2020).

"The municipality is stimulating this exchange of information, without this municipality, I believe it is not a self-sustaining process. So we need some stimulation, or some facilitation. And this is in place, so we need to keep it in place" (CA3, 2021).

The municipality introduces companies to each other and brings them together. They facilitate interactions and gatherings between the companies (MA1, 2020 and H2).

Furthermore, the municipality is the connecting node between the tenants inside InnoFase and potential newcomers. The municipality knows what companies can offer and therefore inform the newcomers about possible cooperations and exchanges (CA1, 2020).

It is important to highlight that the municipality facilitates the process because that allows them to sell the ground, which is their primary goal (CA1, 2020). Their secondary goal is to stimulate cooperation (CA3, 2021).

The municipality enables the context and creates the circumstances for synergies to happen (MA1, 2020)**.** The municipality incentivizes the companies to go to meetings, know each other, and discuss synergies (CA3, 2021) but does not control the entire process (MA2, 2020).

As explained by a municipality interviewee, *"You develop the circumstances where it can happen. But you really can't make it happen you can only create the right circumstances and then and then you cross your fingers and hope that it happens and it did happen."* (MA1, 2020).

It needs to be highlighted that the collaboration between companies is an organic process and cannot be planned with a project management instrument. Therefore, enabling the context is the best that the facilitator can do. These was explained by a respondent.

"We had a discussion about a project the other day, and one of the mistakes we made, was to use the instrument of project management to get the result. And that's not going to happen. These are much more organic processes and that can't be fitted into the template of project management" (MA1, 2020).

Before InnoFase started, the companies housed in the Roelofshoeve area did not know each other. Companies were introverted and only thought about themselves without looking at their surroundings. Companies did not know what their neighbors were doing and were not in speaking terms. Before InnoFase *"It was a bit like the Wild West*" (MA1, 2020). Because of the municipality, this does not happen anymore.

Companies look to themselves and not the outside, but the municipality makes a difference and gets companies out of their comfort zone. The municipality stimulates companies at InnoFase to work together and look for opportunities outside their primary business (CA3, 2020).

As a respondent explained, *"The municipality really was helpful in that and they facilitated that we get out of our comfort zone, get to the municipality house and sit there and have a cup of coffee, discuss synergy and get to know each other" (CA2, 2020).*

The municipality also initiates new ideas and gets companies enthusiastic about them. Their most recent idea is to turn InnoFase into an energy hub (MA1, 2020).

"We develop crazy ideas and talk it through with people on the compound. Sometimes it's having a crazy idea, and then talk it through and try to get make them enthusiastic for it. And sometimes it happens, sometimes it don't" (MA1, 2020).

The municipality also makes the implementation process easier by taking care of burdens such as spatial planning and permits issues to make the park's settlement as easy as possible (MA2, 2020 and CA3, 2021). They also take care of infrastructure and outside management issues (CA3, 2021).

Table 4.8: Overview of policy instruments/ facilitator in InnoFase.

Factor: Policy instruments/ Facilitator	Type of factor	Number of codes
Connects actors	Success	13
Enables the context	Success	11
Helps companies look at their surroundings	Success	6
Initiates ideas	Success	4
Removes burdens	Success	8

Regulations

Most of the interviewees agreed that regulations are a huge barrier to the establishment of synergies. Regulations were described as very restrictive with innovations and solutions. Regulations are not supportive of transition and innovations and do not facilitate change (MA1, 2020).

One of the biggest barriers is that regulation lags behind innovations. Innovations need to adapt to support a circular economy and an energy transition, but that takes time (CA1, 2020). The problem is that while they adapt, regulations are very restrictive (MA1, 2020).

Besides, there is too much legislation. Therefore, instead of helping, it makes cooperation and the creation of synergies more difficult (MA2, 2020). An interviewee explains this. "*Regulations are really killing innovation. They are really annoying. We have really too much legislation*" (CA2, 2020).

One example of regulations lagging is that biogas' price is higher than the price of natural gas. The more natural gas you buy, the cheaper it is. That does not happen with biogas so it cannot compete with natural gas (CA1, 2020). Early adopter companies are frequently harmed by regulations lagging behind innovation (CA2, 2020). Another example is that Dutch laws do not allow companies to provide electricity to your neighbour's neighbour (CA2, 2020).

Another barrier is that in the Netherlands, there are regulations on waste. Legislation qualifies the output as garbage, making it difficult to use it as input for other companies. Companies need a "not a waste" status on the resources that are delivered to other companies. The companies that receive the waste need a permit to acquire those resources (MA2, 2020).

This process to get the "not a waste status" is very slow and difficult in the Netherlands. The time to get the permit can take up to three years. Besides, there is no information on how to get the permits and what the process is (CA2, 2020).

Furthermore, it is not clear what the product demands are to get a "not a waste status." The whole process is very uncertain. It has to be more clear what are the product demands and how to get the status. A clear framework of how to get the "not a waste status" and the product demands is needed (CA1, 2020). The problem was highlighted by a respondent.

"I think it would be better to have a very clear framework or very clear policy on national scale. How to get a "not a waste" status, and what is the planning" (CA1, 2020).

Because of the inefficiency and uncertainty, entrepreneurs think twice before starting the process of recovering waste (CA1, 2020).

InnoFase is also having a lot of problems with the settled limit on nitrogen emissions by the government. This issue is mainly because the Natura 2000 area is near the complex. Because of this, companies cannot start new activities (CA3, 2021). There is also a lack of briefing on how to solve these issues (MA1, 2020).

The European Union legislation is also a big barrier because it makes the exchange of streams more difficult when governmental organisations are involved (CA2, 2020).

As a governmental institution, the water authority cannot buy something from the market if a contract value overcomes a certain amount. This means that they cannot get waste from another company that easily. If the amount is surpassed, they have to go to a European open tender and anyone can subscribe to that project. This only happens when they buy flows, not when flows are sold (CA1, 2020).

A project that involved exchanging sludge between the wastewater treatment plant and AVR failed because of the complexity of tendering. The project led to a quarter of a million earnings for each company, and it was good for the environment. However, an unsustainable alternative was implemented where trucks are used to transport the material 80 km away instead of using streams of AVR, their neighbor. This alternative was more expensive and had a higher negative impact on the environment (CA2, 2020).

However, not every regulation influence negatively the creation of industrial symbiosis and utility sharing. The national regulations force companies to take more sustainability measures and innovate their production processes. For example, companies cannot burn natural gas by 2050 anymore and the water treatment plant has to become climate neutral in 2025 (MA1, 2020). These regulations pushed them to take action and find other solutions, such as exchanging streams.

Table 4.9: Overview of policy instruments/ regulations in InnoFase.

Factor: Policy instruments/ Regulations	Type of factor	Number of codes
Lag behind innovation	Constraining	9
Inefficient process	Constraining	10
Regulations on nitrogen emissions prevent activities	Constraining	3
European Union's requirement to tender	Constraining	7
National regulations force companies to be sustainable	Success	2

Park policy

The municipality of Duiven follows certain criteria for the new companies that join the park. They only house the industrial class companies focusing on circularity that can have synergies with the established companies (CA1, 2020; CA2, 2020). Only companies that contribute to the concept of industrial symbiosis and circularity can join the complex (MA1, 2020).

Only larger companies with a 4 or 5 environmental class are received at the park (MA1, 2020 and CA1, 2020). Category 4 and 5 companies have a great amount of residue that allows them to make

connections in their operations with other companies. Companies with a lower environmental category do not generate that much waste and opportunities for exchanging streams are limited (CA1, 2020).

Even though the economy was not good around 2008, the municipality board stood up with their idea of having a sustainable park and did not sell grounds to any company that did not fill in the selection requirements. They respected their main goals even though the selling of the grounds could take ten more years (MA2, 2020). A respondent explained this. *"We didn't sell ground the last 10 or 12 years because there were companies but we didn't think they fit in the whole idea behind InnoFase and that's something that we are proud of"* (MA2, 2020).

Table 4.10: Overview of policy instruments/ park policy in InnoFase.

Factor: Policy instruments/ Park policy	Type of factor	Number of codes
Contribute to circularity	Success	5
Environmental class 4 and 5	Success	4
Strict with their selection	Success	6

Other policy instruments

Subsidies were described as of great help to innovate and develop new projects. It was suggested that besides facilitating the process of creating synergies, the government should also support companies with money for the infrastructure because it is costly (CA3, 2021). With more subsidies, more projects could be implemented.

Promotion is another success factor. The municipality uses the synergies happening at the park as a strategy to sell the ground. It is attractive for other companies to know that they can be helped with their processes and have a business case (CA2, 2020). They use the name Synergy Park InnoFase as part of their marketing strategy to attract more companies (CA3, 2021).

Table 4.11: Overview of policy instruments/ other in InnoFase.

Factor: Policy instruments/ Other	Type of factor	Number of codes
Subsidies	Success	3
Promotion	Success	4

4.1.11 Economic features

The return of investment is the main driver for the implementation of synergies. Collaborations with neighbors are made because there is a beneficial business case. There must always be a profit with the exchanges that function as an incentive to cooperate. Benefits are economic, social and environmental (MA1, 2020). Therefore, the positive thing about exchanges is that besides decreasing operational costs, they also reduce the environmental footprint (CA2, 2020). Furthermore, it is seen as something positive by society.

However, the economic benefit is the most important. For example, AVR provides electricity to 4PET for half the price of getting it from the grid (CA2, 2020).

If there it is not clear that there is a profit, then projects can fail. One smart steam grid failed because neither of the companies involved wanted to pay for the connection pipes. A smart grid needs oversized pipes in case any other new companies join. However, the price to oversize the pipes was too high. In such a project, it is not sure if a new company is making use of the oversized pipes so it was also too risky. Therefore, non of the companies invested (MA1, 2020).

Companies need to earn money from synergies and with the money earned, then a percentage for other sustainable activities that are not beneficial in terms of money can be assigned. As one respondent emphasized, "*Earning money is the motor for doing things that are good for the environment. Every company has to have a profit to sign a contract*" (CA2, 2020).

Every party that participates in a synergy needs to gain something (CA2, 2020). An interviewee emphasized this. *"I think the unique point of InnoFase is that everybody gains something with it. That's why it's successful"* (CA2, 2020).

The municipality can sell the grounds more easily and more expensive, and the companies reduce costs together and reduce their environmental footprint (MA1, 2020).

One thing to consider is that if a company receives a stream from another company. There is always the risk that the supplier fails. However, if the return on investment is high, then the risk of failure should not be a problem if the cost of fixing the failure is less than the earnings. The risk perception should be based on the return on investment (MA1, 2020).

At InnoFase, the risks of engaging in synergies are low. For example, 4PET only uses 10% of the total amount of biogas produced by the Water Board. Besides, 4PET could also buy the biogas from AVR or get a propane tank in case of unlikely failure. With other supply alternatives, there is no risk in their production process stopping (CA1, 2020).

Companies that participate in exchanges have clearly defined what happens in different situations and who is responsible in case of failure in the delivery of a stream. Clear agreements support the establishment of synergies (CA1, 2020).

Table 4.12: Overview of economic features in InnoFase.

Factor: Economic features	Type of factor	Number of codes
Business case	Success	10
Every participant gains	Success	3
Low risk of failure	Success	6
Clear agreements	Success	1

4.1.12 External context

The external context has also influenced the creation of synergies indirectly. Companies are more aware of sustainability and circular economy and therefore look for more sustainable production alternatives (MA2, 2020). As explained by an interviewee, *"I think it's more successful because sustainability and circular economy becomes much more important that it was five or 10 years ago"* (MA2, 2020).

Also, the economic context has an indirect impact on the creation of exchanges. The crisis from 2008 had a negative effect on InnoFase. No new interesting projects were created at that time (MA2, 2020 and CA3, 2021).

Table 4.13: Overview of the external context in InnoFase.

Factor: External context	Type of factor	Number of codes
Sustainability importance	Success	2
Economic conditions	Constraining	3

4.1.13 Extra factors

Luck was considered as a factor by some respondents. Luck is necessary because It is very hard for the government to program the development of industrial symbiosis, and make it happen. One of the respondents said "*It's a bit like organized luck. You can only create the right circumstances and then and then you cross your fingers and hope that it happens*" (MA1, 2020).

Luck also plays a role when you find the right companies and new ideas. However, this can be influenced by the proposition or by contacting companies (CA1, 2020).

Table 4.14: Overview of extra factors in InnoFase.

Factor: Extra	Type of factor	Number of codes
Luck	Success	7

4.2 Case 2: Industrial Park Kleefse Waard (IPKW)

The information collected for Industrial Park Kleefse Waard is compiled here. For this case, five people were interviewed.

The code for the interviewees can be seen in Table 4.15.

Table 4.15: Table of interviewees for IPKW.

Eco-industrial park	Position	Participant ID
IPKW	Director of IPKW	PM1
IPKW	Communications & Marketing Officer and Project Manager at Veolia	CA4
IPKW	Project manager at Save Plastics	CA5
IPKW	Operational manager at the Mobility Innovation Center	RI1
IPKW	Economics program in the line of Hotspot Energy in the municipality of Arnhem	MA3

Participants' IDs will be used for simplicity. PM refers to park management actor, CA to company actor, and MA to municipality actor.

This case will follow the same structure as the last case, starting with the explanation of what synergies and other sustainable projects are happening at Industrial Park Kleefse Waard. Then the success factors and barriers to the establishment of synergies of IPKW are explained.

4.2.1 Introduction

The park is a brownfield project located in Arnhem at the former site of Algemene Kunstzijde Unie (AKU), a fiber company built in 1941, which later became AkzoNobel (Schipper Bosch, 2016). The area was a place for the chemical manufacturing industry (IPKW, 2018i). In 2003 the park was bought by a family to transform it into a sustainable industrial park specifically focusing on cleantech companies, energy transition and innovation (IPKW, 2018i).

The first step was to restore the buildings and road structure (IPKW, 2020d). This phase ended in 2011 (IPKW, 2018i). In 2011 the goal was to connect the companies and attract new companies by promoting knowledge sharing and synergy (IPKW, 2018i).

Investments were made in communication to draw attention from companies that addressed innovation (IPKW, 2020d). The community of the park increased with large technology companies, startups and educational institutions. An industrial estate image changed to a recognized park that addresses sustainability, innovation, and entrepreneurship (IPKW, 2020d).

When the park was bought, there were around ten companies present (IPKW, 2018i). Today the park houses 80 companies engaged in sustainable innovations, mainly in the energy sector (PM1, 2020). Some of the companies address power generation, hydrogen, mobility and wood preservation (Schipper Bosch, 2016). Other companies are related to fiber production due to IPKW's past (IPKW, 2020a).

Size is not relevant for the park, as it allows big international players or tiny start-ups to join (IPKW, 2018d).

Today the park is 90 hectares (IPKW, 2020b) and has an innovative ecosystem in which economic activities, social activities, production processes, energy and waste flows are intertwined (Schipper Bosch, 2016).

IPKW is working, experimenting and innovating on projects related to the five sustainability themes: energy, mobility, buildings, waste, and people (IPKW, 2020a). Due to the successful implementation of synergies and other sustainable projects, IPKW has won the prize Circular Economy award for being the most sustainable park in the Netherlands in 2019 (MA3, 2020).

An overview of IPKW can be seen in Figure 4.3.

Figure 4.3: Overview of Industrial Park Kleefse Waard (IPKW, 2020i).

4.2.2 Key actors

Park management

The Schipper family is the owner of the ground and all the buildings. They decide what to do and which direction to follow. They also choose who joins the park (PM1, 2020).

There is park management that tries to facilitate the companies inside the park to achieve their goals. The director of the park is in constant communication with the owners of the park. Park management selects the companies that join the park and take care of the facilities (PM1, 2020).

Veolia

Veolia is an environmental services company that can do industrial utilities management, including drinking water production and distribution, biowaste treatment, waste collection, waste recycling, industrial cleaning and maintenance, among other services. Veolia is crucial for the energy goals of IPKW because it applies knowledge to find solutions to use energy, waste, and water more efficiently at the park (IPKW, 2020h).

The inclusion of Veolia in the park was key. Veolia partnered with IPKW to make the whole utility supply sustainable (PM1, 2020). Veolia is the owner of the gas-fired power plant and the waste water treatment plant at IPKW (IPKW, 2020h). Veolia takes care of everything the tenants need, from energy, drinking water, treating wastewater, or other utility (CA4, 2020). Every building depends on Veolia and is connected to Veolia (CA4, 2020). A

Due to their knowledge of all resource input and outputs of the park, they can find more environmentally friendly opportunities, such as reusing residual heat from one company in another (CA4, 2020).

Research Institutions

Students and professors from the HAN University of Applied Sciences collaborate with the companies at IPKW on different projects. Companies share their problems with the HAN to get support to solve their problems and get new ideas (PM1, 2020).

HAN operates three laboratories related to transition and clean energies to foster a hybrid learning environment at IPKW: the Mobility Innovation Center, the Power and the Hydrogen Lab (RI1, 2020).

Environmental and nature organisations

Environmental groups such as Natura 2000 go against biomass and nitrogen emissions. Therefore new companies may not easily join the park. Hence, opportunities for further synergies decrease.

Government

The municipality acts as a supporter. They support companies with subsidies and function as a way of communication between the companies and citizens. The municipality has a key role in promotion, mainly in communicating to citizens that companies' actions at the park are beneficial (CA4, 2020).

Also, the municipality of Arnhem supports innovation projects that address sustainability and innovation. Support is given mainly with subsidies and promotion (CA5, 2020).

The province of Gelderland has an ambitious strategy in the field of sustainability and reduction of the CO2 footprint. They give funding to some projects and promote education and expertise central to achieve an energy transition (RI1, 2020).

4.2.3 Performance/current state

The second sub-research question of *What are the industrial symbiosis and utility sharing activities happening at front-running eco-industrial parks in the Netherlands?* can be answered for IPKW in this section.

IPKW is focusing on five different themes: energy, mobility, buildings, waste, and people. An overview of what the park is doing for each category is given next. IPKW has mainly utility sharing activities, but there are also some exchanges of waste such as plastic or wood between some companies. A map showing the different synergies and other sustainable projects happening at IPKW can be seen in Figure 4.4.

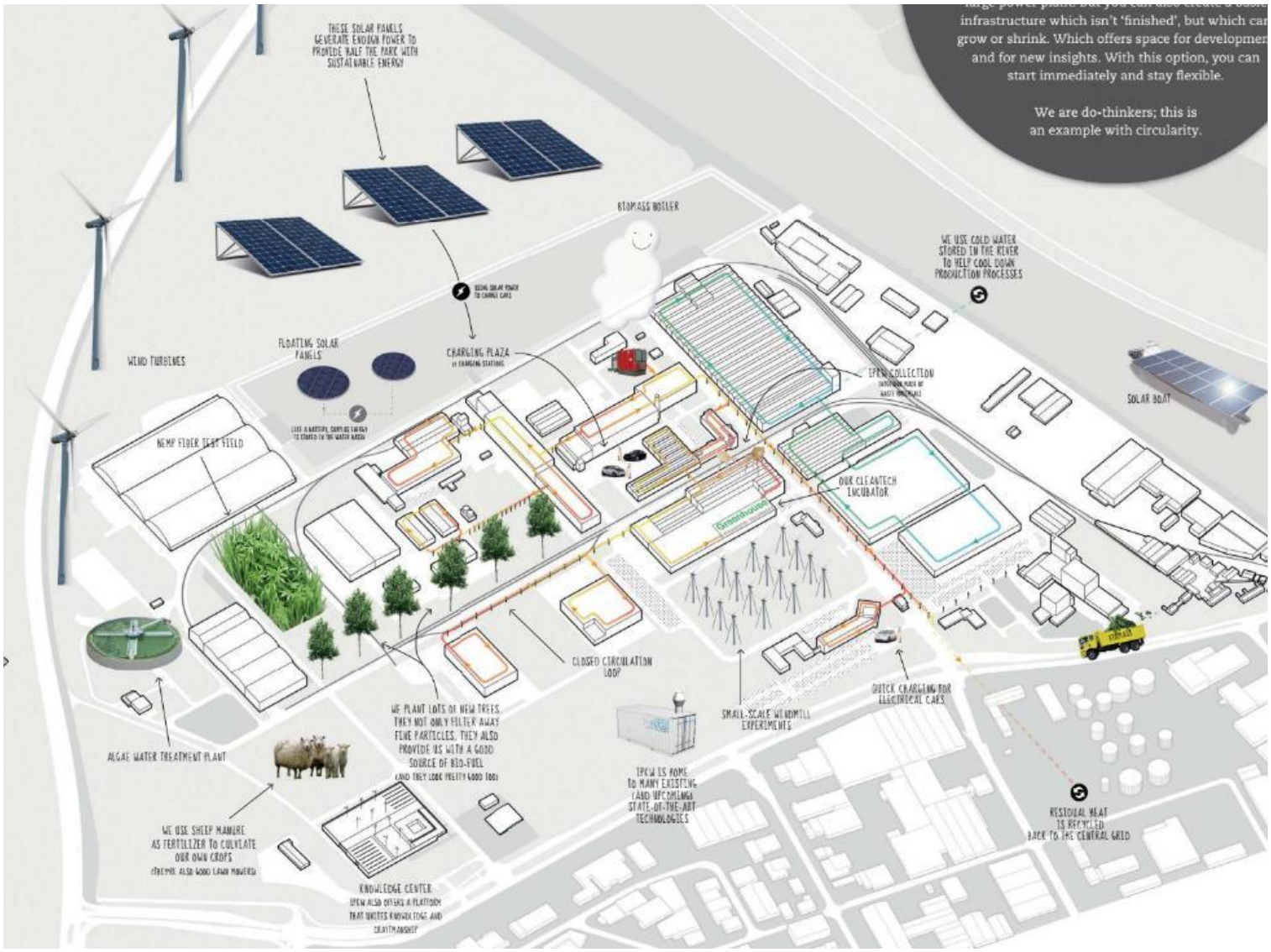

Figure 4.4: Map of the sustainable activities happening at IPKW (Schipper Bosch, 2016).

Energy & water

IPKW has a sustainable and optimized energy infrastructure with shared utilities. Veolia partnered with IPKW, so energy and water are supplied centrally. Thanks to Veolia, there are circular flows of energy and circular water use (Schipper Bosch, 2016).

The park has its own water treatment plant and power plant for heat, electricity, and gas, making the park autonomous. This is possible due to Veolia, which supplies all the necessary utilities for all the park companies (IPKW, 2020h). They provide around 20 utilities through pipelines (PM1, 2020). These include heat, electricity, different qualities of water (process, cooling and drinking), power, steam, natural gas, power grid management, wastewater treatment, compressed air (IPKW, 2018c).

IPKW aims to reduce the reduce gas consumption (PM1, 2020). Therefore, a medium-sized wood-fired biomass boiler was installed in 2018. The biomass boiler uses residual wood collected from residues of a radius of 100 km around the park as an input to generate steam (CA4, 2020).

The biomass boiler works as the base for the generation of steam supply. Steam is then used at the tenants' production processes and to generate electricity that goes to the site's grid (IPKW, 2020h). With the biomass boiler, Veolia has achieved to reduce their gas intake by 84%. In total, Veolia has managed to reduce 60000 tons of CO2 emissions since 2014 (CA4, 2020).

Besides, there is a local heat network on the site where the heat generated by Veolia's chimneys connected to boilers is recovered and used to heat the buildings. The heat from the steam generated by the biomass plant is also collected and goes to the network (IPKW, 2020h). The heat network also functions as a backup system for the city of Arnhem (PM1, 2020).

The heat from the chimneys is also used to preheat the boiler waters for steam production (CA4, 2020). The heat network can be seen in Figure 4.5 (IPKW, 2018c; IPKW 2018h).

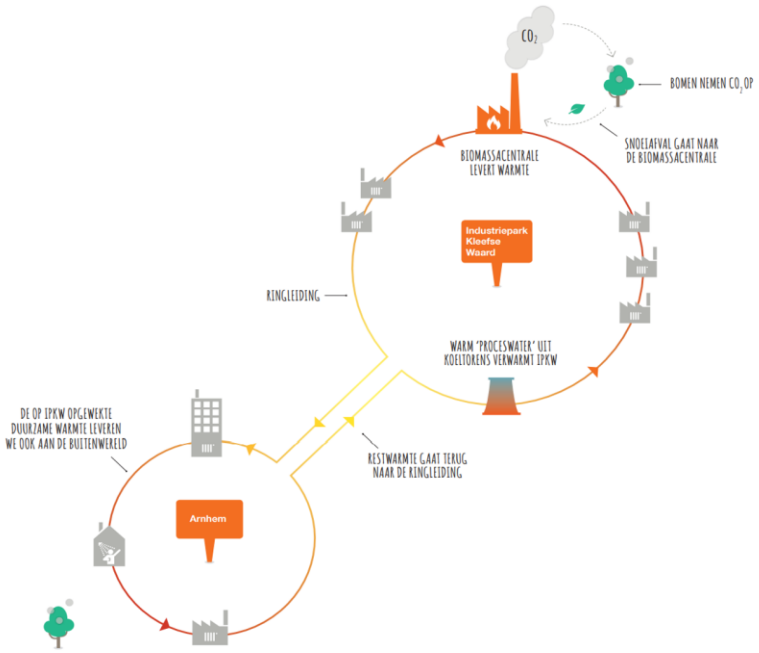

Figure 4.5: IPKW has a circular use of heat (IPKW, 2018h).

IPKW also generates renewable energy. Now, the park has almost 25,000 solar panels installed on the buildings' roofs and is installing solar fields to have a total of 50,000 solar panels (PM1, 2020). The collected energy is stored in batteries which are used for the electric car charging plaza located at the park (IPKW, 2018i). Also, there will be four wind turbines on the park's border next year (PM1, 2020).

There is also electricity is generated with running water by a watermill developed at the IPKW's incubator (IPKW, 2018i).

The goal of IPKW is that 2/3 of the total energy consumption is generated by wood, sun and wind (IPKW, 2018h).

Waste

There is a shared materials bank at the park where waste is collected separately to be reused for new products and raw materials (IPKW, 2018i). The waste collected includes plastics, organic waste, wood, and paper. The collected waste is transformed into new products or used as raw materials by companies at the park (IPKW, 2018i). The collection bank can be seen in Figure 4.6.

Figure 4.6: Waste collection bank (IPKW, 2018h)

Wood is collected and used for the biomass boiler. Plastic is processed and transformed into new products by Save Plastics, a company located at the park (IPKW, 2018i). Save Plastics makes benches from the plastic waste from other companies at the park. Then, benches are bought by IPKW and put around the park (IPKW, 2018i). Today, there are ten of these benches spread around the park.

In this project, other companies located at the park also participated. Apetrots designed the benches, the wood was made by Platowood, and the frame plastic frame was made by Save Plastics (CA5, 2020).

The interior of the restaurant at IPKW is also made of residual waste from companies at the park. The restaurant has fiber cloth lamps made by Freudenberg, chair legs made by Accsys Technologies, bucket seats of aramid made by Teijin, and tabletops and seats made from PET bottles. Besides, part of the old furniture was refurbished with sustainable modified wood from Platowood and Accsys Technologies (IPKW, 2018i).

Furthermore, there is also an office of fifty square meters at IPKW that was made of old plastics (PM1, 2020).

Mobility

The park gives a lot of importance to sustainable mobility. IPKW functions as a pick-up, drop-off, and charging hub for Amber Car with more than 70 charging points (IPKW, 2018d).

There is also a pilot project focused on sharing ten e-bikes inside the park available for IPKW residents. These e-bikes can be used in or outside the park. The project was built between IPKW, HAN, Slim & Schoon Onderweg, and VNO-NCW to foster the use of bike-sharing and public transport instead of the car (IPKW, 2018d).

IPKW has been offering the park tenants a free electric shared car in the last few years. The use of an electric car may incentivize tenants to choose an electric car for their next car (IPKW, 2018i).

Another recent project is where distribution packages are delivered in electric cargo bikes instead of delivery buses inside the park. This project reduces CO2 emissions on the site (PM1, 2020).

Furthermore, together with HyGear, NedStack, HyMove, HAN Automotive and Arnhem city council, IPKW is piloting and testing hydrogen technologies such as a filling station and cars (IPKW, 2018e; IPKW, 2018h).

Buildings

The buildings on the park are owned by the Schipper Bosch family. Buildings at IPKW were renovated with new climate control and new designs aiming for an energy Label A (IPKW, 2020c).

IPKW tries to reuse the buildings' existing materials as much as possible in the redevelopments (IPKW, 2018i). For example, IPKW works with demountable walls to be easily redesigned when needed to grow or shrink spaces (IPKW, 2018i). Besides, sustainable modified wood is used as much as possible in buildings. IPKW is trying to avoid building in steel and concrete and is using wood because it is more sustainable (PM1, 2020). The sustainable wood comes from Platowood and Accsys, two tenants of the park (IPKW, 2018i).

People

In IPKW, collaboration and working together are crucial. Therefore, involvement and social responsibility also play an important role. Interactions among people are fostered through events and sports at the park (IPKW, 2020e).

IPKW believes in an inclusive society, so the park helps people with occupational disabilities. The packages delivered with cargo bikes inside the park are delivered by people with a distance to the labor market. Therefore, this project gives job opportunities to people who are struggling to find a job besides reducing CO2 emissions (PM1, 2020).

4.2.4 Vision and ambition

In 2003, the park was bought from AkzoNobel by Schipper Bosch with the goal of transforming it into a sustainable ground for cleantech companies that focus on themes such as energy and innovation (IPKW, 2018i).

Since the park was bought, the vision was to transform the industrial estate into a sustainable ground. The director has the ambition of becoming circular and the most sustainable park in the Netherlands by 2025 (PM1, 2020). IPKW aims to make the park completely circular where its operations do not affect the environment and nothing needs to be purchased from the outside.

IPKW wants to become the leading example to industrial sites of how to make the whole utility supply sustainable (CA4, 2020).

The vision of how the director wants the park to look is a few decades ahead, contributing to its success (PM1, 2020).

As explained by an interviewee, "*They have certain ambition and vision about being the most sustainable park. And I think that's what makes them strong"* (MA3, 2020).

IPKW is also aiming to involve education in the park. IPKW was a production site before, however they want to become like a campus where there is production, but also R&D and education. Today, there are a lot of students from the HAN at IPKW working with the companies on different projects (PM1, 2020).

As explained by the respondent, sustainability and education are their main goals. *"Those two goals, involving education in the park and becoming the most sustainable place for production in the Netherlands, this is where we work on quite hard"* (PM1, 2020).

Even though the park aims to become the most sustainable park in the Netherlands, due to its second goal of involving education, IPKW is not seeking to become entirely symbiotic like Kalundborg. This decision was made because IPKW has big production companies but also startups that do R&D. Besides, on the contrary to Kalundborg, there are a lot of events and students around IPKW (PM1, 2020).

This was clearly explained by the director of the park. *"If we want to be an eco-industrial park on the scale that they are (Kalundborg), we cannot make it like a campus. We have to make other decisions. And I don't want that. I think it's important to become like a campus, like a small village. We are like a gated community" (PM1, 2020).*

The vision and ambitions of IPKW are portrayed in the "Future Map", developed by the director. The map shows how he wants the park to look in a clear and appealing way. He printed the map in ten meters by ten meters size for exposure to employees and visitors and put it on the building so nobody could miss it (PM1, 2020). A Future Map is also given to the visitors of IPKW so they can understand the vision easily and in a visual way (PM1, 2020). With this, employees and visitors know what IPKW is aiming for and can be motivated to achieve this vision.

A respondent explained this. *"I made a future map. We printed it like 10,000 times. So everybody who was here in my office, I will give a future map for years now. And that's the vision that we want to go to. It's very easy to understand" (PM1, 2020).*

Even though the Future Map started only as a vision, the ideas and projects displayed have been slowly achieved through the years. Nonetheless, it is not sure that all the projects portrayed in the Future Map are going to be implemented. As explained by the director, synergy projects require an incremental process that needs small steps. There is not a specific roadmap of how to do this (PM1, 2020). This was explained by the respondent.

"So where we end? I couldn't tell so and I still can't tell where we will end. And I also can't tell exactly what are the steps we have to make. Because it's such an incremental process " (PM1, 2020).

Table 4.16: Overview of vision and ambition in IPKW.

Factor: Vision and ambition	Type of factor	Number of codes
Private initiative	None	3
Sustainable vision	Success	12
Future map	Success	5

4.2.5 Location-specific physical features

IPKW is the base of innovative companies in Arnhem (MA3, 2020). There are plenty of companies at IPKW that relate to energy transition and together form a cluster (RI1, 2020 and MA3, 2020).

Every company in the park has similar ambitions of becoming cleaner and circular (CA4, 2020 and MA3, 2020). This makes a common ground that facilitates cooperation (CA4, 2020). Because companies at IPKW are innovative and have the same ambition of becoming more sustainable, collaborations are more likely to happen *(CA5, 2020).* These aspects are attractive for other companies to join the park.

The director explained the complementarity and synergy between companies. *"We are not a cheap place. So if you want your company here on the site you come here because of the ecosystem. And because of the synergy that's possible between you and the other companies" (PM1, 2020).*

A respondent from a company confirmed the latter. "*There are other companies located with which you can collaborate to even develop more innovations. So that why we decided to move to IPKW"* (CA5, 2020).

The short distance between companies also helps companies to find solutions together (CA4, 2020). Because of the short distance, employees can go around the park and see some other companies' projects. Cooperation with a mutual advantage has happened by coincidence with employees having a walk around the park and seeing a piece of equipment from another company that could benefit them. They started to make tests together (RI1, 2020).

Proximity also enables the HAN to collaborate with IPKW. The HAN chose to put their labs at the park because of the proximity (RI1, 2020). As explained by the manager of one of the laboratories,

"And across the hallway, within the building itself, you have the HAN University of Applied Sciences. You can easily go there and interest students for your company, you can try to do some projects with them. So then the threshold to actually start a cooperation will be very easy" (RI1, 2020).

Table 4.17: Overview of location-specific physical features in IPKW.

Factor: Location-specific physical features	Type of factor	Number of codes
Complementary companies	Success	6
Short distance between companies	Success	4

4.2.6 Location-specific social features

The social features at IPKW are mainly positive, however, there are some aspects where it can improve.

IPKW is a park with a collaborative culture. Companies at the park are willing to help each other and work together (CA4, 2020). They are flexible and open, so it is easy to see where they can help each other so all involved parties can and profit from cooperation. This was explained by an interviewee (RI1, 2020).

"Due to the flexibility and openness of both parties in such project, it's easy to also see where you can help one another and where you can profit from one another" (RI1, 2020).

Besides laboratory facilities, workshops and machines are shared at the park if needed (RI1, 2020).

Communication is good between some actors. The park management is easily approachable by the companies and there is a good relationship between them (RI1, 2020). There is also a close relationship and constant communication between IPKW and the municipality of Arnhem because they are developing the project Connectr together (MA3, 2020).

Veolia has good communication with the companies that are connected to them (CA4, 2020). This enables creating new opportunities because Veolia knows the companies' inputs and outputs.

However, the communication between the companies inside the park, excluding Veolia, could be improved. This was explained by a respondent. *"It would be worthwhile, I think, and also enhance the value of the of the location of the industrial state as a whole, If it would be possible to find a way to get that interaction more easily" (RI1, 2020).*

Lack of communication and interaction also causes that industrial companies at IPKW only focus on their own plant and their own processes. They do not look at the surroundings. It is important to consider that any deals made with companies related to utilities may impact the whole park. However, this is not seen by the individual companies. It is only seen by Veolia (CA4, 2020).

A respondent explained that companies are not aware of what happens outside their plant. *"The industrials take their own actions to have their plants more sustainable, but they only look at their own thing, they are not looking at the total park" (CA4, 2020).*

Another interviewee confirmed that companies are not aware of their surroundings. *"From some big companies, I know more or less what they do. But there are smaller ones, which I don't even have any idea what they are doing or where they are" (RI1, 2020).*

If every company at the park knew what other companies at the park are doing, more cooperation and synergies could be created (RI1, 2020).

A success factor is that at IPKW, there is joint problem-solving. Companies at the park collaborate with the HAN constantly. Companies share their problems with the HAN to support the companies with research or practical work (PM1, 2020).The HAN contributes to projects that companies are working on, but they also come with new initiatives (CA5, 2020).

For example, the HAN collaborated with IPKW to develop the shared mobility with the e-bikes project and with Save Plastics by doing research in bioplastics.

There are other examples of joint-problem solving and cooperation. Save Plastics and Airhunters cooperated to make the outside of a new office only of plastic waste. Besides, Save Plastics has cooperated with Time Shift energy, another company inside IPKW, to store energy from the solar

panels installed in their Safe Home, a house entirely made of recycled plastic. Some companies in the park also give their plastic waste to Save Plastics, who makes benches out of it. These collaborations would not have been possible somewhere else (CA5, 2020).

Startups also go to the labs inside IPKW owned by the HAN to ask for help in specific engineering fields where they do not have the required knowledge. The HAN shares knowledge with the companies and cooperates with them to develop new projects. This was emphasizd by a respondent

"They were not very knowledgeable in that specific engineering field. We said well just come to us and we'll help you with that" (RI1, 2020).

Besides, labs' facilities, workshops, and machines are also shared with companies inside the park (RI1, 2020).

Furthermore, whenever IPKW has a new project idea, they prioritize working with companies located at the park, as claimed by a respondent.

"We don't do those things alone. We always work together if we can with people from the park and if it's not possible from the park, people related in the city of Arnhem or close by" (PM1, 2020).

The recruitment is also tackled collaboratively at IPKW. Finding technically skilled people in the Netherlands is not easy. Therefore, IPKW and companies at the park, such as Veolia, join forces to promote the site and attract more engineers (CA4, 2020).

Knowledge sharing is also important at IPKW. Knowledge among IPKW's actors is shared during events. More than a hundred events occur every year at IPKW, where knowledge sharing is central. Events focus on themes important for developing a circular future, such as building and area development, energy, waste, people and mobility (IPKW, 2018i). Companies of the park, outsiders, entrepreneurs, politicians, startups, designers and managers assist in these events.

IPKW encourages encounters and knowledge sharing between tenants are with a shared restaurant inside the park (IPKW, 2018i).

Veolia also shares its knowledge with other companies in other minor aspects, such as applying for new permits. This was explained by a participant. *"Because I'm very experienced in a particular permit, because we have the largest one on the site, it's easier that they can come to you like, we have this problem, do you know a solution?*" (CA4, 2020).

Furthermore, IPKW will reinforce knowledge sharing and cooperation with a project called Connectr. This project has the objective of building an innovation lab in the field of energy efficiency and energy transition. The project is being developed by big energy production companies, startups and scaleups from IPKW, the HAN, and the University of Nijmegen, the municipality of Arnhem and the province of Gelderland (PM1, 2020).

Finally, a barrier that hampers the social features is that the understanding between Veolia and IPKW, when they work together on new projects, is sometimes hard. Veolia looks at the technical part of the projects and IPKW at the managerial side, making it difficult to communicate sometimes**.** This barrier was explained as well by a participant. *"IPKW and Veolia, we don't always speak the same language, because Veolia is a very technical partner. The other industrials, we are more*

understanding of each other. So that makes the conversation easier when you try to look at new opportunities" (CA4, 2020).

Table 4.18: Overview of location-specific social features in IPKW.

Factor: Location-specific social features	Type of factor	Number of codes
Collaborative culture	Success	8
Easy communication	Success	4
Companies focus on their core business	Constraining	2
Joint problem solving	Success	11
Knowledge sharing	Success	3
Lack of understanding between different actors	Constraining	1

4.2.7 Business-specific features

There are some specific characteristics of the companies at IPKW that are important to consider.

Companies in the park are sustainable in the way they think, work and manufacture. They have a vision with sustainable solutions that aim to make the planet a better place (PM1, 2020). Even though there are different sized companies at IPKW, all of them have high sustainability targets and want to be innovative (CA4, 2020). The sustainability vision and strategy of IPKW and companies inside the park attract new companies to join the park (RI1, 2020).

Also, companies that participate in synergies and stream exchanges require or generate a huge amount of waste. Production companies with a higher volume need for utilities are connected to the network and have a direct agreement with Veolia. However, not all the companies inside IPKW are connected to the heat network. Small companies are not (CA4, 2020). This shows that only big companies participate in synergies because smaller companies sometimes do not even generate or need the streams.

Save Plastics is a smaller company that is not able to reuse all the plastic waste generated in the park because they do not have the resources and storage to handle that much plastic. Therefore, new synergies with other companies are not able to happen. More capacity would mean more waste exchange and more plastic processing to new products. A participant explained this situation.

"They call us a lot of time and we often have to disappoint them because we don't have that much storage because we already have enough plastic waste from the municipal sources" (CA5, 2020).

Companies at IPKW also have an entrepreneurial mindset. Interviewees emphasized that an entrepreneurial mindset is required for companies to take part in synergies and cooperation, as explained by the respondent.

"There should be a preparedness, a willingness to think outside the box and outside your own factor" (CA4, 2020).

At IPKW, every company at the park has an entrepreneurial mindset and wants to be innovative and create new projects that pursue sustainability and become cleaner for the future (CA4, 2020).

Financial capacity is also important. Industrial companies with the capacity to make investments are the ones that join the heat network. Some smaller companies prefer to keep their old production system than joining the heat network because of the expensive costs (CA4, 2020). Hence, companies

need to be financially capable of investing and innovate to make their production processes more sustainable and participate in synergies. It is important to remark that some non-industrial smaller companies that do not have production processes are not connected to the network.

Another characteristic is that IPKW is disposed to make long-term investments. he owners of IPKW do not consider selling the park to make short-term money. They have a long-term vision and invest all the money back into the park to make it more attractive for companies to join the park. They are willing to have no profits in the short-term to become more sustainable (PM1, 2020).

IPKW has invested in projects that do not have an instant benefit and take too long to develop. Examples of this are the gatehouse, the park restaurant and the construction of a heat network in

Willingness to collaborate with other companies is necessary for synergies to happen (CA4, 2020). At IPKW, companies are enthusiastic and willing to make an extra effort to pursue their sustainability vision and goals, as remarked by a respondent. *"The enthusiasm of the parties involved, to go the extra mile, so to speak, to really make a bit of effort to make the project worthwhile"* (RI1, 2020).

Companies are not the only ones that have the willingness to perform as best as possible. Willingness is also shown by the park management (CA4, 2020).

Also, the success of IPKW relies partly on partnering with Veolia. Veolia makes the whole utility supply sustainable (PM1, 2020). Veolia acts as the spider in the web because every company is connected to them. Veolia takes care of everything the tenants need, from energy, drinking water, treating wastewater or whatever other utility they need (CA4, 2020).

Thanks to Veolia, stream exchanges are possible. Besides delivering utilities, Veolia also communicates with the park companies to find more efficient solutions on how to deliver and exchange streams (CA4, 2020).

A barrier between IPKW and Veolia emerges when there is a new idea to implement a project because Veolia moves much slower than park management. Veolia is a company that cannot stop its operations because the utility supply of the whole park depends on them. Any innovation needs to function in safety and other aspects before being implemented. Therefore, Veolia deals with R&D, safety tests, backup systems, and permits, making the implementation of any synergy slow (CA4, 2020). On the other hand, IPKW does not have to deal with technical issues, and hence their part of the project is faster.

Table 4.19: Overview of business-specific features in IPKW.

Factor: Business-specific features	Type of factor	Number of codes
Sustainability vision	Success	8
Companies that require/generate a huge amount of waste	Success	1
Entrepreneurial mind	Success	4
Financial capacity	Success	2
Industrial type companies	Success	1
Disposed to make long term investments	Success	2
Willingness to commit	Success	5
Spider in the web	Success	2
Different industral standards	Constraining	5

4.2.8 Proposed measures

Proposed measures for synergies, cooperations and new projects may come from different actors. Initiatives may come from the HAN. As explained previously, they cooperate with companies constantly. The HAN can either contribute with knowledge and applied work to existing projects or come with new ideas. For example, they helped Save Plastics with research on new uses for recycled plastic (CA5, 2020).

Sometimes the opportunities for synergies are identified by Veolia. Veolia is connected to every company at the park so they can see the flows that go in and out of every company. They can identify new opportunities, such as reusing waste heat generated by one company in another company (CA5, 2020). This was described by a respondent.

"We can help them see a better solution, which is actually more environmentally friendly. Because they only see their own production environment, they don't see what's happening with their neighbors" (CA5, 2020).

Sometimes, the park management comes with new ideas of synergies. For example, they had the idea of doing some studies to see what waste from companies could be reused. Veolia is always involved in doing feasibility studies of any new project ideas related to utilities that the park management has (CA5, 2020).

Table 4.20: Overview of proposed measures in IPKW.

Factor: Proposed measures	Type of factor	Number of codes
By research institutions	Success	3
By companies themselves	Success	5
By park management	Success	2

4.2.9 Organisation of decision-making

IPKW is a private project. The Schipper Bosch family is the owner of the land and buildings (IPKW, 2018i). Therefore all the decisions are made by the director and the owner of the park. They decide which direction to go (PM1, 2020).

Since Veolia is the owner of the power plant and water treatment plant and partnered up with IPKW to supply all the utilities to the companies at the park, they are involved in some decisions (PM1 2020).

The municipality and the province were not involved and are still not involved in making decisions. They are important partners and stakeholders, but they do not have a role in decision-making. As one respondent defined, being a privately owned eco-industrial park is a rare situation (PM1, 2020).

Since IPKW is the only decision-maker together with Veolia on some projects, there is no need to wait for municipalities to approve projects. They have some freedom to operate. In the process of getting approval from other parties, plenty of projects may fail. One respondent emphasized the benefits of being the only decision-maker. "*In that process, a lot of other industrial parks will lose momentum and support and won't get as far as they initially hoped to get" (PM1, 2020).*

IPKW has its own park management organisation that does the management, oversees the facilities and does different technical tasks in the park (PM1, 2020; IPKW, 2018d). The park management is comprised of 15 employees, a big number if compared with other industrial sites in the Netherlands (*PM1, 2020).*

The park management is in charge of organizing events, maintaining the facilities and selecting the companies based on the complementarity to other companies. However, the opinions of companies on the site are also considered to select the companies (PM1, 2020).

With only one decision-maker, IPKW can focus on doing. They do not focus as much on research and do not look at the science that is behind the projects. They take action instead of spending too much time on research and getting approval from other parties as explained by a respondent(PM1, 2020).

"*We just do, we're not doing a lot of research and we don't look for the science that is behind the projects. And we just want to do, and we take small steps, which in the end become altogether a big step. And that's important" (PM1, 2020).*

When IPKW sees an opportunity of a new project, they act and see on the way what are the next steps to take. This characteristic of IPKW was emphasized by a respondent. *"I think that is also a strength of IPKW they see a lot of chances. And they don't know where they end but they take them and going to build them. And so they will collapse and also they'll succeed. They see chances and they get a take them"* (MA3, 2020).

IPKW is the one that decides which infrastructure to implement in the park. The decision of implementing the biomass boiler was made between IPKW and Veolia. However, companies are the ones that choose if joining the projects, such as the heat network.

A barrier is that in terms of money, the HAN has a limited budget and can only cooperate with IPKW or companies in some projects if the municipality or the province have authorized a grant (RI1, 2020).

Lots of interests

Another barrier in decision-making is that since many companies involved at the park, Veolia, as the manager of the utilities, has to deal with the conflict of interests of the different companies (CA4, 2020).

Table 4.21: Overview of organisation of decision-making in IPKW.

Factor: Organisation of decision-making	Type of factor	Number of codes
One decision-maker	Success	10
Take action in the short-term	Success	4
Companies decide what projects to pursue	Success	1
Different decision-making models difficult cooperation	Constraining	2
Lots of interests	Constraining	2

4.2.10 Policy instruments

Facilitator

At IPKW, there are two facilitators, the park management and Veolia. The park management enables interaction between actors by organising events and connecting companies to cooperate in different projects. Veolia is responsible for handling the utilities and advice companies if they can join any other synergies.

Veolia functions as the "spider in the web" because every company is connected to them. Every company at IPKW depends on Veolia.

Companies cannot see what is happening with their neighbors, but thanks to Veolia, more sustainable solutions can be found. Veolia can see the inputs and outputs of all the companies at the park and suggest more environmentally friendly solutions with their flows (CA4, 2020). This was explained by an interviewee. *"We sometimes say we have waste heat over there that we might be able to use for you. And then you don't need a new gas solution, we can do a different thing. And that is the value for us, to be able to talk to all these people" (CA4, 2020).*

When IPKW has an idea of a new project, they always try to involve companies and people at the park (PM1, 2020). IPKW connects all the different topics and projects. They recognize opportunities and link the companies depending on their abilities. This was emphasized by an interviewee *"We don't do those things alone. We always work together if we can with people from the park and if it's not possible from the park, people related in the city of Arnhem or close by" (PM1, 2020).*

The park management initiated a recent project to reuse the waste at the park. Different companies participated in separating and collecting waste to transform it into new products such as furniture. Companies inside the park that participated in this project include Klaas Kuiken, Luuk Wiehink, Teijin, Aramid, 4PET, Freudenberg, Accsys Technologies (Schipper Bosch, 2016).

IPKW is supportive of the companies at the park to accomplish their goals and set-up collaborations (CA5, 2020).

The park management enables the context for collaborations to occur. They facilitate encounters and connections by incentivizing workers to leave their buildings to the shared activities and areas with events, shared meeting facilities, and a restaurant (IPKW, 2018i). The park management organizes events where companies can interact with other firms inside and outside the park (CA5, 2020). Around 60,000 people assisted to the events in the last years (IPKW, 2020i). At the moment, there are some events held online due to COVID-19 (CA5, 2020). These events are good for networking and enable the possibility of finding partners for new cooperations.

A respondent remarked on the help of park management. "*it really helps to be able to have a facility that understands your desires and where you want to grow towards and be even helped with them"* (CA5, 2020).

IPKW also helps as much as possible the companies to fulfill their projects by providing adequate facilities for them and removing any burden encountered in the process. An example of this is IPKW lending an event room for half a year to Save Plastics to work on the Safe Home project. This event room was the only place in the park where they could work on that project and IPKW emptied the place and reserved it for them (CA5, 2020).

As explained in the opportunity identification, park management and Veolia as facilitators also come with new ideas for different projects at the park, which sometimes includes synergies.

Table 4.22: Overview of policy instruments/ facilitator in IPKW.

Factor: Policy instruments/ Facilitator	Type of factor	Number of codes
Connects actors	Success	4
Enables the context	Success	2
Helps companies look at their surroundings	Success	2
Removes burdens	Success	1
Initiates ideas	Success	3

Regulations

Regulations were mentioned as a big constrainer for synergies by most respondents. *"For us the biggest blocker is always the regulations. It is my headache, every month. And not just for IPKW" (CA4, 2020).*

Respondents agreed that regulations are a constrainer for innovations because they take time to catch up with new solutions (CA4, 2020 and CA5, 2020). Innovations are quicker than regulations and this problem is commonly found. Early adopters are particularly affected by lagging regulations (MA3, 2020). A respondent highlighted this issue.

"A lot of the things that we do is new, and the laws are not in place yet to actually the right restrictions" (CA4, 2020).

Pilots may help to change the regulations. Regulations are removed for the pilot, and if is successful, then the regulations are changed (MA3, 2020).

The Dutch government was also described as changeful. The government supported biomass in 2016 because it was seen as a sustainable option for energy generation. It was one of the best scoring projects for subsidies. However, now the public opinion is against biomass. Therefore, the government is not supporting biomass anymore (PM1, 2020). Furthermore, due to elections, the government council also changes. This also contributed to the government changing its stance about biomass (CA4, 2020).

Respondents agreed that the process to get permits with the government is too slow. Particularly, Veolia needs to deal with a lot of permitting, environmental restrictions, and a lot of law because they work with energy utilities, water flows and waste flows (CA4, 2020). The process to get the permits is a constrainer for the creation of new synergies, as explained by an interviewee.

"The biggest blocker is always regulations. The permitting process from the province and the national government is too slow and also too inflexible at the moment to do innovative projects. Especially on large scale but everything we do as Veolia is large scale. I could do a lot more if I could have those things go smoother (CA4, 2020).

Part of the inefficiency in the government's process to give permits may be because there is a different time-lapse in the government's decision-making because of the various layers such as the region, province and municipality (MA3, 2020).

Natura 2000 is also a barrier for IPKW. This nature organisation is against nitrogen emissions and therefore makes it difficult for IPKW to get permits to make new buildings for companies. Every company has a permit for nitrogen emissions, but this is a problem for the newcomers.

There are discussions on solving this by summing the total amount of nitrogen emitted by companies of IPKW as a whole and using the remaining space for the new companies' emissions. At the moment, there is no solution on how to fix this (MA3, 2020).

However, regulations also have a positive impact on synergies. The government has the ambition of becoming 50% circular by 2030 and completely circular by 2050 (CA5, 2020). Therefore, the government implements new regulations that bring them closer to this goal.

Companies need to comply with new emission targets for 2022 to reduce the national government's gas intake (CA4, 2020). Consequently, companies need to be innovative and take action to meet the new norms and help the government accomplish its goals (PM1, 2020). A respondent addressed this point. *'We were not asked or pushed, we were actually forced by the national government to reduce our gas intakes. And with the biomass boiler, we have reduced our gas intake with 84%"* (CA4, 2020).

Table 4.23: Overview of policy instruments/ regulations in IPKW.

Factor: Policy instruments/ Regulations	Type of factor	Number of codes
Lag behind innovation	Constraining	7
Changeful government	Constraining	5
Inefficient process	Constraining	7
Regulations on nitrogen emissions prevent activities	Constraining	4
National regulations force companies to be sustainable	Success	4

Park policy

The park policy is important at IPKW. The type of companies that are housed at IPKW must have a sustainability theme and focus on cleantech. Cleantech includes companies that aim for a circular economy, energy transition. IPKW also houses companies related to fibers because that is the heritage of IPKW (PM1, 2020).

Companies are selected on their complementarity to other companies. Companies on the site are asked what kind of company is missing and what kind of company they need and after, park management searches for those companies (PM1, 2020). The park uses a balloting system in which it is asked to the companies which tenant fits and which does not (IPKW, 2018i).

IPKW houses large scale manufacturing companies in the processing industry up to and including environmental category 4 (IPKW, 2018b) but is also a place for design and R&D, including small start-ups (IPKW, 2018f).

IPKW is strict with the selection of companies. IPKW stood up for its vision and ambition even though there were tough times during the economic crisis. IPKW preferred to reject money from tenants that were not complementary to the park (IPKW, 2020i).

Table 4.24: Overview of policy instruments/ park policy in IPKW.

Factor: Policy instruments/ Park policy	Type of factor	Number of codes
Contribute to circularity	Success	2
Strict with their selection	Success	2

Other policy instruments

The government uses other policy instruments to support synergies, such as subsidies used for research and development for circular economy and innovations that help companies expand and innovate. These subsidies help companies innovate and engage in more cooperations (CA5, 2020).

For example, there is a subsidy called Sustainable energy investment subsidy. Biomass projects were the best-scored project for this subsidy. Therefore Veolia and IPKW went for the option of installing a biomass boiler (PM1, 2020).

Recently, a subsidy was given by the municipality of Arnhem for the project Connectr, which supports research for an energy transition (MA3, 2020).

However, more subsidies could be given to startups. Startups produce a lot of innovations in the field of energy and circular economy but struggle to sell their first products. The municipality does not give enough support for this issue. A solution would be that the municipality saves some money to buy those first products. This would help tackle product problems early and simplify selling the next products (PM1, 2020).

The municipality is aware of this difficulty for the startups and plans to do something to change it.

Being known as an EIP helps IPKW to attract companies (PM1, 2020). Since 2015, IPKW focuses more on communicating what the park is doing to become the leading example and attract more companies (PM1, 2020). Furthermore, IPKW is good at selling their story so it helps to attract more companies that fit the park (CA4, 2020). The local government also supports IPKW with promotion to attract more companies to the park (CA4, 2020).

The promotion of successful synergy projects draws a lot of attention. Therefore, new companies may get interested in recycling their products or using the product that resulted from the synergy. It is about creating awareness (CA5, 2020). This happened to Save Plastics, when the Save Home project, a house-made with bricks from residual plastic waste, was a success and raised awareness. More companies approached Save Plastics to ask if they could cooperate with them on a new project (CA5, 2020). This was explained by a respondent.

“Awareness is also a factor because when you see our material you wouldn't know it was plastic. So the story isn't known when you see the material in the city. But because you do something good it

does help with awareness and people knowing your name. And because of that new collaborations can form" (CA5, 2020).

Table 4.25: Overview of policy instruments/ other in IPKW.

Factor: Policy instruments/ Other	Type of factor	Number of codes
Subsidies	Success	8
Promotion	Success	9

4.2.11 Economic features

Having a business case was repeated as a success factor. Before taking part in a synergy project or innovation, companies must have a business case and profits. Companies cannot do innovations all the time. CAPEX, OPEX and investors are important in new projects. The project needs to be feasible in the end. Money is required to pay the employees, and then the leftover money can be used for synergies, R&D and new technologies (CA4, 2020). This was clearly remarked by an interviewee.

"We cannot be innovative all the time, we need to have a business, to create a profit and to have money to actually do R&D and to invest" (CA4, 2020).

Also, the biomass boiler was chosen because it was the only alternative to comply with the gas intakes asked by the government that was economically feasible (CA4, 2020). As it can be seen, a business case is a driver for every new synergy or innovation.

It is important to highlight that for companies to cooperate, there needs to be a mutual advantage (RI1, 2020). In other words, the participants of the cooperation must gain something.

It was also mentioned that having clear agreements is very important when cooperating with another company in any exchange that explains what happens in different situations (CA4, 2020).

Table 4.26: Overview of economic features in IPKW.

Factor: Economic features	Type of factor	Number of codes
Business case	Success	8
Every participant gains	Success	1
Clear agreements	Success	1

4.2.12 External context

The external context also influences the creation of synergies and sustainable projects at IPKW.

A success factor is that there is a lot of attention for the circular economy going on at the moment (CA5, 2020). This means that companies are more actively looking for new circular initiatives.

However, the external context has also had negative effects on IPKW. The way the markets work is difficult and makes too slow a transition to an energy or climate transition (CA4, 2020).

Besides, public opinion may negatively affect synergies between companies. At iPKW, social media and fake news have affected the projects going on at the park. Social media may shape public opinion with unbalanced information and can damage a project in development. As said by an interviewee, "*Public opinion can kill projects"* (CA4, 2020).

Furthermore, in the Netherlands, there are environmental groups that are against biomass. The biomass boiler at IPKW complies with every regulation and is successful in a technical field because gas is almost not used anymore. Still, some groups do not see it as something positive. Hence discussions are going on with the environmental groups about the real impact of biomass on the environment. Because of the discussion, Veolia gets its image negatively affected. Hence, other companies do not want to engage in cooperation with Veolia (CA4, 2020).

The Dutch government supported the biomass project with a subsidy, but there was a shift in their perception of biomass due to the change in public opinion (PM1, 2020). Now biomass projects are seen as bad for the environment. However, IPKW has to run the biomass boiler for 15 or 20 years to make it profitable (PM1, 2020).

Finally, human capital is an important factor in the context. An energy transition is not possible without the proper technical staff. There is a lack of technical personnel in the Netherlands and therefore, companies cannot grow at the desired pace. The lack of prepared applied engineers is slowing the realization of a circular economy (IPKW, 2018i). As mentioned before, companies at IPKW work together on recruitment because of the extreme difficulty of finding applied engineers (CA4, 2020).

Table 4.27: Overview of the external context in IPKW.

Factor: External context	Type of factor	Number of codes
Sustainability importance	Success	1
Market conditions	Constraining	1
Public opinion	Constraining	2

4.3 Case 3: Biopark Terneuzen in Zeeland

The information collected for Biopark Terneuzen in Zeeland is collected here. Four people were interviewed for this case.

The code for the interviewees can be seen in Table 4.28.

Table 4.28: Table of interviewees for Biopark Terneuzen

Eco-industrial park	Position	Participant ID
Biopark Ternezuen	Partner at Van de Bunt Consultancy	CONA1
Biopark Ternezuen	Partner at Van de Bunt Consultancy	CONA2
Biopark Ternezuen	Assistant Professor and Researcher	RI2
Biopark Ternezuen	CEO of TransForum Program	PA1

Participants' IDs will be used for simplicity. PM refers to park management actor, CA to company actor, MA to municipality actor, and PA to program actor.

The interviewees were involved with the park development or studied the park many years ago and are no longer related to the park. Therefore, the information for this park could not be updated. The analysis of the case starts with a description of what synergies are happening at the park. Then an explanation of the success factors and barriers to the creation of synergies follows.

4.3.1 Introduction

Biopark Terneuzen project started in 2007 (Spekkink & Boons, 2016). It is an agro park located in the Province of Zeeland in the Canal Zone area that applies industrial ecology principles to greenhouse farming and agro-processing industry (TransForum, 2009; van Waes & Huurdeman, 2009). Biopark Ternezuen is a project that found solutions for the linearity of processes in this industry (PA1, 2021).

The main goal of Biopark Terneuzen is to establish connections between the activities of existing and new industrial companies located in the Ternezuen Port area (TransForum, 2009) to promote the use of sustainable energy resources, improve energy efficiency, and reduce CO2 emissions (Chamber of Commerce of Molise, 2017). Besides, it also aims to attract new businesses to the park and generate more jobs (TransForum, 2009).

Biopark Terneuzen was built by linking different smaller isolated projects by smaller groups of companies that were already happening (CONA2, 2020). Companies in the area were interested in bioeconomy and were working on projects in bioeconomy and sustainability. Van de Bunt consultancy realized that these ideas could be linked and make something bigger.

Van de Bunt brought the separate initiatives together to a larger collaboration (CONA2, 2020). As a consequence, many parties near the area, such as companies, universities, the province of Zeeland, the municipality of Terneuzen, and Zeeland Seaports, were interested and asked TransFormum to do some studies regarding the technical and economic feasibility of exchanges (Santos, 2015).

TransForum paid for these studies and concluded that it was possible to make exchanges between companies at the zone. This was when Biopark Terneuzen was born, making the common ground in bioeconomy explicit (RI2, 2021).

As one respondent remarked, *"One element of success there was that they were building on things that actors were already doing. So that was not a completely new blueprint. But they were sort of building on interests and concerns and projects that were ongoing. So there is kind of a binding effect" (RI2, 2021).*

The park is running synergies such as by-products used as feedstock, shared installations for water treatment, and collective gathering and removal of waste materials (Chamber of Commerce of Molise, 2017; Spekkink & Boons, 2016). These activities are achieved with which the park promoters call "smart links" (Massard et al., 2014). By converting waste streams into smart links, companies' get value from residues that would otherwise get unused (Biopark Terneuzen, 2012).

According to Biopark Terneuzen (2012) the smart links have several benefits, such as:

- Eliminate storage and disposal costs
- Reduce environmental taxes
- Optimise production costs
- Improve yields
- Preserve non-renewable raw materials
- Reusing raw materials
- Reduce waste and pollution
- Contribute to sustainable industrial growth

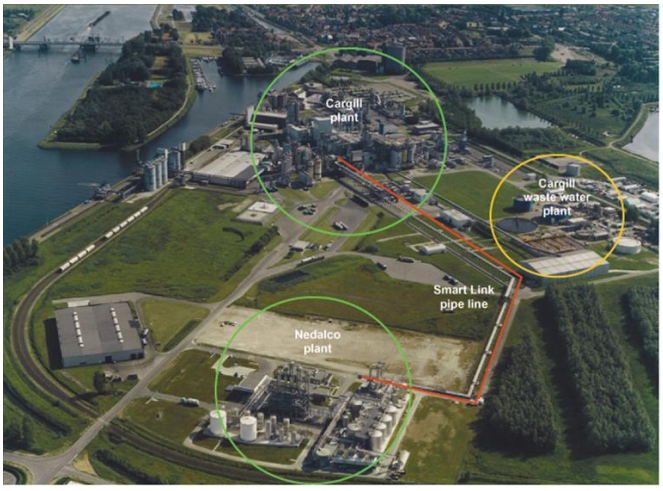

Figure 4.7: Overview of a part of Biopark Terneuzen and its smart links (PressRelease, 2008).

4.3.2 Key actors

There were 18 partners involved in the project. These partners included companies, Zeeland Seaports, the municipality of Terneuzen and the province of Zeeland. Respondents from Van de Bunt depicted Zeeland Seaports, the province of Zeeland, Yara and the municipality of Terneuzen as the most important actors for developing the park (CONA1, 2020). Van de Bunt is also considered because, in the planning phase, they played a crucial role.

The structure of the actors is shown in Figure 4.8.

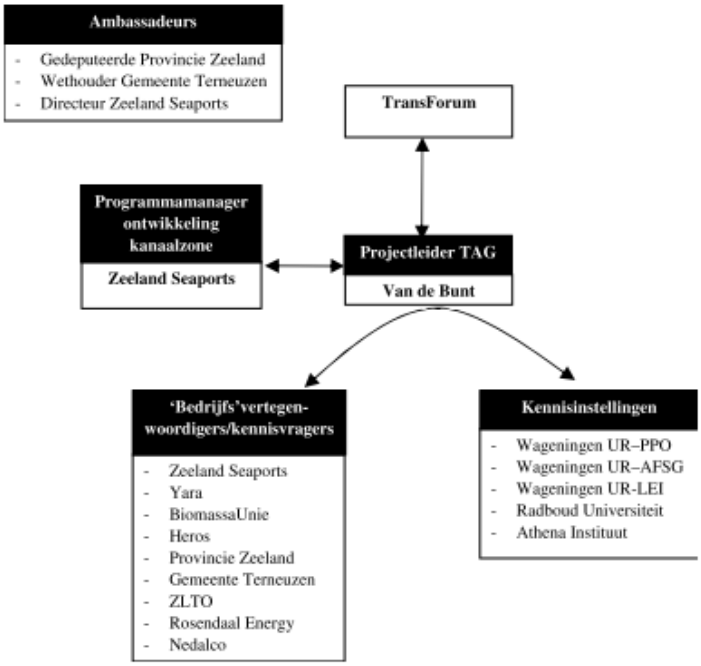

Figure 4.8: Role and responsibilities (van Waes & Huurdeman, 2009).

Province of Zeeland

The province of Zeeland came up with the initiative of Biopark Terneuzen. However, they did not know how to start or which direction to follow (CONA2, 2020). They also gave funds for the infrastructure of the project (PA1, 2021).

Van de Bunt consultancy

The Province asked Van de Bunt for help to find if something could be done related to agro parks in the area of Zeeland. They did a scan of the companies in the area and asked them one by one about their processes. Van de Bunt realized that exchanges of flows could be done between companies in the area (CONA2, 2020).

Van de Bunt was the project leader in charge of the organizational, soft side of the project, such as process management (CONA1, 2020). They selected Zeeland Seaports as the leaders of the project (van Waes & Huurdeman, 2009).

They were in charge of communicating, providing information, convincing companies to join and arranging meetings. They also contributed with some research about the possibility of exchanges (CONA2, 2020).

Zeeland Seaports

Program manager and leader of the project. They invested substantial money in infrastructure and put a lot of effort into the project (PA1, 2021).

Besides, they directed the communication between participants, including policymakers, stakeholders in the area and local and regional NGOs (van Waes & Huurdeman, 2009). Zeeland Seaports selected which companies could join the complex (CONA1, 2020).

Research institutions

They helped Van de Bunt to study further the feasibility of the synergies (CONA2, 2020). The research institutes provided companies with technical and feasibility studies related to greenhouse horticulture, energy, CO2, water management, and biomass. Knowledge institutions that participated include Wageningen University, Radboud University, the University of Amsterdam and Kortrijk College (van Waes & Huurdeman, 2009; TranForum, 2009).

TransForum Agro and Green

TransForum was a program to stimulate innovation. The program was started by the government, industry, societal organisations and five universities (PA1, 2021). TransForum had the objective of establishing new alliances between entrepreneurs and knowledge developers for a sustainable agriculture food sector (van Waes & Huurdeman, 2009).

TransForum helped with their experience, knowledge and financial support. They paid mainly for research to find stream connections and study their feasibility (PA1, 2021). Due to the uncertainty, risks, and limited readiness to invest at the beginning of the project, the support from TransForum was crucial (TransForum, 2009). They had a budget of 60 million euros (PA1, 2021).

TransForum participated because it was interested in getting knowledge out of innovative projects such as Biopark Terneuzen (PA1, 2021).

Yara

The presence of Yara was crucial for the formation of Biopark Terneuzen (RI2, 2021). Yara was pushing their project forward to find a solution to their waste streams and was enthusiastic about it (PA1, 2021). Therefore, Yara created WarmCO2 as a new company with the necessary infrastructure to process the waste and exchange their residual heat and CO2 with the greenhouses (CONA2, 2020).

Besides Yara, every actor involved in synergies is also a key actor. The role of these key actors is explained in the next section.

4.3.3 Performance/current state

The second sub-research question of *What are the industrial symbiosis and utility sharing activities happening at front-running eco-industrial parks in the Netherlands?* is addressed in this section. However, for this park, the question could not be entirely answered.

According to the literature, there are several stream exchanges happening at the park. The “smart links” between companies include the exchange of heat, CO2, biomass, water, electricity, steam and starch as shown in Figure 4.9 (Biopark Terneuzen, 2012).

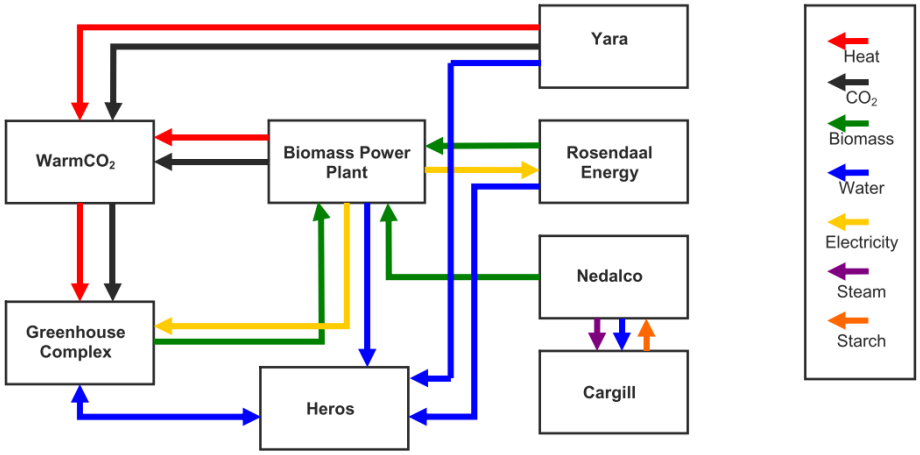

Figure 4.9: Map of the "smart links" (Biopark Terneuzen, 2012).

Not any people that are involved in the park today could be contacted. The contacted interviewees are not involved with the park anymore. Therefore the information of what is happening at the park today could not be updated. However, It seems that Biopark Terneuzen is not as strong as some years ago. This may be partly caused by plenty of former people who developed the initiative working for Yara, Zeeland Seaports, or the province are no longer working at those organisations.

The remaining initiatives are isolated but not as a part of a bigger project anymore (RI2, 2021). One respondent highlighted this *"This idea of the larger network that they were hoping to develop around it. I think that's more or less gone. They have just become sort of self-contained initiatives"* (RI2, 2021).

Still, an important finding is that contrary to what is shown in some papers such as in Massard et al. (2014), not all the exchanges shown in Figure 4.9 materialized. A new map considering the exchanges that interviewees stated did not happen and the ones they think are still happening is shown in Figure 4.10. However, the updated map needs to be confirmed by someone currently involved in the park because it may not be entirely accurate.

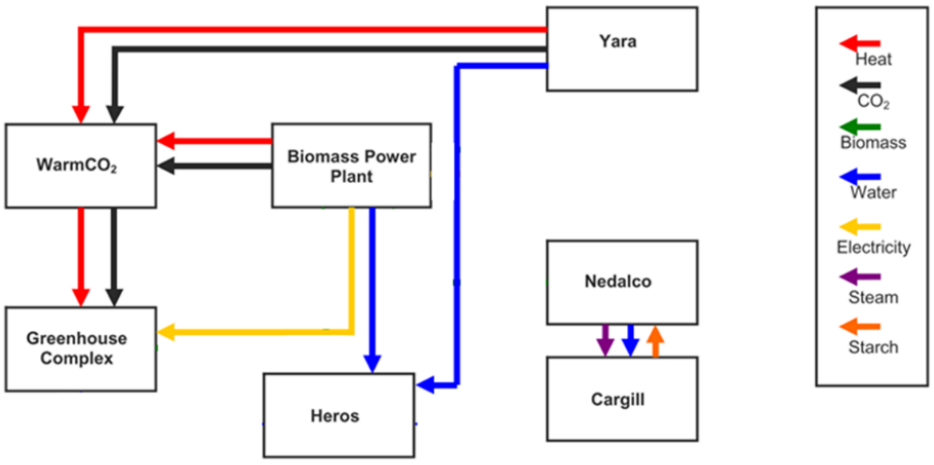

Figure 4.10 : Updated map of the "smart links".

Explanation of the exchanges

WarmCO2: Company that developed a technique to use residual heat and CO2 in greenhouse horticulture. The project was realized by Yara Sluiskil and Zeeland Seaports, who are now the shareholders. Residual heat and CO2 from Yara flows through underground pipelines and arrive at the horticulture greenhouses in Zeelandic Flanders. This gives the growers cheaper and more environmentally friendly heat and CO2 (WarmCO2, 2020). This exchange is apparently still happening (CONA2, 2020).

Greenhouse Complex "Zeeuws-Vlaanderen": Tomato, pepper and eggplant growers can be found at the greenhouse complex (North Sea Port, 2020). There are more than 250 hectares of greenhouses (CONA1, 2020). Residual heat and CO2 from Yara are reused at the greenhouse, allowing sustainable production.

The exchange of biomass between the greenhouse and the biomass plant apparently did not happen because the amount of biomass was too small (RI2, 2021). Apparently, the water exchange between the greenhouse and Heros did not happen either (CONA2, 2020).

Biomass power plant: A biomass plant was also built in the terrain of Heros. The biomass plant is still running. They get the biomass from different sources, such as manure (CONA1, 2020). They never received biomass from Nedalco because of a low volume of biomass (CONA2, 2021).

The biomass that was supposed to come from the greenhouse complex and Nedalco apparently did not materialize because the amount of biomass was too small (RI2, 2021).

Heros Sluiskil: Mining company produces and sells secondary raw materials obtained from recycling residual and construction materials (Heros, 2020). It seems that they still receive the water from Yara and the biomass plant. However, apparently, the exchange of water between Heros and the Greenhouse did not happen because of a low volume (CONA2, 2020). Also, Rosendaal Energy is not there anymore (CONA2, 2020).

Yara Sluiskil: Produces nitrogen (ammonia) fertilizers and industrial chemicals using North Sea gas (Yara, 2020). Yara delivers CO2 and heat to WarmCO2, and their wastewater to Heros. It seems that these exchanges are still happening (CONA2, 2020).

Rosendaal Energy: Biodiesel manufacturer which had waste collection, treatment and disposal and materials recovery as main activities. The company went bankrupt in 2009 (FaillissementsDossier, 2020).

Cargill: Company that develops products related to the food and agriculture industry in a sustainable way (Cargill, 2020). Cargill gives starch to Nedalco and receives water and steam from Nedalco. These exchanges existed before the park was formed (RI2, 2021).

Nedalco: Producer of drinkable and industrial alcohol that was acquired by Cargill in 2011 (Cargill, 2020). The connection between Nedalco and the biomass plant was not made at the end. It was an opportunity, but after doing feasibility studies, it was not implemented (CONA2, 2020).

4.3.4 Vision and ambition

Visit an existing EIP

After realizing that there were several independent projects related to sustainability in the area, the Port authority of Zeeland, the municipality of Terneuzen and the province of Zeeland went on an excursion to Cargill in Canada, where they visited an existing EIP. They realized that a similar park concept could be built at Terneuzen. The visit was one of the reasons that inspired the initiative Biopark Terneuzen (RI2, 2021).

Other successful EIPs such as Kalundborg are often a source of inspiration for other EIPs initiatives. The Rietvelden park initiative in Den Bosch was also inspired to some extent by a visit to Kalundborg. Kalundborg is commonly an example of how to make industrial parks more sustainable (RI2, 2021).

Province's initiative

After having the concept of an EIP already in mind, the Province of Zeeland released a document that highlighted their interest in working with clusters. One of the objectives of the province was to invest in Zeeland to compete with the Port of Rotterdam somehow (CONA2, 2020).

Van de Bunt, a consultancy, was hired by the province to study how to create a cluster (Santos, 2015). The province gave Van de Bunt only one text line: we want to do something related to agro parks (CONA2, 2020). After this, Van de Bunt went to talk with companies in Zeeland, such as farmers of potatoes, onions, and tomatoes, to search for opportunities to make an agroproduction park (CONA2, 2020).

After Van de Bunt convinced the companies to join the project, approximately over a two-year period, meetings were organized to align the vision where every stakeholder participated (CONA1, 2020 and RI2, 2021).

The development of the vision was a collaborative process (RI2, 2021). An alignment was easily reached because exchanging flows has plenty of benefits from a technical point of view, and that was attractive to companies (CONA1, 2020).

The agro park's vision is to use the waste streams of one plant can be used by another plant (CONA1, 2020) to decrease environmental emissions of agricultural and industrial activities in the region (Spekkink & Boons, 2016).

As explained by van Waes & Huurdeman (2009), there were three different ambition strategies considered that varied from light forms of cooperation to ambitious goals:

- Limit the project to the exchange of flows and energy between companies.
- Transform Biopark Terneuzen into an important cluster in biobased economy and put Biopark Terneuzen as an important cluster on the map.
- Collaborate with Ghent Bio-Energy Valley to function as the number one European center of biobased economy.

Collaborating with Ghent to become the European center of biobased economy was chosen as the best option.

Initially, the project aimed to make cooperation between Terneuzen and Ghent. It was supposed to be a cooperation between industries and borders. However, doing a cross-border project was too complicated, so the scale was reduced to only Terneuzen.

Figure 4.7 shows the vision of Biopark Terneuzen. It shows the ideal scenario with the maximum possible synergies within the network that could be made in the area, considering the different projects that were going on already (RI2, 2021). After the possibilities were considered, the feasibility studies were made to see if they were possible financially and logistically (CONA2, 2020).

As explained previously, not everything shown in figure 4.7 was implemented. There were variables such as the financial crisis or the amount of waste generated that were an obstacle for new synergies to happen (RI2, 2021).

It is not strange that not all the exchanges were implemented because an EIP is a really complicated process and therefore, not all the projects will occur as planned. This is explained by a respondent. *"I think a vision is something to lead your activities, to take us a guidance of your activities. But of course, in this kind of complex process, things usually don't work out exactly as you hope they will. And there's a lot of things out of your control" (RI2, 2021).*

Table 4.29: Overview of vision and ambition in Biopark Terneuzen.

Factor: Vision and ambition	Type of factor	Number of codes
Visit an existing EIP	Success	4
Province's initiative	None	4
Develop vision collaboratively	Success	5
Sustainable vision	Success	2
Future map	Success	5

4.3.5 Location-specific physical features

The high diversity of industrial actors contributed to the success of Terneuzen (RI2, 2021). A great variety of industrial companies enables creating more synergies (Chamber of Commerce of Molise, 2017).

However, there were difficulties at the beginning in bringing greenhouse companies to the area. They had really few companies, making it difficult to make something interesting in the area (RI2, 2021). The more companies that are at the park, the more attractive the park becomes for other companies.

The proximity of companies is a success factor for synergies to occur. If a company wants to deliver a stream to another company, it may build a plant next to each other because a short distance between companies facilitates the delivery (CONA1, 2020).

For example, Yara was able to connect their streams to the greenhouses because of the short distance between them (CONA2, 2020).

On the other hand, an opportunity to exchange biomass between the greenhouses and Nedalco was not implemented because Nedalco was on the other side of the canal. A long-distance meant that the infrastructure for the connection was too expensive.

Table 4.30: Overview of location-specific physical features in Biopark Terneuzen.

Factor: Location-specific physical features	Type of factor	Number of codes
Complementary companies	Success	2
Short distance between companies	Success	2

4.3.6 Location-specific social features

A respondent highlighted that the synergies' social aspects are even more important than the technical ones (RI2, 2021). Biopark Terneuzen had a supportive social context. The park has a context where there is a collaborative culture. People know each other and can easily contact each other (RI2, 2021).

As with the other two cases, a barrier is that exchanging streams is not something companies were primarily interested in. Companies at Biopark Terneuzen mainly focused on their core business and their main products, not on their surroundings and not on their waste streams (CONA1, 2020).

Companies only focus on their core business and do not care much about their waste streams. As a respondent remarked, *"A greenhouse produces tomatoes, that's their core business, where the heat and CO2 come from they don't care as long as they have it"* (CONA1, 2020).

The lack of attention to other companies' processes is partly because many eco-industrial parks do not focus on exchanging main product streams. They focus on exchanging secondary streams (CONA1, 2020). If it is related to their main product streams and there is a business case by exchanging flows, companies find each other (CONA1, 2020). However, this does not happen with secondary streams.

For exchanging secondary streams and companies to realize the possibilities and benefits of exchanging streams with other companies, a facilitator is needed.

In the case of Biopark Terneuzen, thanks to Van de Bunt, companies got in contact and became aware of their surroundings.

After the project started, there was a sense of collective responsibility among the different actors. Besides, with Van de Bunt's intervention and meetings organized by Zeeland Seaports, companies developed stronger ties (PA1, 2021). People inside the park could interact and talk with each other about the project (RI2, 2021). Companies and people were easy to contact (CONA2, 2020). As explained by an interviewee at Biopark, *"Right people know each other. They are already somehow connected with each other. And it makes it easier to develop this kind of thing (EIP)"* (RI2, 2021).

Zeeland Seaports put a lot of effort in developing trust and forming a community. These meetings also contributed to the creation of trust between participants (PA1, 2021).

Besides, at the meetings, people shared their ideas about what projects they thought could be possible (PA1, 2021). Solutions were developed jointly at the meetings. For example, the ideal map of exchanges with the possible connections in Figure 4.9 was developed as a joint effort between all parties involved in the project (CONA2, 2020).

Another collaboration that emerged is that companies started a program called Biobase Europe, a cooperation between Zeeland Seaports and Ghent. In this project, companies collaboratively train

operators working in something related to bio-economy instead of training them individually (CONA1, 2020).

One responded highlighted that strong ties contributed to the success of collaborations. *"I think what also helps which is that you get this feeling of togetherness, all of a sudden, it's not Yara and Rosendaal running their plants, but it's these companies get a kind of joint responsibility for an area in Terneuzen" (CONA1, 2020).*

Another important factor is that there was a collaborative culture in Zeeland because people tend to know each other, making it easier to collaborate and create synergies (Chamber of Commerce of Molise, 2017). Furthermore, Biopark Terneuzen's development shaped a sharing culture between people at the park (RI2, 2021). This was to a great extent thanks to the big effort of Zeeland Seaports to promote interaction and forming a network. The project of Biopark Terneuzen gave the companies a sense of a collective identity (PA1, 2021). In a way, this increased awareness and cooperation among other companies (Chamber of Commerce of Molise, 2017).

A respondent highlighted the importance of a collaborative culture. *"With the parties in the region, there's kind of a collaborative culture. I think that's also not necessarily present everywhere. That probably also contributed"* (RI2, 2021).

It is important to remark that besides having economic and environmental benefits, synergies between companies also lead to other benefits on the soft side. These include cooperating in secondary projects such as the Biobase Europe training center, or approaching the government together (CONA1, 2020).

Another barrier in the social features is that Biopark Terneuzen's project involved the participation of companies, research institutions, the municipality, and the province. A variety of actors led to difficulties in the planning because it seemed that each actor spoke a different language. For example, companies had practical questions that they wanted to answer, but research institutes answered them theoretically. Also, the municipality had problems coping with the companies' entrepreneurial way of working (CONA2, 2020). It was not easy to align all the different goals (CONA2, 2020). To facilitate the understanding then project management must always be involved (TransForum, 2009).

"The different languages between universities, companies, municipality, and the province which were not that entrepreneurial. That was a difficulty" (CONA2, 2020).

Table 4.31: Overview of location-specific social features in Biopark Terneuzen.

Factor: Location-specific social features	Type of factor	Number of codes
Companies focus on their core business	Constraining	10
Companies know what other companies do	Success	1
Easy communication	Success	3
Trust	Success	1
Knowledge sharing	Success	1
Joint problem solving	Success	3
Collaborative culture	Success	2
Lack of understanding between different actors	Constraining	3

4.3.7 Business-specific features

There are some characteristics of businesses and actors at Terneuzen that facilitated the creation of synergies.

The Biopark Terneuzen initiative was inspired by the sustainable projects that were taking place before in the area (RI2, 2021). For example, Yara was already planning to give their extra heat and CO2 to the greenhouses. Companies were thinking of reusing streams suggests that companies had a sustainability vision before the Biopark Terneuzen project officially started.

Also, public bodies, such as the Port Authority, wanted to become a frontrunner in sustainability and bioeconomy (RI2, 2021). This shows that every actor must be aiming to be sustainable for an EIP project to go forward and for exchanges of streams to be created.

Furthermore, the companies' main attitude towards the Biopark Terneuzen project was positive (CONA2, 2020). Involved actors were committed to the project and actively participating (Chamber of Commerce of Molise, 2017). Yara was one of the companies that were really active and pushing their project of exchanging heat and CO2 with the greenhouses forward (PA1, 2021).

The companies housed at Biopark had a lot of industrial processes, which also facilitates synergy creation. There were a biofuel factory and a biomass plant (RI2, 2021). Also, Heros is a mining company. Yara is a big multinational that creates fertilizers and industrial chemicals. Housed companies are related to the industry. For example, Yara had a considerable amount of residual heat and CO2, which allowed greenhouses to use Yara's residual streams (RI2, 2021).

Some synergy initiatives failed because the supplier could not guarantee to deliver a specific amount of waste (CONA1, 2020). For example, an exchange of streams between Heros and the greenhouse complex did not happen because the amount of biomass coming from the greenhouses was smaller than imagined for Heros to have benefits (RI2, 2021). It was mentioned that it is also important that the technical specifications of the stream comply. If not, projects also fail (CONA1, 2020).

Interviewees emphasized that the most interesting examples of exchanges and industrial symbiosis are when companies make long-term investments and commit to exchange waste products (RI2, 2021).

An expensive infrastructure needed to exchange streams is not installed to exchange a small amount of streams. If a company decides to invest in infrastructure, it is committing for a long time because the investment is not recovered quickly (RI2, 2021). Therefore, companies that participate in an exchange of streams need to be willing to make long-term investments.

Companies that participated in the project had an entrepreneurial mindset (CONA2, 2020). However, public bodies such as the municipality of Terneuzen had some trouble working with an entrepreneurial thinking way. They did not have it (CONA2, 2020).

It was highlighted that participants of synergies need financial capacity to make investments. The constructions of pipelines to exchange streams are very costly. Not all companies are able to and willing to make such an investment (PA1, 2021).

The huge amount of money invested by TransForum Agro and Groen into the project also facilitated the development of the project. As one respondent said, *"One reason why it happened is that there was money" (RI2, 2021).* If there is not enough money to pay for the investments, synergy plans will fail. A lot of possibilities are not implemented because of problems with financing (RI2, 2021).

Table 4.32: Overview of business-specific features in Biopark Terneuzen.

Factor: Business-specific features	Type of factor	Number of codes
Sustainability vision	Success	2
Willingness to commit	Success	2
Industrial type companies	Success	2
Companies that produce/require a huge amount of residue	Success	2
Disposed to make long term investments	Success	1
Entrepreneurial mind	Success	3
Financial capacity	Success	5

4.3.8 Prosposed measures

Several actors such as Van de Bunt, the province of Zeeland, and research institutes participated in the creation of Biopark Terneuzen and played a role in the identification of opportunities (CONA2, 2020).

Even though the government did not discover any specific exchange possibilities, the province of Zeeland came up with the initiative of developing an agro park (CONA2, 2020). The province wanted to bring more attention to the port area because they could not compete with the Port of Rotterdam. Therefore they aimed to develop a niche in bioeconomy to compete in some way (RI2, 2021).

The Province of Zeeland asked Van de Bunt to research the possibility of an agro park next to the canal zone (CONA2, 2020).

Van de Bunt did a scan of all the companies in Zeeland looking for synergies and saw the possibility of making combinations because they had similar developments (CONA2, 2020). Some companies already had some smaller project ideas before Biopark Terneuzen started (RI2, 2021).

This means that Van de Bunt was the first that realized that several stream exchanges could be made. One respondent explained the situation.

"We asked what the developments were in the different companies. And, then we saw possibilities to make combinations. And we made a project out of it" (CONA2, 2020).

Once Van de Bunt came with a proposal, the Province agreed to move the project forward. Afterwards, Van de Bunt asked for help from Wageningen University to do further research because they were also interested in agro parks (CONA2, 2020).

The University of Wageningen had a group that was already studying EIPs, which also contributed to the research from a scientific perspective (CONA1, 2020).

Table 4.33: Overview of proposed measures in Biopark Terneuzen.

Factor: Proposed measures	Type of factor	Number of codes
By government	Success	7
By companies	Success	5
By consultancy	Success	6
By research institutions	Success	6

4.3.9 Organisation of decision-making

There was a steering committee that guided the course of the project (CONA2, 2020). The board was formed by four public parties and one member in the representation of the businesses (van Waes & Huurdeman, 2009). TransForum could also intervene in case the project was not led in the right direction (PA1, 2021).

TransForum (2009) stated that there must be a leader when forming a cluster of companies. In this case, the leadership was taken by Zeeland Seaports. Zeeland Seaports was the program manager of the project and took the lead. Companies agreed with Zeeland Seaport getting this role of distributing power, costs and revenues between parties. This was not complicated because Zeeland Seaport was an initiator of the cluster (van Waes & Huurdeman, 2009).

Zeeland Seaports chose the companies to establish in the area and had an important role in communicating with all the companies.

It is improant to understand that the decision-making is project-based. Companies are the ones that decide to participate in a synergy individually. Each project can be seen as a separate module. The Biopark Terneuzen project is an accumulation of these different modules in which decision-making was made separately (RI2, 2021).

Therefore, a lot of the decision-making was not done on the park itself (CONA1, 2020). Decisions happened mainly between the companies and Zeeland Seaports (CONA2, 2020).

A barrier found is that due to the great number of actors involved in an EIP, aligning the interests is not easy. A respondent specified this. *"Everybody has their own problems and their own ideas and if you want to combine them, it is difficult"* (CONA2, 2020).

At an internal level in a company, it is also hard that everyone agrees on innovating the production processes and participating in an exchange of streams. Engineers are easily convinced that synergies are beneficial. However, people in charge of finance are worried about the cost and people that look at the juridical aspects do not want to be held responsible if the process fails. Therefore, aligning the different interests is not easy (CONA1, 2020).

Table 4.34: Overview of organisation of decision-making in Biopark Terneuzen.

Factor: Organisation of decision-making	Type of factor	Number of codes
Steering committee	Success	2
Companies decide what projects to pursue	Success	2
Lots of interests	Constraining	3

4.3.10 Policy instruments

Facilitator

Zeeland Seaports and Van de Bunt were the facilitators of the project. Zeeland Seaports was leading the development (CONA2, 2020) and Van de Bunt played a crucial role in the planning phase communicating with the different companies and convincing them to join the project (CONA2, 2020 and RI2, 2021).

At Terneuzen, companies did not know about their neighbors' activities. They were focusing on their own projects and not interacting between them before Van de Bunt showed them the possibilities and benefits of exchanging flows with their neighbors Van de Bunt initiated the ideas for new projects and pushed them forward. Companies then decided to join the project (CONA2, 2020). An interviewee highlighted the importance of helping companies to look at their surroundings

"*What you like to do is that you make companies aware of their neighbors make them aware of the fact that they can exchange flows and products, which are not their core products. You make companies aware of what they can do together. It is a very slow process, but that is what makes parks successful"* (CONA1, 2020).

Van de bunt was the one that convinced the companies to join the project. The consultancy talked to each of the companies, answered their questions about the project, and convinced them to join and build an alliance (RI2, 2021). One of the partners in Van de Bunt is good at telling stories which also helped. He made the companies realize the project's benefits and possibilities and convinced them to join (CONA2, 2020).

Van de Bunt also made sure that all the interests of the parties were aligned and all were looking in the same direction (PA1, 2021). Van de Bunt was active in bringing people together to the meetings to align the vision (RI2, 2021).

It is important to highlight that Van de Bunt led the project only in the planning phase. Their participation ended after the three-year subsidy of TransForum finished. After Van de Bunt left, Zeeland Seaports was the only project leader (CONA2, 2020).

Talking about the other facilitator, Zeeland Seaports, they also enabled the context for synergy creation. They facilitated the process by organizing meetings between all the industrial actors to look at each other's activities, share ideas and interact (PA1, 2021). They put a lot of effort into building a close network and motivated the actors to get enthusiastic and to believe in the project. As a respondent explained, *"Zeeland Seaports said listen, people, we together form the industrial community that can make this happen"* (PA1, 2021).

Zeeland Seaports also was a link to the local government and got money from the province to be invested into the project (PA1, 2021). Inside Zeeland Seaports, there was a specific person that was considered as a success factor by an interviewee.

"I think her personal influence, and her the way she works was a success factor. And she emphasized a lot that it's a lot about people management, building context, building relationships, maintaining relationships, keeping in touch with people" (RI2, 2021).

It is important to highlight that Van de Bunt led the project only in the planning phase. Their participation ended after the three-year subsidy of TransForum finished. After Van de Bunt left, Zeeland Seaports was the only project leader (CONA2, 2020).

Even though the role of a communicator was something that Zeeland Seaports normally did, the performance of Zeeland Seaports was not as good as the one of Van de Bunt (CONA2, 2020). In the implementation phase, the facilitator's performance was much looser (RI2, 2021). An interviewee explained the situation.

"We had to let go of our role. And I think that was a bit of a difficult moment for the companies to go ahead. And we begun a little bit earlier putting Zeeland Seaports in the role of keeping all parties together and making progress. It was a role suitable for them but they had a lot of other things to attend also. So it was a bit going down. They did not do it with the same spirit" (CONA2, 2020).

It seems that Zeeland Seaports and Van de Bunt did great together, but once Van de Bunt left, Zeeland Seaports did not have the same performance and hence the connections and enthusiasm of the companies about Biopark Terneuzen weakened. This was emphasized by a respondent, *"After they actually started implementing things that the focus shifted back mostly to individual projects. The focus of the larger whole was not very strong anymore"* (RI2, 2021).

Table 4.35: Overview of policy instruments/ facilitator in Biopark Terneuzen.

Factor: Policy instruments/ Facilitator	Type of factor	Number of codes
Initiates ideas	Success	1
Helps companies look at their surroundings	Success	3
Connects actors	Success	18
Enables the context	Success	2

Regulations

The Dutch government wants to become less dependant on natural gas and implement regulations to pursue sustainability (RI2, 2021). Companies can only operate if they comply with the regulations. These regulations push companies to take action on more sustainable processes such as exchanging streams (PA1, 2021).

The carbon tax also started around the time Biopark Terneuzen was developed, which also played a role (PA1, 2021). For example, Yara felt the urgency to change its processes because the government implemented more strict regulations and requirements regarding CO2 emissions. Yara had to reduce their CO2 emissions somehow, so they started exchanging their CO2 and heat (RI2, 2021).

However, a barrier highlighted by respondents is that changes in policy attitudes may shift the course of synergy projects. The Dutch government initially supported biomass plants and was offering high subsidies for their installation. However, after some debates around biomass, the government changed its perspective. The subsidies provided for bio-related projects way lower as initially planned. Therefore, Nedalco cancelled the plans of developing a new plant (RI2, 2021). The cancelled plans were a reason for some planned synergies to fail.

Table 4.36: Overview of policy instruments/ regulations in Biopark Terneuzen.

Factor: Policy instruments/ Regulations	Type of factor	Number of codes
National regulations force companies to be sustainable	Success	5
Changeful government	Constraining	4

Park policy

Biopark Terneuzen also had some park policies when selecting the companies housed at the park.

Zeeland Seaports only accepted companies that fit into Biopark Terneuzen's concept and ecosystem. Companies had to contribute somehow to bioeconomy and circularity (PA1, 2021; CONA1, 2020).

TransForum (2009) said it is essential to keep the fundamentals and not to abandon the vision. Biopark Terneuzen followed its initial vision (RI2, 2021) throughout the project by being strict with the companies that could join the park.

Table 4.37: Overview of policy instruments/ park policy in Biopark Terneuzen.

Factor: Policy instruments/ Park policy	Type of factor	Number of codes
Contribute to circularity	Success	3
Strict with their selection	Success	1

Other policy instruments

The government's financial support is really important for companies to implement synergies (CONA1, 2020). Zeeland Seaports attracted money from the province into the project for infrastructure, which incentivized companies to join Biopark (PA1, 2021).

The European Union wanted to develop certain bioeconomy regions and therefore also gave a huge subsidy for Biopark Terneuzen's development (CONA1, 2020; RI2, 2021).

TransForum also gave a subsidy for Biopark Terneuzen that was key (CONA1, 2020). One euro invested by a company meant two euros by TransForum. The subsidy was very attractive for companies to join (CONA2, 2020). TransForum's money was used mainly for research and knowledge development (PA1, 2021). One respondent emphasized the importance of this subsidy. *"The subsidy was a magnet and was a vehicle for us to make the Alliance. Without it, we would not have come this far*" (CONA2, 2020).

Infrastructure for stream exchanges is very expensive. Therefore, some synergy projects failed because of problems with financing (CONA2, 2020). Nedalco did not receive a subsidy for their

biofuel factory as initially planned. The reason for not receiving a subsidy is related to the change in public opinion against biofuels and the government not supporting biofuels as much as at the beginning. In the end, no subsidy meant not enough money for the project and the project had to be canceled (RI2, 2021).

The name of Biopark Terneuzen as a sustainable park helped to create more unity in the project and make it more attractive (PA1, 2021). A change in the name incentivized some parties' to join (TransForum, 2009).

Some actors such as the deputy of the Province of Zeeland, the alderman from Terneuzen, and the director of Zeeland Seaports took an important role in propagating the project (van Waes & Huurdeman, 2009)

Table 4.38: Overview of policy instruments/ other in Biopark Terneuzen.

Factor: Policy instruments/ Other	Type of factor	Number of codes
Subsidies	Success	8
Promotion	Success	1

4.3.11 Economic features

Interviewees mentioned the importance of having a business case to create synergies. Companies need to have some revenue to participate in an exchange of streams (RI2, 2021). Yara was motivated to make exchanges to transform their waste into a profit by setting WarmCO and reusing the waste. It was to be financially interesting for the companies to participate (PA1, 2021). One participant emphasized the importance of a business case. *"There has to be a good business case because otherwise, they don't go along" (CONA2, 2020).*

For example, Nedalco did not participate in an exchange of flows because the pipelines' construction was so expensive because of a long distance between companies that there was no business case anymore (CONA2, 2020).

Also, for synergies to occur, it is necessary that every participant gains something. Partners in the alliance joined the project when they realized there was something was interesting for them (CONA2, 2020). Every participant had some benefit with the creation of the park and the synergies instead of putting the streams into the air (PA1, 2021).

In order for connections to be successful, there needs to be a low risk of the production process stopping. When companies are engaged in stream exchanges, their risks are transferred to other companies. Therefore, companies may become dependent on each other. If a supplier of one resource stops for maintenance or technical issues, then the whole production process fails (CONA1, 2020).

If the risks of the connection are higher than the benefits, then an exchange will not happen. A backup system can help to decrease the risk of failure. There must be a system that ensures that resources are still delivered in case of any adversity. The problem is that back-up systems are too expensive and in theory, never used (CONA1, 2020).

In the case of Biopark, the streams involved a low risk. Exchanges among companies included CO2 and heat, which can easily be obtained from other sources. With easy substitutable resources, if a

supplier fails, there are other solutions. It was explained that in another project that did not belong to Biopark, an exchange of streams between two companies was possible. However, the dependency was so high that it was not established because the resource was not easy to substitute (PA1, 2021).

Table 4.39: Overview of economic features in Biopark Terneuzen.

Factor: Economic features	Type of factor	Number of codes
Business case	Success	7
Every participant gains	Success	2
Low risk of failure	Success	8

4.3.12 External context

There are some external developments that are out of the control of park developers, such as policy attitudes and changes in economic conditions that influence the development of synergies (RI2, 2021).

The economic crisis hit the development of Biopark Terneuzen. The economic crisis was an unexpected event that difficult the possibility of developing plenty of projects, especially in the greenhouse sector (RI2, 2021). Only a few greenhouses were able to come to the area as initially planned. Still, the exchange of flows between Yara and some greenhouses did happen (RI2, 2021).

Also, a biofuel plant went bankrupt due to the economic crisis and the government's lack of support (Spekkink & Boons, 2016).

The difficult market conditions also affected a biofuel factory project at the terrain of Heros. There were unfavorable market conditions for biofuels (RI2, 2021). The fact that biofuels were more costly than other fuels also contributed to the biofuel factory not being installed. Biofuels could not compete with other cheaper fuels (CONA2, 2020).

It seems that the biomass plant also went bankrupt partly because the market was not favorable for its products (RI2, 2021).

Market conditions also affected greenhouses. It was expected to install 200 hectares of greenhouses in the first two years (PA1, 2021). In the end, only a few greenhouses were installed because the market situation for greenhouses changed (RI2, 2021).

Public opinion is also an important factor for synergy creation. In 2005, people were very optimistic about biofuels. Some of the projects of Biopark Terneuzen involved biofuels and therefore got pushed (CONA1, 2020). However, a few years later around 2008, it was noticed that biofuels had some indirect adverse effects such as the cutting of forests. There were debates around biomass that shifted the government's and the public's opinion about biofuels (RI2, 2021).

As a consequence, the government stopped supporting biofuel projects. Therefore, the biofuel factory of Nedalco was not built because the government gave less subsidy for the project than promised (RI2, 2021).

Even though it is not at Terneuzen, another example was given by a respondent. A possible exchange of streams that involved greenhouses and chicken farms did not happen because chicken farms have

a bad image for animal welfare. Therefore, the greenhouses did not want to be linked to these farms. In the end, the exchanges were not realized (CONA1, 2020).

Also, companies must be seen as responsible by the public because society needs to accept a company's practices to operate. In the case of Biopark, with increased importance to sustainability by society during its development, companies were pressured to come with better solutions for the amount of waste generated by their processes. Society pushed companies to make their processes more sustainable and reuse streams (PA1, 2021). This can be seen as positive for the creation of synergies.

Table 4.40: Overview of the external context in Biopark Terneuzen.

Factor: External context	Type of factor	Number of codes
Economic conditions	Constraining	6
Market conditions	Constraining	3
Public opinion	Constraining	7
Sustainability importance	Success	1

5. Cross-case analysis

In this chapter, information is compared to answer the main research question: *What are the main factors that influence the implementation of industrial symbiosis and utility sharing in front-running eco-industrial parks in the Netherlands?*

This chapter will also lead to an answer to the third sub-research question of the study: *How can developers facilitate the implementation of industrial symbiosis and utility sharing activities in eco-industrial parks in the Netherlands?*

The similarities and differences in the factors between the three cases are going to be highlighted. Each of the different factors is analyzed in this section. The different factors analysed are vision and ambition, location-specific physical features, location-specific social features, business-specific features, proposed measures, organisation of decision-making, policy instruments, economic features and external context.

A summarised comparison of the factors found in each of the three cases can be found at the end of each factor. Summarized tables with a description of the differences between the three cases can be found in Appendix I.

5.1 Vision and ambition

Table 5.1: Overview of vision and ambition for the three cases.

Factor: Vision and ambition	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Province's initiative	None			●	4
Municipality's initiative	None	●			3
Private initiative	None		●		3
Sustainable vision	Success	●	●	●	22
Develop vision collaboratively	Success	●		●	7
Future map	Success		●	●	10
Visit an existing EIP	Success	●		●	6

The three parks are brownfield developments, which means that there were already existing developments in the area of the parks. At InnoFase, there were already some companies in the area exchanging some streams. IPKW was built in an area with a chemical manufacturing industry, and Biopark was built in the canal zone, which already had some companies. It seems that building parks on existing developments is effective.

Each of the parks was initiated by a different actor. The municipality came up with InnoFase's initiative. Biopark was initiated by the Province of Zeeland, and IPKW was formed as a private project. It is interesting that two of the projects were initiated by the government and one as a private initiative. Even though initiated differently, the three of them are successful in terms of synergies. The difference in the initiatives shows that it does not matter if the initiative is top-down or bottom-up. Synergies and successful parks can be accomplished both ways.

Sustainable vision

The three parks are aiming to be more sustainable. This vision has functioned as a guide for their following actions. InnoFase and Biopark Terneuzen aimed primarily for industrial symbiosis and exchange of flows, while IPKW aims for utility sharing and not so many waste exchanges because it is not as industrial as the other two parks. However, the three parks were ambitious with their goals. InnoFase wants to push the concept of industrial symbiosis as far as possible. IPKW wants to become the most sustainable park In the Netherlands, and Biopark to become the center of the biobased economy. Ambitious goals in the three parks led to successful results.

Develop vision collaboratively

The vision of two out of the three parks was developed collaboratively. In InnoFase and Biopark Terneuzen, companies and governmental actors had several meetings to align the vision of the parks. With this, all involved actors' interests and opinions were considered, motivating them to participate in the project. In the case of IPKW, as it is a private project, the vision was developed by the owners of the park.

Future map

A future map with the vision was present in IPKW and Biopark. The future maps at both parks show the maximum number of synergies possible. Both of them were aware that this was only a vision and that achieving all of the proposals was very difficult and depended on many variables. However, this worked as a guideline and motivation to the developers during the process.

Visit an existing EIP

It seems that visiting an EIP reinforces the idea of copying the concept of industrial symbiosis in other areas. This happened at InnoFase and Biopark. A visit to an EIP in Canada gave the idea to the Port Authority, the municipality and the province of Zeeland to develop something similar at Terneuzen. The program manager of Duiven visited Kalundborg to understand better the concept of industrial symbiosis. This suggests that visiting an EIP motivates actors to copy the concept of industrial symbiosis to other areas after seeing the possible benefits.

5.2 Location-specific physical features

Table 5.2: Overview of location-specific physical features for the three cases.

Factor: Location-specific physical features	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Complementary companies	Success	●	●	●	11
Short distance between companies	Success	●	●	●	7

Complementary companies

At the three parks, companies are complementary to each other by adding some value to the other companies. At InnoFase, all the companies have an environmental category 4 and 5 and generate a

lot of waste, which attracts other companies with a high environmental category. At IPKW, most companies are related to energy transition, which allows for more cooperations to innovate. At Biopark, companies relate to bioeconomy and therefore attract other bioeconomy related companies. Each cluster has a different type of company, but all of the companies complement each other and create a common ground with similar ambitions. Companies form a type of ecosystem inside the parks and that is what attracts other companies to join.

Short-distance between companies

Also, the importance of a short distance between companies was mentioned at the three parks. Companies that participate in synergies at the three parks are close to each other. A short distance greatly increases the possibilities of creating synergies. A short distance has plenty of benefits, such as lowering infrastructure and transportation costs. Also, companies can easily contact other companies if needed because they are only some meters away.

At InnoFase and Biopark, a long-distance between companies led to the failure of some projects due to the increase in infrastructure costs.

5.3 Location-specific social features

Table 5.3: Overview of location-specific social features for the three cases.

Factor: Location-specific social features	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Companies focus on their core business	Constraining	●	●	●	18
Companies know what other companies does	Success	●		●	6
Easy communication	Success	●	●	●	10
Lack of understanding between different actors	Constraining	●	●	●	5
Joint problem solving	Success	●	●	●	16
Knowledge sharing	Success	●	●	●	6
Collaborative culture	Success	●	●	●	19
Trust	Success	●		●	7

Companies focus on their core business

One of the most mentioned constraining factors is that companies focus on their core business and are not aware of what is happening outside their own company. Exchanging streams with other companies is not a priority for company managers. This situation was found at the three parks, suggesting that it is a common and recurring barrier.

Companies know what each company does

The latter barrier was solved with a facilitator that motivates companies to look at their surroundings and realize the benefits of collaborating with their neighbors by exchanging streams. The task force implemented by InnoFase works very well for this. At the task force, companies share with each other information about their current projects. Therefore, all the companies know what

other companies do. Biopark also did some meetings to enable communication and interaction but not as recurrent as InnoFase. IPKW mainly supports interactions by organizing events.

At IPKW, still not every company is aware of what is happening with their neighbors. IPKW was way more companies than InnoFase and Biopark, which suggests that this may be a reason for companies not to be aware of every activity going on at the park. However, Veolia, the utility provider at IPKW, knows in detail the inputs and outputs of every company, which allows Veolia to optimize the stream connections in the park.

Easy communication

In general terms, there is constant and easy communication between the actors in the three parks. There is a good relationship between companies and they can contact each other if needed.

Lack of understanding between different actors

However, there are some barriers to clear communication and understanding among the different actors. Primarily between companies and research institutes. A lack of understanding between research institutions and companies was highlighted at InnoFase and Biopark. Research institutes do extensive theoretical research when companies want practical solutions.

It was also mentioned that there were some understanding issues between entrepreneurial actors from park management and technical actors from the companies or governmental actors when new projects are discussed at IPKW and Biopark.

Joint problem solving

Joint problem-solving was mentioned in the three cases. At InnoFase, companies look for solutions together at the task force and some companies are working together with the municipality and research institutions on a research agenda. At IPKW, every project initiated by park management is tried to be developed jointly by involving companies inside the park. Also, Veolia works together on recruitment with companies at the park. Besides, research institutes and companies are constantly working together on different research and applied projects. At Biopark, solutions were also searched jointly at the meetings organized by Zeeland Seaports.

Companies at the three parks work together on different projects besides synergies such as research, recruitment, or training, showing that problem solving is not limited to exchanging flows.

Knowledge sharing

Knowledge sharing is present at the three parks. Knowledge is shared at the task force in InnoFase, and at the meetings that were held at Biopark. At the meetings, companies update other companies about the state of their projects and new ideas.

At IPKW, there is knowledge exchange between some companies. For example, between Veolia and the other industrial companies at the park or between the HAN and startups.

Sharing culture

There is also a sharing culture, which was mentioned as one of the most crucial factors and it is present in the three cases. Companies are willing to cooperate and help each other. Companies do not only look for their own benefit.

Facilitators played an important role in enabling interaction and getting companies to know each other for the collaborative culture to emerge in the three cases.

Trust

Trust was mentioned as a crucial factor for synergies to happen because companies invest time and money. Trust is something that takes time to develop and it is present at InnoFase and Biopark. Trust was formed with interactions at periodic meetings.

Trust was not mentioned explicitly at IPKW. However, there must be some level of trust among the companies and Veolia. If not, exchanges would not happen in the first place.

Trust among companies is more noticeable at InnoFase and Biopark. Probably the smaller number of companies plays a role here as well. It seems that fewer companies in a park enable more interaction more development of trust.

5.4 Business-specific features

Table 5.4: Overview of business-specific features for the three cases.

Factor: Business-specific features	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Companies that produce/require a huge amount of residue	Success	●	●	●	5
Disposed to make long-term investments	Success	●	●	●	6
Entrepreneurial mind	Success	●	●	●	10
Financial capacity	Success	●	●	●	10
Industrial type companies	Success	●	●	●	7
Sustainability vision	Success	●	●	●	19
Willingness to commit	Success	●	●	●	9
Spider in the web	Success	●	●		8
Different industral standards	Constraining	●	●		6

There are several characteristics of the companies that are important for synergies to occur.

Companies that produce/require a huge amount of residue

The three parks have big-sized companies. Big companies with scale generate more waste than small companies and therefore may compete with the normal grid. Small companies do not generate the necessary amount of waste to make a significant exchange. Synergies at InnoFase and Biopark failed because the amount of waste generated by companies was smaller than expected.

There may be an available residual stream, but no receiver for the stream, and hence the connection is not made. At InnoFase, one company had the capability of delivering heat to the city's heat network. However, another company was already delivering heat to the network. Therefore, a different purpose needs to be found for the extra heat.

At IPKW, something similar happened. A company does not have the capacity to receive and process all the plastic from companies and therefore needs to deny cooperation with some companies. In other words, there needs to be both enough supply and enough demand of streams for exchanges to occur.

Disposed to make long-term investments

Private companies usually prefer a short-term return on investment. However, the companies at the three studied parks were willing to have a long-term return on investment because achieving their sustainability goals is also a priority. Therefore, another important factor for success is that companies at the parks must be disposed to make long-term investments and less short-term profits because the synergy projects are expensive.

Entrepreneurial mind

An entrepreneurial mind is one of the most important characteristic of actors that engage in synergies. At the three parks, companies have an entrepreneurial mindset and are looking for new opportunities to innovate and participate in synergies with their neighbors. In Biopark, it was shown that the cooperation between entrepreneurial actors such as companies with non-entrepreneurial actors such as the municipality was more difficult but, in the end, still possible.

Financial capacity

Financial capacity is an important feature that companies need to have in order to engage in synergies. Exchanging streams require an expensive infrastructure that small companies cannot afford. Considering that companies that participate in synergies in the three parks are big-sized, it can be assumed that they have the financial capacity for this type of project.

Industrial type companies

It was highlighted at the three parks that in order to create synergies, industrial companies are needed. Companies that have a high environmental category have more waste and hence more opportunities to exchange their streams. For example, a logistics company does not have processes requiring the transformation of raw materials and having residual waste.

InnoFase and Biopark are more industrial than IPKW. IPKW has industrial companies with a maximum of environmental category four and also has startups and laboratories. Hence the opportunities for waste exchange are less than in the other two parks. The more industrial and higher the company's environmental category, the more waste is generated, and hence more opportunities for exchanges are possible.

Sustainability vision

Another of the most important features of companies to engage in synergies is to have a sustainability vision. All the companies housed at the three parks have a vision of becoming more sustainable and are ambitious about it. This was the most mentioned code in the interviews. It seems that it is a must that a company has a sustainability vision to participate in synergies.

Willingness to commit

Actors of the three parks showed commitment, willingness and enthusiasm to make an extra effort to participate in synergies and achieve their sustainability goals.

Spider in the web

In two parks, it was mentioned that a company that works as a central node in the network and exchanges streams with several companies is significant for the exchanges to happen. At InnoFase the central node is 4PET and at IPKW is Veolia. This type of company was called a spider in the web by one respondent. Without these companies, there would be considerably fewer exchanges of flows. At Biopark, a specific company with these characteristics was not mentioned; however, in figure 4.7, the biomass power plant could be the company that plays this role.

Different industrial standards

A constraining factor of having different industrial standards was mentioned at InnoFase and IPKW. Companies that cooperate and exchange a stream may have different industrial standards. For example, a power plant has very high safety and documentation standards. On the other hand, some production plants have more basic documentation and more basic engineering, so their standards are not high. That makes coordination and time schedules more complicated between the companies. Also, heavily standardized industrial plant as Veolia needs many permits, safety tests and backup systems. Therefore, their developing time for new projects is way slower than the time expected by park management. The difference in standards and ways of working may lead to some discussions and obstacles.

5.5 Proposed measures

Table 5.5: Overview of proposed measures for the three cases.

Factor: Proposed measures	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
By companies	Success	●	●	●	18
By research institutions	Success	●	●	●	12
By park management	Success		●		2
By government	Success	●		●	10
By consultancy	Success			●	6

By companies

In the three parks, the most common way of finding an opportunity for a new synergy is by companies themselves. However, it is important to highlight that this mostly happens once they are already aware of the possibility of synergies. In most cases, awareness of companies about opportunities occurs after the facilitator already participated in some way. The facilitator enables the context for interactions to happen then companies realize the possibility of new synergies.

At IPKW, the company Veolia identifies opportunities thanks to their ability to see all the inputs and outputs at the park.

Research institutions

Research institutions also play a very important role in opportunity identification. They were mentioned in the three cases. Research institutions either come with new ideas or test the feasibility of the companies' ideas. At InnoFase, the research institutions were crucial at the beginning of the project to help to identify new opportunities for synergies. After the companies realized they could exchange flows, they got their own internal people in charge of looking for new opportunities. Universities are still contributing to identify opportunities but not as much as in the beginning.

At Biopark, universities contributed to synergy identification after Van de Bunt Consultancy identified the opportunities in the first place. At IPKW, universities contribute mainly to research and work on innovation projects not related to residual streams, such as hydrogen cars. However, they have also contributed smaller synergies, for example identifying how to make building blocks for houses out of plastic.

By park management

At IPKW, some ideas for cooperation were identified by park management. An example is making a collection center to reuse wood and plastic materials to make new products by different companies at the park.

By government

The opportunity identification for synergies can also be made by the government. In the case of InnoFase, the municipality was the one that started the InnoFase project by identifying synergy opportunities after finding out about the stream exchange between AVR and the Water Authority. Today, the municipality is in charge of identifying synergies and coming with new project ideas. At Biopark, the province identified that an agro park could be made at the zone canal zone.

By consultancy

As mentioned before, Van de Bunt consultancy had to follow up on the province's idea of creating an agro park and did some research about possible stream connections. In the end, the consultancy was the one that identified most of the opportunities for exchanging waste.

5.6 Organisation of decision-making

Table 5.6: Overview of organisation of decision making for the three cases.

Factor: Organisation of decision-making	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Steering committee	Success			●	2
Park management	Success		●		3
Have an informal cooperation	Success	●			3
Companies decide what projects to pursue	Success	●	●	●	8
Different decision-making models difficult cooperation	Constraining	●	●		3
Lots of interests	Constraining	●	●	●	8
One decision-maker	Success		●		14
Have decision-makers together	Success	●			14

The three parks' decision-making models are very different, meaning no specific decision-making model is needed to create stream exchanges and have a successful EIP.

Steering committee/park management

At Biopark, there is a steering committee that guides the direction of the project, such as choosing which companies could join the development. IPKW is the only park with formal park management. The park management is in charge of initiating some projects, together with Veolia, the owner of the utility plants at the park. At InnoFase, there is no park management as such. The municipality of Duiven does some similar tasks to park management. The municipality is mainly a facilitator who chooses who joins the development and also do minor maintenance tasks of the surroundings.

Informal cooperation

The task force at InnoFase is an informal cooperation that has worked really well. Plant managers are comfortable with the results of informal meetings and networking. It seems that informal cooperation works because actors already trust each other. On the other hand, Biopark had a formal alliance. We can see that both models work.

Companies choose what projects to pursue

Even though the three parks have different decision-making models, participation in synergies is voluntary at all of them. Companies are the ones that choose if joining a project or not. Stream exchanges are arranged separately between the companies.

Different decision-making models difficult cooperation

InnoFase and IPKW struggle with the decision-making models of organisations that participate in synergies. For example, a governmental body such as a water authority has a slower decision-making process than a private company. As a consequence, the process for creating a synergy between a private and governmental organisation is slower than between two private companies.

Lots of interests

The three parks mentioned conflict of interest as a constraining factor. This is a problem when decisions are made and different actors are involved. For example, implementing a new plant at the park may lead to environmental groups or surrounding communities' complaints.

Also, inside the company, It is difficult to align all the interests of the different departments. Engineers are easily convinced that synergies lead to benefits. However, financial people and juridical people that do not want to be responsible are not that easily convinced.

One decision-maker

Another success factor mentioned at IPKW is that having only one decision-maker is a huge advantage. Since it is a private project, they decide which direction to go, and there is no need to consult any other actors when decisions are made. Momentum for initiatives may be lost when a lot of decision-makers are involved, but this is not an issue for IPKW.

Have all decision-makers together

A significant factor mentioned only at InnoFase is to have all the decision-makers together when discussing synergies. There is a task force meeting every three months where every decision-maker of the company assists and shares updates and new project ideas. Meetings facilitate communication between the managers and helps to discuss connections. At Biopark, meetings also gathered all the decision-makers. However, this was not mentioned by the interviewees. Gathering all the decision-makers could be considered as a best practice.

5.7 Policy instruments

Facilitator

Table 5.7: Overview of policy instruments/ facilitator for the three cases.

Factor: Policy instruments/ Facilitator	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Connects actors	Success	●	●	●	35
Enables the context	Success	●	●	●	15
Helps companies look at their surroundings	Success	●	●	●	11
Initiates ideas	Success	●	●	●	8
Removes burdens	Success	●	●		9

The importance of having a facilitator and for creating synergies among companies was evident. The three parks have a facilitator that supports the formation of synergies. Park management and Veolia facilitate in the case of IPKW, Zeeland Seaports and Van de Bunt in the case of Biopark and the municipality in InnoFase.

According to the study, the facilitator has five main tasks: connect actors, enable the context, help companies look at their surroundings, initiate ideas, and remove burdens. The facilitators executed the same tasks at the different parks.

Connects actors

The facilitators at the three parks connected the different companies at the park. The facilitator knows what each company does and what are their input and output flows. With this knowledge, the facilitator is able to connect the different companies according to their needs and capacities. New companies that join the complex are also well connected to the corresponding actor by the facilitator.

Enables the context

Enabling the context is another important task made by facilitators at the three parks. The facilitator creates the circumstances for companies to cooperate. The facilitator gets companies out of their comfort zone by organizing and events or meetings to get all of the actors together. In these events, companies interact and exchange information with each other. If there are any issues, the facilitator also aligns the interests of actors during these meetings.

Help companies look at their surroundings

One of the most mentioned barriers is that companies only pay attention to their core business, but facilitators can eliminate this barrier. Facilitators make companies aware that companies can exchange flows with their neighbors. They may be the difference between a company working only on their core business or cooperating with other companies.

Also, the facilitator stimulates and makes the actors enthusiastic about the projects.

Initiate ideas

Facilitators at the three parks are creative and generate new ideas for new projects. Sometimes companies may think some of these ideas are crazy, but the facilitator may convince companies that it is not. However, this is not entirely necessary because companies can also have new ideas themselves.

Remove burdens

Finally, another task mentioned at InnoFase and IPKW is that the facilitator also removes any burden or obstacle that blocks any project development. This task includes helping the companies by getting money, permits, doing maintenance tasks, or solving other minor issues that hamper the process of synergy creation.

Regulations

Table 5.8: Overview of policy instruments/regulations for the three cases.

Factor: Policy instruments/ Regulations	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
National regulations force companies to be sustainable	Success	●	●	●	11
Lag behind innovation	Constraining	●	●		16
Changeful government	Constraining		●	●	9
European Union's requirement to tender	Constraining	●			7
Inefficient process	Constraining	●	●		17
Regulations on nitrogen emissions prevent activities	Constraining	●	●		7

National regulations force companies to be sustainable

A success factor about policy instruments is that regulations regarding CO2 emissions reduction have forced companies to look for more sustainable methods to produce at the three parks. Companies took more sustainable measures such as exchanging streams due to obligation. However, regulations were mainly criticized by respondents. Critics for regulations were recurrent and sometimes harsh.

Regulations lag behind innovation

InnoFase and IPKW struggle with innovations moving quicker than regulations. Regulations restrict some of their innovation plans. For example, the Dutch law only allows companies to supply electricity to their neighbors, not their neighbor's neighbor, which has restricted some synergy opportunities at InnoFase.

Changeful/discrepant government

Two cases confirmed that the Dutch government is too changeful with its policies, which harmed some of the projects at the parks. Two of them were affected by the government's position towards biomass. First, the government was supportive of biomass and, after some time, against it. At IPKW, a biomass boiler was installed due to the considerable subsidy granted by the government towards biomass projects. Now, the government does not support biomass anymore. At Biopark, a biomass plant was canceled because the government decreased the subsidy after changing their perspective on biomass.

The government is also discrepant. Top-down, they motivate companies to have more sustainable processes and become circular. However, bottom-up, the government does not support products coming from circular processes such as recycled plastic.

European level regulation asks to tender

InnoFase houses a Water Authority, which is a governmental organisation. Therefore, they have to comply with European regulations requiring them to tender to buy something from the market above a specific budget. In other words, they cannot get residual streams such as heat from their neighbor. They need to tender. This problem was not found in other parks because they do not have governmental bodies inside that participate in exchanges of flows.

A synergy opportunity between AVR and the Water Authority failed at InnoFase due to the complexity of tendering. Instead of this profitable and environmentally friendly synergy, a non-environmentally friendly option was chosen.

Inefficient process

InnoFase and IPKW had also struggled with getting permits from the government because the process is extremely inefficient and slow. There are strict regulations that require companies to get a "not a waste" status before recovering waste from another company. Without this permit, it is not allowed to exchange flows.

Permits to exchange waste can take up to three years to get. There is no specific framework or clear guidelines on how to get a not a waste status or how long it takes to get it, which makes the process harder for companies. There is a lot of uncertainty for applicants. Sometimes, getting a permit to exchange flows takes so long that projects fail.

Companies may be reluctant to participate in synergy projects because of the long time to obtain the necessary permits. Part of the problem seems to be that there are many governmental layers such as the municipality, province, and National government, and therefore the process is not efficient. Decisions among layers take a long time.

Regulations on nitrogen emissions

The protected area of Natura 2000 is close by to InnoFase and IPKW. The two parks are having the same problem with environmental organisations and nature organisations. These organisations are fighting against some of the projects related to biomass and against the inclusion of new companies at the parks.

Besides, IPKW and InnoFase struggle with the nitrogen emissions regulations because they overcome the nitrogen emissions limit with the inclusion of new companies. The government is working on solutions to reduce nitrogen somewhere else so the parks can build more companies.

Park policy

Table 5.9: Overview of policy instruments/park policy for the three cases.

Factor: Policy instruments/ Park policy	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Contribute to circularity	Success	●	●	●	10
Environmental class 4 and 5	Success	●			4
Strict with their selection	Success	●	●	●	9

Contribute to circularity

The three parks had well-defined selection criteria for the new companies. Companies are selected depending on their complementarity to other companies. Only companies that contribute to industrial symbiosis or circularity are allowed at the parks. This ensures that synergies are possible between companies.

Environmental class 4 and 5

Besides, InnoFase only allows companies with environmental categories 4 and 5. A higher environmental category means more waste and, therefore, more opportunities for exchanges between the companies. At IPKW, the maximum environmental category allowed is category 4. Thus, the possibility of synergies is less than at InnoFase. A higher environmental category allows for more opportunities for exchanges.

Strict with their selection policy

Besides, all of the parks are strict with this selection policy. If companies are not complementary to other companies at the park or do not contribute to circularity somehow, they are rejected. This criterion was followed at InnoFase even though the economic conditions were not the best. This shows that parks need to be strict with their selection policy and not deviate from their main goals even with challenging conditions.

Other policy instruments

Table 5.10: Overview of policy instruments/ other for the three cases.

Factor: Policy instruments/ Other	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Subsidies	Success	●	●	●	19
Promotion	Success	●	●	●	14

Subsidies

Subsidy money was another factor mentioned at the three parks. Companies agreed that subsidy money is a motor for new projects. At Biopark, it was the motor for the whole park, as every euro put by one company was doubled by a subsidy from TransForum. AT IPKW's decision to install the biomass boiler was partly due to the obligation to reduce emissions and partly due to the huge subsidy for biomass projects. For InnoFase, it was mentioned that the government should support projects with more subsidies for infrastructure. One smart grid could have been made at InnoFase, but the companies did not want to pay for the project. A subsidy could have changed this decision. In a few words, subsidies are a decision changer for implementing synergies and sustainable projects.

Promotion

Another repeatedly mentioned success factor is the importance of being promoted as an EIP. At the three parks, synergies are used as a marketing strategy for new companies to join. Companies are attracted to these parks because collaborating with their neighbors can bring them economic benefits.

Also, the promotion that projects receive may lead to the success or failure of a project. The promotion for projects may result in more collaborations happening or projects failing. For example, Save Plastics at IPKW obtained more offers to cooperate with companies when their recycled plastic product was exposed in the news. On the contrary, other companies did not want to get involved in

any collaborations with Veolia since the environmental groups are promoting their biomass boiler project as something negative for the environment.

5.8 Economic features

Table 5.11: Overview of economic features for the three cases.

Factor: Economic features	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Business case	Success	●	●	●	25
Every participant gains	Success	●	●	●	6
Low risk of failure	Success	●		●	14
Clear agreements	Success	●	●		2

Business case

In the three cases, a success factor was that synergy projects have a business case. Having an economic profit is the most important aspect for companies when initiating a new project. A business case is the main driver and motor of companies engaging in synergies.

If there is no revenue, then no company will participate in an exchange of streams. Companies may be really striving to become more sustainable. However, they still need to pay their employees and shareholders. Sustainability comes in second place. If an exchange of flows brings economic profits and makes the production process more sustainable, companies will participate in the exchange. It is a win-win for companies.

Every participant gains

In the three cases, every actor that participates in a synergy must have some benefit. For example, the municipality of InnoFase is interested in creating more synergies because it makes the park more attractive for buyers, and companies decrease costs and their environmental footprint. AT IPKW companies cooperate to get a mutual economic and environmental advantage. At Biopark, partners joined the project when they realized there was a benefit for them. The province got more exposure, the municipality brought more jobs, the consultancy got paid, companies decreased costs and their environmental footprint. Actors will join a synergy or an EIP project if there is some benefit for them.

Low risk of failure

It was mentioned at InnoFase and Biopark that having low risks is a requirement for companies to join a synergy project. The companies that participate in synergies at InnoFase have a very low risk for their required flows not to be supplied. For example, if the company that provides energy to a neighbor stops working, then they can easily connect to the grid again. Similarly, if biogas is not able to be delivered, companies can ask for gas tanks while the problem is solved. Besides, there is no risk of resource shortage because companies only use only a small percentage of the total waste generated.

At Biopark, the streams exchanged, such as CO2 and heat, also involve low risk. If CO2 and heat are not supplied by a neighbor, there are other options to get them.

Another option to ensure a low risk of delivery is to have a backup system. However, the backup system is really expensive and leads to responsibility issues because companies do not want to pay for something that is, in theory, never used.

It is a requirement that companies do not have the risk of stopping their process. The solution is to have a secondary source of having their resource delivered. If companies become dependent on the other companies' delivery and there is no alternative to get the resource, cooperation is unlikely to happen.

Clear agreements

The importance of clear agreements when participating in synergies was mentioned briefly at two parks. Agreements clarify each company's responsibilities in case of a failure on delivery of a resource in different scenarios.

5.9 External context

Table 5.12: Overview of external context for the three cases.

Factor: External context	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Economic conditions	Constraining	•		•	9
Market conditions	Constraining		•	•	4
Public opinion	Constraining		•	•	9
Human capital	Constraining		•		1
Sustainability importance	Success	•	•	•	4

Economic conditions

Stream exchanges are indirectly affected by the external context. Respondents of the three parks mentioned that the economic context negatively affected some of the park's planned projects. The economic crisis of 2008 was mentioned at InnoFase and Biopark. The economic crisis led to tough times for InnoFase because fewer companies were looking to buy a place at the park. At Biopark, some projects such as the installation of a biofuel plant had to be canceled.

Market conditions

IPKW and Biopark highlighted that unfavorable market conditions might also influence the products created by synergies. At Biopark, the Rosendaal biofuels plant went bankrupt partly because the market was not favorable for its products. This plant was expected to have some synergies with other companies at the park. However, this did not happen, partly to the unfavorable market conditions for biofuels. It is important to highlight that the market moves slowly and therefore, it is problematic for new innovations such as biofuels to settle.

Public opinion

Public opinion is another external factor that had a negative impact on IPKW and Biopark. People were in favor of biomass, and therefore, the government was supportive of biomass projects. When people's stance changed against biomass, then the government also shifted its perspective and decreased its subsidies that supported biomass projects. Plans for installing a biofuel plant at

Terneuzen had to be canceled partly because of the government's perspective change. At IPKW, the biomass boiler at IPKW now is also seen as harmful by environmental groups who try to stop the use of biomass at the park.

Human capital

Another constraining factor for the development of synergies and for a circular economy in general mentioned at IPKW is that there is a lack of technical workers in the Netherlands. Companies cannot do all of their projects at the desired speed due to the absence of technical engineers.

Sustainability importance

The success of the parks and the synergy creation also comes from companies being more aware of circular economy and sustainability than they were some years ago. In a way, public opinion also forces companies to innovate their processes to be more sustainable. More attention to sustainability by society and companies supports synergies and other activities that help companies become more circular.

5.10 Guidelines for implementation of industrial symbiosis and utility sharing at EIPs in the Netherlands

The cross-case analysis and helped to understand which factors and subfactors led to a successful implementation of synergies and which barriers were encountered at the three parks. With this, the third sub-research question can be answered. *How can developers facilitate the implementation of industrial symbiosis and utility sharing activities in eco-industrial parks in the Netherlands?*

The developers of EIPs may follow these guidelines/recommendations based on what the studied parks did to increase the likeability of implementing industrial symbiosis or utility sharing successfully. Recommendations are made for each one of the main factors.

Vision and ambition

- The relevant actors' vision and ambition need to be aligned before the project starts. Periodic meetings work for this. During these meetings, the interests of every stakeholder must be addressed.
- Having a sustainable vision that guides the developers through the whole project is crucial. Portraying the vision in a graphical future map showing the utopian scenario of the different flow exchanges and other sustainability-related projects works as a guide for every actor involved.
- A visit to an existing successful EIP such as Kalundborg by interested actors may refine their vision of creating an EIP and make them more enthusiastic about the idea. Seeing what can be accomplished at an EIP may push actors to want to copy the concept.

Location-specific physical features

- Search for companies that complement each other processes. For example, if a company needs heat, it will be attracted by a location next to a company with a considerable amount of residual heat for exchange. Also, complementarity is present when companies look for

the same goals. For example, if the park has only companies that focus on innovation and energy transition, cooperation is facilitated.
- The distance between companies must be short for exchanges of flows to occur. A short distance reduces the cost considerably. A long-distance may cause the project to fail.

Location-specific social features

The social dimension is very important for industrial symbiosis and utility sharing to occur in a park. A favorable social context includes awareness of neighbor activities, a sharing culture, easy communication, constant contact between actors and knowledge sharing between companies. A facilitator is crucial to enable a supportive social context for synergies to occur.

- Companies must be aware of what other companies are doing and in what projects they are involved.
- One of the biggest barriers is that companies only focus on developing their own primary business without looking at their surroundings.
- An easy communication where companies are easily approachable by other companies is ideal. Communication must be constant so people at the park know each other well. Constant communication facilitates interaction and an exchange of ideas.
- Problems should be solved together by actors. Involving universities to look for solutions works well. Joint-problem solving may lead to cooperation in research, recruitment, or training. Joint problem solving emerges once social ties are strong.
- Companies should notify other companies about their current projects and proposals for new projects. Companies should share knowledge about anything that can make synergies easier, such as how the required permits to exchange streams. Universities must be involved to share their theoretical knowledge and find more opportunities.
- Companies need to have sharing culture for synergies to happen. A sharing culture means having an open mind and be willing to collaborate with other companies. This can be incentivized with interactions.
- A barrier to the creation of a supportive social context is the difference in the mindset of actors. Universities and companies may sometimes struggle to understand each other. Universities deliver theoretical results and companies want a more practical approach. Communication problems may also arise between companies with a technical mindset and park management with a business mindset. Also, problems in the mindset may arise between governmental actors and entrepreneurial companies. Establishing clearer requirements and more communication may help to solve this.
- Trust is necessary between actors for synergies to happen because engaging in industrial symbiosis or utility sharing requires an investment of time and money. Developing trust takes time. Trust is developed with interactions in meetings and events.

Business-specific features

If companies at the park have the next characteristics, it is more likely that synergies occur.

- Have a vision of becoming more sustainable and be ambitious for it.
- Have an entrepreneurial mind. A synergy is an innovation, therefore thinking outside of the box is required.

- The company must have the financial capacity to innovate the process and infrastructure. Synergy projects are expensive.
- Companies need to be willing to commit to the project. They must be motivated and enthusiastic about the project and aiming to make their processes more sustainable.
- Industrial-type companies lead to more possibilities to exchange flows because of the higher need for raw material to produce and higher generation of waste than, for example, a logistics company.
- Actors must be disposed to make long-term investments. Industrial symbiosis and utility sharing are projects that lead to profit after some time. Many companies prefer short-term profit.
- Companies that generate/require a great amount of residue are necessary. A considerable amount of streams is needed for the exchange to compete with the normal grid. Big-sized companies are the ones that generate enough residue. Small companies do not generate an amount to make an interesting business case.
- Bringing in a company that takes the role of a spider in the web is important. A company that functions as a central node in the network can incentivize other companies to exchange streams.

Proposed measures

Opportunities for stream exchanges may be found by different actors.

- Companies themselves
- Research institutions
- Consultancy
- Government
- Park management

Research institutions play a key role in finding new opportunities for synergies. They should be involved at least at the beginning of the project.

Organisation of decision-making

- Joining a synergy project must be voluntary. Companies themselves should make decisions about joining a project.
- There must be some leader for the EIP project. This may be a steering committee, park management, a company or the government.
- Different decision-making models among actors may slow processes. Private companies have a faster decision-making process than government organisations. This must be considered when cooperating between government and private companies.
- An EIP project affects a lot of stakeholders. Therefore it is hard to address the interests of everyone involved. Interests of all stakeholders, including surrounding communities and environmental organisations should be considered during the planning phase. It is important to consider that the decision-making process with actors from outside of the park is harder than projects with actors inside the park.
- Bringing all the decision-makers of companies or government at one table is important. This allows to decide if participating in new projects or not in an efficient way. Besides, with

these meetings and interactions, knowledge sharing, joint-problem solving and trust are developed. It is advised that these meetings are held at least quarterly.

- With a few decision-makers, the easier and quicker the process. Having only one or two decision-makers at a park facilitates the implementation of new projects. Momentum and opportunities may be lost with plenty of decision-makers and a slow decision-making process.
- There is no need to make a legal form of cooperation between companies at the park. Informal cooperation works and may be just as effective as formal cooperation. Informal cooperation works if there are strong social ties between actors.

Policy instruments

Facilitator

A presence of a facilitator is crucial to create a favorable social context at the park, which is key for the development of synergies. A facilitator may be park management, a company, a consultancy, a municipality, or a governmental organisation.

- A favorable social context is created with the interactions of actors. The facilitator needs to organize meetings and events for actors to join.
- The facilitator must make companies aware of what is happening at other companies and make companies realize the opportunities outside their core business and boundaries.
- The facilitator must know the companies' and potential newcomers' input and output flows to find possible opportunities for exchanges. The facilitator should show the potential benefits of the possible connections to the actors and stimulate them to join the project.
- The facilitator should propose ideas for new connections or new projects.
- Obstacles and burdens found in the process to implement the synergies should be removed by the facilitator. These tasks include maintenance of infrastructure and support with the acquisition of environmental permits.

Park policy

There must be internal park policies for the selection of companies.

- Newcomers must support the concept of industrial symbiosis and circularity. New companies must add value to the concept of the park and be complementary to the existing companies.
- Selecting companies with a high environmental category enable making more connections due to their more elevated amount of residual streams and waste.
- Park policies must be strictly followed even during difficult times (e.g, financial crisis).

Economic impact

- There must be a profitable business case for the participants of a synergy. Profit is more important than becoming more sustainable for companies.

- In a synergy project, there must be mutual benefits. Every participant in the project must have some kind of gain.
- Exchanges must be of low risk. There must be a secondary option to get the resource in case the supplier fails. Connections, where one company becomes entirely dependent on another company, do not work.
- Contractual agreements should clearly explain the responsibilities of participants of an exchange and what happens if conditions are not met.

External context

The external context factors are non-controllable, however, it is important to highlight that these factors also play a role in the development of synergies and the success of the park.

- Sustainability is more important in society than ten years ago. Companies, governments and society are more aware of their environmental footprint. This works as a push factor for more sustainable measures in production, such as exchanging streams.
- Bad economic conditions may cause planned synergy projects to get canceled. Bad economic conditions may lead to new companies not joining the parks and companies not innovating their production processes with synergies because innovations require a huge investment.
- Also not specific for EIPs, but market conditions also affect the development of EIPs. Products developed by the companies at the park (e.g, biofuels) may not be successful in the market and therefore planned or ongoing exchanges involving these companies fail.
- Public opinion may shape the direction of a project. Public opinion may change the government's position towards a specific project or technology. As a consequence, the subsidies for these projects may be modified.
- The implementation of innovations such as industrial symbiosis and utility sharing requires people with technical knowledge. However, the Netherlands has a limited number of technical workers that hamper a transition to more sustainable production processes.

5.11 Results of the cross-case analysis

With the cross-case analysis, an answer to the main research question of the study can be provided. *What are the main factors that influence the implementation of industrial symbiosis and utility sharing in front-running eco-industrial parks in the Netherlands?*

Table 5.13 shows the results of the cross-case analysis in a visual way. The table shows which factor main factors were present in each park. The table shows that nine different main factors influence the implementation of industrial symbiosis and utility sharing (1) vision and ambition, (2) location-specific physical features, (3) location-social specific features, (4) business-specific features, (5) proposed measures, (6) organisation of decision-making, (7) policy instruments, (8) project economic features and (9) external context.

Several subfactors that influence the creation of industrial symbiosis and utility sharing is also displayed under each factor. In total, 64 subfactors that influence industrial symbiosis and utility sharing were found. Table 5.13 explains if the factor contributed to a successful implementation of synergies or was a constraining factor.

Table 5.13: Factors that influence the implementation of industrial symbiosis and utility sharing.

Factor	Sub-factor	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Vision and ambition	Province's initiative	None			●	4
	Municipality's initiative	None	●			3
	Private initiative	None		●		3
	Sustainable vision	Success	●	●	●	22
	Develop vision collaboratively	Success	●		●	7
	Future map	Success		●	●	10
	Visit an existing EIP	Success	●		●	6
Location-specific physical features	Complementary companies	Success	●	●	●	11
	Short distance between companies	Success	●	●	●	7
Location-specific social features	Companies know what other companies do	Success	●		●	6
	Easy communication	Success	●	●	●	10
	Joint problem solving	Success	●	●	●	16
	Knowledge sharing	Success	●	●	●	6
	Collaborative culture	Success	●	●	●	19
	Trust	Success	●		●	7
	Companies focus on their core business	Constraining	●	●	●	18
	Lack of understanding between different actors	Constraining	●	●	●	5
Business-specific features	Companies that produce/require a huge amount of residue	Success	●	●	●	5
	Disposed to make long-term investments	Success	●	●	●	6
	Entrepreneurial mind	Success	●	●	●	10
	Financial capacity	Success	●	●	●	10
	Industrial type companies	Success	●	●	●	7
	Sustainability vision	Success	●	●	●	19
	Willingness to commit	Success	●	●	●	9
	Spider in the web	Success	●	●		8
	Different industral standards	Constraining	●	●		6
Opportunity identification	By government	Success	●		●	10
	By research institutions	Success	●	●	●	12
	By companies themselves	Success	●	●	●	18
	By consultancy	Success			●	6
	By park management	Success		●		2

Table 5.13 (continued)

Factor	Sub-factor	Type of factor	InnoFase	IPKW	Biopark Terneuzen	Total codes in the three cases
Organisation of decision-making	Companies decide what projects to pursue	Success	●	●	●	8
	Different decision-making models difficult cooperation	Constraining	●	●		3
	Have decision-makers together	Success	●			14
	Have an informal cooperation	Success	●			3
	Park management	Success		●		3
	Lots of interests	Constraining	●	●	●	8
	One decision-maker	Success		●		14
	Steering committee	Success			●	2
Policy instruments/ Facilitator	Connects actors	Success	●	●	●	35
	Enables the context	Success	●	●	●	15
	Helps companies look at their surroundings	Success	●	●	●	11
	Initiates ideas	Success	●	●	●	8
	Removes burdens	Success	●	●		9
Policy instruments/Regulations	National regulations force companies to be sustainable	Success	●	●	●	11
	Lag behind innovation	Constraining	●	●		16
	Changeful government	Constraining		●	●	9
	European Union's requirement to tender	Constraining	●			7
	Inefficient process	Constraining	●	●		17
	Regulations on nitrogen emissions prevent activities	Constraining	●	●		7
Policy instruments/ Park policy	Contribute to circularity	Success	●	●	●	10
	Environmental class 4 and 5	Success	●			4
	Strict with their selection	Success	●	●	●	9
Policy instruments/ Other	Subsidies	Success	●	●	●	19
	Promotion	Success	●	●	●	14
Economic features	Business case	Success	●	●	●	25
	Every participant gains	Success	●	●	●	6
	Low risk of failure	Success	●		●	14
	Clear agreements	Success	●	●		2
External context	Economic conditions	Constraining	●		●	9
	Market conditions	Constraining		●	●	4
	Public opinion	Constraining		●	●	9
	Human capital	Constraining		●		1
	Sustainability importance	Success	●	●	●	4

6. Discussion

In this chapter, the modifications to the framework of Eilering & Vermeulen are explained. Other aspects mentioned in the literature about Dutch EIPs are also discussed. The chapter continues by explaining the contributions, limitations, future research.

6.1 Interpretation and framework reflections

According to this study, all the factors mentioned by Eilering & Vermeulen (2004) were relevant for creating industrial symbiosis and utility sharing in the studied parks. However, data revealed that other factors not considered in the framework of Eilering & Vermeulen (2004) were also important. These factors are the project economic features and external context.

The importance of a business case was constantly highlighted by the interviewees. This means that companies will not implement synergy projects that are not profitable. A proposed synergy project must have beneficial economic features in order to move forward. Therefore, the factor of project economic features is situated in between proposed synergies and performance because an opportunity for an exchange may be discovered but not implemented if it is not profitable.

The external context was also mentioned repeatedly by interviewees. Even though it is an uncontrollable factor, it plays an important role in the development of synergies. Subfactors of the external context such as sustainability importance given by society support the implementation of industrial symbiosis and utility sharing projects by companies. Other external elements such as market conditions, public opinion and human capital may play an indirect negative role in the development of synergies. Therefore, the factor of external context was also added to the framework.

Regulations are considered as policy instruments by Eilering & Vermeulen (2004). However, the framework does not show that regulations may also influence companies' decisions to engage in more sustainable activities such as industrial symbiosis and utility sharing. The case studies showed that companies get involved in exchanges of streams to comply with the emission limits that regulations require. Therefore, regulations have an impact on proposed measures as well.

Furthermore, facilitators, which are considered as a policy instrument by Eilering & Vermeulen (2004) may also propose new synergy projects. The case studies revealed that one of the tasks performed by facilitators is to come with new project ideas. Therefore, an arrow was added to the framework to show that policy instruments (regulations and facilitator) have an influence on the proposed measures.

It is important to highlight that besides supporting proposed synergies to be implemented, regulations may also play a negative effect on proposals. Regulations such as the need to tender by governmental organisations, or the requirement to have a “not a waste” status may cause proposed measures to fail.

Policy instruments such as park policies play a role in the location and business-specific features of the park. The park policies are the base for selecting good fitting companies that form a favourable park context for synergies. For example, park policies may require that only companies with complementary flows to other companies or companies with an environmental category 4 or 5 are allowed. In other words, park policies shape the context of the park, something that the framework of Eilering and Vermeulen (2004) does not remark.

This means that policy instruments also play a role in forming the context of the park, in new proposed measures, and in helping the implementation from proposal to performance not only from proposed measures to performance, as Eilering & Vermeulen (2004) suggest.

The changes made to the framework of Eilering & Vermeulen (2004) are shown in Figure 6.1 marked in red.

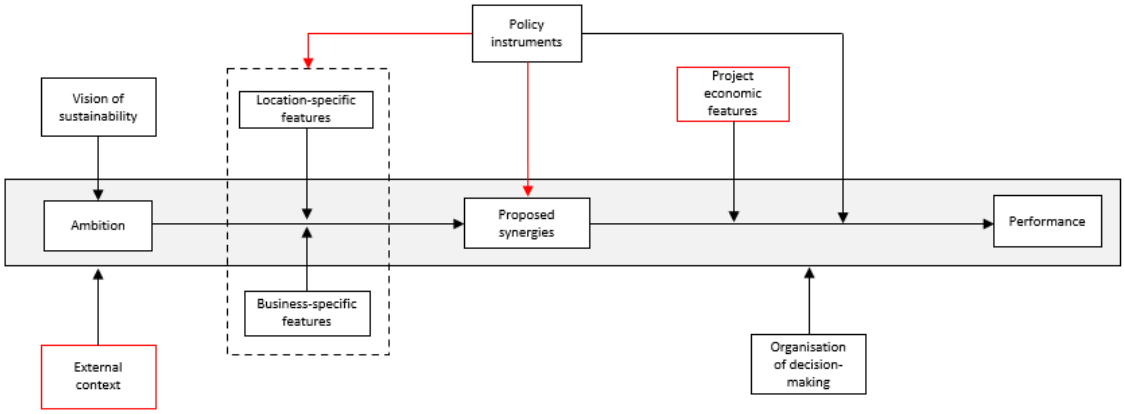

Figure 6.1: Modified framework of Eilering & Vermeulen (2004).

This study provides initial proof that the social aspects of an EIP play a vital role in the development of synergies. Data supports that other subfactors enable a supportive social context to form industrial symbiosis and utility sharing, such as a sharing culture, knowledge sharing, easy communication, joint-problem solving, and trust. Data also points out that a facilitator is key to form a favourable social context for the creation of synergies.

Furthermore, Eilering & Vermeulen (2004) mention that a facilitator is a type of policy instrument. They argue that the factor of policy instruments is less decisive than the context of the park formed by location and business-specific features. This is true because industrial symbiosis and utility sharing cannot happen without the appropriate companies at the appropriate location. However, the importance of a facilitator to achieve industrial symbiosis and utility sharing should not be minimized. It seems that in the cases of InnoFase and Biopark Terneuzen, although the companies had complementary flows, the majority of exchanges would not have happened without the help of a facilitator. Apparently, without a facilitator, exchanges would have remained as isolated events.

According to this study, a facilitator is someone who supports the development of an EIP by doing five main tasks: connect actors, enable the context, make companies aware of their surroundings, initiate project ideas and remove burdens for implementation.

Another important point to remark is that facilitation may happen at different levels. Facilitation can occur at the network level, where the facilitator's role is mainly to connect actors and enable the context. This type of facilitator creates new ties between the different nodes in the network and strengthens the existing ones. Network facilitation was made by the municipality of Duiven at InnoFase, by Van de Bunt Consultancy at Biopark and by park management at IPKW. However, the network facilitation at IPKW is not as notorious as the one taken by the municipality of Duiven and Van de Bunt.

There is also facilitation at a more strategic level, where there is a body that defines the vision and makes strategic decisions to develop the park. IPKW has formal park management, who defined the vision of the park and makes most of the strategic decisions. Zeeland Seaports play a similar role at Biopark Terneuzen by being the leader, steering the direction of the project and getting funds. The

municipality of Duiven also plays a similar role at InnoFase by steering the direction of the park without being a formal park management organisation.

It is important to remark that getting funds is crucial to support synergy implementation because synergy projects are very expensive. Some facilitation may be required to get the funds. Getting the funds might be easier if an entire region is aiming to become more circular than only having isolated projects.

There is another level of facilitation that involves technical aspects. IPKW has technical facilitation performed by Veolia. Veolia is the company that does the feasibility studies and the implementation of synergies related to utilities of any project suggested by the park management. In other words, Veolia takes care of all the technical issues.

What is evident is that there are different type of facilitation in the parks. There is facilitation focused on building network connections, facilitation focused on steering the project at a strategic level, and facilitation in the technical implementation. It is also seen that there can be one actor for each level of facilitation or one actor that addresses two levels. It seems that the actors that address two levels, such as the park management at IPKW, or the municipality at InnoFase, are more focused on one level of facilitation, having a weaker role on the other one.

Furthermore, it is important to highlight that some interviewees mentioned that the factor of luck contributed to the successful implementation of synergies. It is interesting that people interviewed by Santos (2015), who studied Biopark Terneuzen and HOST park in Hawaii, also mentioned luck as a success factor. Some authors may consider luck or chance as a factor. However, it was not considered for this framework because you cannot give any value to luck. It can be argued that some kind of luck/chance is already included in the location-specific features and business-specific features. For example, developers may choose a company with a specific profile to join the park, however, the type of employees in the company cannot be entirely controlled. Companies having entrepreneurial people that are willing to innovate and commit to sustainable projects can be considered partly luck-based.

There are other points for discussion. Heeres et al. (2004) say that in the Netherlands, EIP projects are pursued due to economic and environmental reasons, which seem equally important. According to this study, economic reasons are more important than environmental ones. A company will not participate in any industrial symbiosis or utility sharing activity without a profit even though it is sustainable.

Heeres et al. (2004) say that first, the focus on new EIPs should be on utility sharing and then on exchanging streams because utility sharing is less risky. However, this is not necessary. At InnoFase, exchanges of streams were achieved without passing through utility sharing first.

Heeres et al. (2004) also say that a champion is not needed because business associations often take that role. Cases in this study were successful without a business association. For example, at InnoFase, there is not any formal association between companies. The cooperation is informal. Furthermore, InnoFase and Biopark show that a champion/facilitator is needed for the creation of a park. It is not needed for isolated exchanges, but for a park with plenty of exchanges, a facilitator/champion is required.

6.2 Limitations

There were some limitations to this study. First, some secondary sources used for the cases were in Dutch. Google Translate was used to translate these sources because the researcher is not a Dutch speaker. This method may cause that the translations were not 100% accurate.

It is important to highlight that this thesis was written during the COVID-19 outbreak and therefore, all the interviews had to be made online. Also, no visits to the parks were made. Visiting the sites would have given the researcher a deeper understanding of the developments. However, some relevant insights were still obtained.

Getting interviewees for the parks was a challenge. Due to the lack of interviewees, the selection of cases had to be readapted to other cases where interviewees were found.

The research was also limited by the type of interviewees. For IPKW, only one industrial company and only one person from park management were interviewed. Interviewing more people from park management or other industrial companies would have added more value to the study. However, these companies did not reply to the invitation for interviews. Another person from park management could have been interviewed. However, there were language barriers and therefore, the interview did not happen.

For Biopark Terneuzen, only people that were involved in the development of the park 14 years ago were interviewed. This may cause the information collected is not as accurate. People that are involved today did not reply to the interview invitations. However, some relevant insights were still obtained.

The type of people interviewed for the parks was not the same. For example, IPKW and Biopark interviews included one person from a research institution, InnoFase did not. The cases of InnoFase and IPKW included one person from the municipality, but the case of Biopark did not. Ideally, the same type of actors had to be interviewed. However, this was not possible because not every person replied to the invitations. Still, the different perspectives of the interviewed actors added value to the study.

Furthermore, this thesis gave an overview of each one of the parks and only one interviewee per company was contacted. More detailed information about the process of each one of the synergy projects could be obtained if more people from the same involved companies are interviewed.

It also has to be highlighted that this was a qualitative study. Therefore the grouping of information was done according to the interpretations of the researcher. The quotations may have been grouped in a different form by other researchers.

6.3 Scientific contribution

This study provides initial proof that all the factors (1) vision and ambition, (2) location-specific physical features, (3) location-social specific features, (4) business-specific features, (5) proposed measures, (6) organisation of decision-making, (7) policy instruments portrayed in the framework of Eilering & Vermeulen (2004) influence the success of industrial symbiosis and utility sharing.

This thesis also contributes to refining the framework by adding two factors (8) project economic features and (9) external context and adding other connections to the factor of policy instruments

that play a role in the success of synergies. The latter were not considered in Eilering & Vermeulen's framework. These modifications make the framework a more accurate tool for analysis for future researchers that study EIPs.

Also, this study updated the success and constraining factors that influence the success of industrial symbiosis and utility sharing in the Netherlands. As mentioned, nine main factors and 64 sub-factors were found to be relevant to the implementation of industrial symbiosis and utility sharing.

This thesis also gathered data about three parks in the Netherlands. Very little literature is available about InnoFase and IPKW. Therefore, adding to the literature what activities are happening at these two parks is relevant.

The cross-case analysis led to other findings, such as the importance of facilitation for the successful development of industrial symbiosis and utility sharing and the different types and levels of facilitation possible.

Insights are also given with the importance of coincidence to the success of industrial symbiosis and utility sharing activities. Corrections to some claims made by Heeres (2004) are also made. These include profit being more important than sustainability, the possibility to implement industrial symbiosis activities without implementing utility sharing beforehand, the non-requirement of an association to have success in synergy implementation, and the requirement of a facilitator or champion to implement synergies successfully.

6.4 Practical and managerial relevance

This thesis has managerial relevance because implementing industrial symbiosis and utility sharing is a decision taken by managers of companies or managers of EIPs. The majority of the interviewees had a top managerial role in their companies or at the park.

Utility sharing and industrial symbiosis are an innovation in the production processes to make them more sustainable. Front-running companies apply this innovation to their processes to remain competitive. Managers of the companies are the decision-makers for this innovation and the ones that overview the implementation process.

The developers of EIPs, such as park managers, managers of companies, or government, can use the refined framework of Eilering & Vermeulen to have a deeper understanding of what factors influence the success of industrial symbiosis and utility sharing. Furthermore, the developers can follow the guidelines shown in section 5.10 to increase the likelihood of success in the implementation of synergies. These guidelines are made considering the cross-case analysis of three successful parks in the Netherlands.

Developers involved in the three studied cases can also follow the recommendations to improve the current performance of the parks.

6.5 Future research

There is still plenty to discover regarding EIPs, industrial symbiosis and utility sharing. Every interviewee added more important information to the research.

More research should be done in other parks in the Netherlands with the same framework to confirm if the success of the parks was caused by the same factors as portrayed by the refined framework of Eilering & Vermeulen (2004) with the added factors from this study.

It is important to study if the new factors added to the framework, economic features and external context are also relevant in other parks in the Netherlands. This could give further proof that the additional factors included in Eilering & Vermeulen's (2004) framework are accurate.

Ecofactorij and De Trompet were going to be studied because these were portrayed as front-running parks by an expert. However, the researcher's network did not provide any relevant contacts to get people involved at these parks. Other researchers with a different network might get relevant contacts to study Ecofactorij and De Trompet.

Also, deeper research could be done at InnoFase, IPKW, and especially Biopark Terneuzen, as every interviewee added new insights to the study. More people from park management and industrial companies could be interviewed at IPKW. More people from industrial companies could be interviewed at InnoFase and people that are still involved in the park could be interviewed at Terneuzen. However, due to time constraints, the number of interviews also had to be limited.

This study could not answer the question of what is happening at Biopark Terneuzen today because the people interviewed were not involved currently in the development and did not know about the current state of the park. Other researchers with a wider network may find out what is the current state of Biopark Terneuzen. Visiting the park to ask around is also a method that could work to get interviewees.

This study mainly resulted in finding success factors. Constraining factors were also found. However, there were not as highlighted as success factors, probably because the three studied parks are successful. It would be interesting to study parks that failed to know the reasons for it. A constraint that needs to be considered is that getting interviewees for failed parks might be even harder than for successful parks.

6.6 Link and reflection on the MOT program

This thesis was written as part of the Management of Technology (MOT) program and part of the Circular Economy thesis circle.

As explained in section 6.4, this thesis relates to the program because EIPs are an innovation of standard industrial parks to pursue sustainability. Specifically, industrial symbiosis and utility sharing are innovations of production processes where managers of the parks or managers of companies are in charge of executing their implementation.

Due to the complexity of EIPs, and its mix of business, industry and sustainability fields, this study needed a multidisciplinary understanding to be fulfilled, something emphasized by the MOT program.

Regarding MOT, I think the program has an ideal balance by addressing several key areas needed in the business world. The program addresses management, marketing, finance, economics, and entrepreneurship but always related to technology and innovation.

I also think it is ideal to have all the courses during the first year and then being able to choose a specialization from 6 different options. This flexibility allowed me to choose the Innovation, Strategy and Entrepreneurship track and work on a thesis related to sustainability and innovation, an area of my interest since my bachelor studies.

For me, it was also ideal to have the freedom to include some elective courses related to my personal interests in entrepreneurship.

The only point I would improve I the program is the Integration Moment course. I think this is the most important course of the first year and should be given more attention. Personally, I think the guidance and feedback that we got during the course was not enough, which made it just an extra course. Involving more professors in the course could help to give more attention and guidance to the students, making it more relevant and unique.

MOT was a great program choice because it helped me to grow personally, academically and gave me the tools and opportunities to grow professionally. It has given me the base to reach one of my aspirations of becoming an entrepreneur someday in the future. Besides, it also helped me with building a network in the Netherlands. I can conclude that it was totally worth coming to study MOT from abroad.

7. Conclusion

In this chapter, a short recap of the answers to the three sub-research questions and main research question is given. In the end, recommendations for the developers of EIPs are specified.

7.1 Conclusions

This study addresses the problem of EIPs in the Netherlands not usually having an exchange of residual flows even though it is the most important aspect of EIPs. This research aimed to find how to support the implementation of industrial symbiosis and utility sharing in the Netherlands. The motivation to do this came from the literature review revealing some gaps to be addressed, such as literature on EIPs in the Netherlands being old, limited, and with few empirical studies.

An answer to the first sub-research question was found with the literature review: *What factors influence the implementation of industrial symbiosis and utility sharing in eco-industrial parks according to literature?*

The factors for success and barriers to industrial symbiosis and utility sharing were divided into the factors found in general literature and factors found in the literature that particularly addressed EIPs in the Netherlands. Many factors were mentioned repeatedly in the general literature. Factors in the Netherlands were more limited. Some of the success factors to implement synergies are supportive policies, trust, facilitators, willingness, and effective communication. Some of the barriers are the lack of financial resources, large distance between companies, lack of communication, lack of infrastructure, and lack of awareness of IS. All the factors and barriers can be found in Table 2.7.

The literature review and the answer to the first sub-research question gave the possibility to find the framework of Eilering & Vermeulen (2004). This framework was considered suitable for the

analysis because it considers plenty of the relevant factors for the creation of synergies displayed in Table 2.7.

The second sub-research question was answered in chapter 4. *What are the industrial symbiosis and utility sharing activities happening at front-running eco-industrial parks in the Netherlands?*

Three front-running EIPs in the Netherlands were studied to find their current industrial symbiosis and utility sharing activities. The three studied parks are: InnoFase in Duiven, Industrial Park Kleefse Waard in Arnhem, and Biopark Terneuzen in Zeeland. Secondary and qualitative data was collected to answer this question.

Data revealed that InnoFase is engaged in many industrial symbiosis activities by exchanging different types of flows such as biomass, biogas, water, electricity and heat with other synergies in development. The current state of InnoFase is described in section 4.1.3.

For IPKW, there are mainly utility sharing activities with Veolia supplying the necessary utilities to the entire park through their gas-fired powerplant and wastewater treatment plant. There are other smaller flow exchange activities that include plastic, biomass, and wood reuse by some companies at the park. The current state of IPKW is described in section 4.2.3.

For Biopark Terneuzen it was found that the map that is typically used in the literature showing the exchange of flows is not accurate because some connections never materialized. A description of the exchanges that appear to still be happening can be seen in section 4.3.3.

The third sub-research question was answered in chapter 5. *How can developers facilitate the implementation of industrial symbiosis and utility sharing activities in eco-industrial parks in the Netherlands?*

Qualitative data was collected through semi-structured interviews to answer this question. The best practices and most important success factors of each park were gathered to make these guidelines.

Some of the most important guidelines are shown next. The full answer to the question is found in section 5.10.

- The relevant actors' vision and ambition need to be aligned before the project starts.
- Companies must be aware of what other companies are doing and in what projects they are involved.
- A presence of a facilitator is crucial to create a favorable social context at the park, which is key for the development of synergies.
- There must be a profitable business case for the participants of a synergy. Profit is more important than becoming more sustainable for companies.

The main research question was finally answered. *What are the main factors that influence the implementation of industrial symbiosis and utility sharing in front-running eco-industrial parks in the Netherlands?*

To answer this question, the data collected through semi-structured interviews were analysed following the predefined structure of Eilering & Vermeulen's (2004) framework. The three front-running EIPs in the Netherlands were compared with a cross-case analysis to understand what led

to their success and what constraining factors developers found during the process to implement synergies.

It was found that the seven main factors displayed by Eilering & Vermeulen (2004) influenced the success of the three analysed cases. The seven factors are (1) vision and ambition, (2) location-specific physical features, (3) location-specific social features, (4) business-specific features, (5) proposed measures, (6) organisation of decision-making, and (7) policy instruments. However, other two main factors were also found to influence the success of synergy implementation. The new factors added are (8) economic features and (9) external context. The nine factors are displayed in a refined framework where the relationship between these factors is shown.

These nine factors are divided into 64 sub-factors that have played a role in the development of the studied cases. All the factors are listed in Table 5.13.

7.2 Recommendations

Finally, some recommendations can be made to the park developers and the government to support industrial symbiosis and utility sharing in future EIP developments.

Some punctual recommendations are also made to the studied parks.

Recommendations for developers

- Develop a future map showing all the possible stream connections that guide every actor involved.
- Visit a successful EIP to motivate involved actors to participate in synergy projects.
- Search for companies that complement each other's processes and have similar sustainability ambitions.
- Only locate companies with an entrepreneurial mindset, financial capacity, willingness to participate in synergy projects, and disposed to make long-term investments
- Only locate companies that support the concept of circularity.
- Only companies that generate/demand a huge amount of residues should participate in the exchanges.
- Keep in mind that companies will only participate in synergy projects that have a business case.
- Get a facilitator that supports the creation of synergies at a technical, network and strategic level.
- Involve research institutions to find more opportunities for exchanges.
- Enable a supportive social context for synergies to occur with increased awareness of neighbor activities, a sharing culture, trust, easy communication, constant contact and knowledge sharing between companies.
- Get a company or body that leads the EIP project in terms of vision and strategy.
- Bring all the decision-makers of companies or government to one table to discuss the projects and keep the momentum.
- Consider the interests of every stakeholder during the planning phase of the projects to avoid future problems.

Recommendations for the government

- National regulations such as limiting the CO2 emissions from companies should continue because these make companies innovate and implement more sustainable production processes, including the exchange of streams.
- National regulations lag behind innovations and hamper the creation of synergies. National regulations have to be revised and updated to support exchanges.
- European Union tendering regulations should be revised and subject to some exceptions. Regulations have restricted the possibility of making sustainable and profitable exchanges of streams between companies and governmental bodies.
- The process to get permits to exchange waste need to be considerably optimized. At the moment, the processes to get the required permits to exchange waste can take years.
- A framework on how to get the permits to exchange waste is needed. Applicants do not have information on how to get the permit and the process to follow.
- The government's subsidies are a motor for synergy projects. Subsidies to support research for synergy opportunities and infrastructure should increase.

Recommendations for InnoFase

- Get a company that has a central position and is in charge of the development of the long-term vision of the park. Let the municipality focus only on enabling the context for the vision to happen.
- Develop a future map with all the possible connections and how the park is expected to look like. Other parks have represented the optimal state they aspire to achieve on a map and it has worked as a guide for the involved actors.
- Keep the cooperation between companies informal. There is no need to make a legal form of cooperation. Informal cooperation has been effective and strengthened social ties. Managers are comfortable with this way of working.
- Improve communication with the research institutions and be clear that more practical results are expected instead of theoretical results.
- The interest of every stakeholder, such as nature organisations and the surrounding communities, should be considered when a new project is planned. Involving every affected party may prevent problems from happening.

Recommendations for IPKW

- Park management should focus more on making companies aware of what is happening at other companies at the park. Some companies do not know what their neighbors are doing. The activities of smaller companies are particularly unknown.
- Enhance interaction between companies. Periodic meetings and events where every company update each other about their current projects may uncover more opportunities for cooperation and strengthen social ties.
- Due to COVID and the lack of physical interaction, a communication platform where companies can easily contact each other and share information on their actual projects can help. Having a description on the IPKW website about what companies do seems to be not very helpful for companies to know what other companies are doing.
- Consider the interests of every stakeholder when a new project is planned. Involving every affected party, such as nature organisations may prevent future problems from happening.

Recommendations for Biopark Terneuzen

- Get another network facilitator that involves new companies and recreates strong ties between actors. Since the network facilitator left the project, strong ties between actors disappeared.
- Increase the promotion of the park to attract more companies to join the project. There is no information about the current state of the park.

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Appendices

A. Results of search using selection criteria

A1. Results of Google Scholar

Relevant papers about EIP			
Date	**Keywords**	**Number of hits**	**Papers to review**
26/5/2020	allintitle: eco industrial park	665	Gibbs, D., & Deutz, P. (2007). Reflections on implementing industrial ecology through eco-industrial park development. *Journal of Cleaner Production*, *15*(17), 1683-1695. Chertow, M. R. (1998). The eco-industrial park model reconsidered. *Journal of Industrial Ecology*, *2*(3), 8-10. Lambert, A. J. D., & Boons, F. A. (2002). Eco-industrial parks: stimulating sustainable development in mixed industrial parks. *Technovation*, *22*(8), 471-484. Côté, R. P., & Cohen-Rosenthal, E. (1998). Designing eco-industrial parks: a synthesis of some experiences. *Journal of cleaner production*, *6*(3-4), 181-188. Chertow, M. R. (2000). Industrial symbiosis: literature and taxonomy. *Annual review of energy and the environment*, *25*(1), 313-337.

			Chertow, M. R. (2007). "Uncovering" industrial symbiosis. *Journal of industrial Ecology*, *11*(1), 11-30. Lowe, E. A., Moran, S. R., Holmes, D. B., & Martin, S. A. (1996). *Fieldbook for the development of eco-industrial parks*. Indigo Development. Roberts, B. H. (2004). The application of industrial ecology principles and planning guidelines for the development of eco-industrial parks: an Australian case study. *Journal of Cleaner Production*, *12*(8-10), 997-1010. Tudor, T., Adam, E., & Bates, M. (2007). Drivers and limitations for the successful development and functioning of EIPs (eco-industrial parks): A literature review. *Ecological Economics*, *61*(2-3), 199-207. Gibbs, D. (2003). Trust and networking in inter-firm relations: the case of eco-industrial development. *Local economy*, *18*(3), 222-236.

EIP in the Netherlands			
Date	**Keywords**	**Number of hits**	**Papers included**
26/5/2020	allintitle: eco-industrial netherlands OR dutch OR holland	3 (three included)	Heeres, R. R., Vermeulen, W. J., & De Walle, F. B. (2004). Eco-industrial park initiatives in the USA and the Netherlands: first lessons. *Journal of cleaner production*, *12*(8-10), 985-995. Van Leeuwen, M. G., Vermeulen, W. J., & Glasbergen, P. (2003). Planning eco-industrial parks: an analysis of Dutch planning methods. *Business Strategy and the Environment*, *12*(3), 147-162. Baas, L. W., & Korevaar, G. (2010). Eco-Industrial Parks in the Netherlands: The Rotterdam Harbor and Industry

			Complex. *Sustainable Development in the Process Industries, Wiley, Hoboken, NJ*, 59-79.
26/5/2020	allintitle: industrial symbiosis Netherlands OR dutch OR holland	4 (three included)	Boons, F., & Spekkink, W. (2012). Levels of institutional capacity and actor expectations about industrial symbiosis: Evidence from the Dutch stimulation program 1999–2004. *Journal of Industrial Ecology*, *16*(1), 61-69. Spekkink, W. (2013). Institutional capacity building for industrial symbiosis in the Canal Zone of Zeeland in the Netherlands: a process analysis. *Journal of Cleaner Production*, *52*, 342-355. van Duijnhoven, N. (2018). Creating Synergies: A business process model for the development of Industrial Symbiosis: Combining theory and practice to identify the steps that a private facilitator should take to develop a regional Industrial Symbiosis network in the Netherlands.
26/5/2020	Netherlands OR dutch OR holland "eco innovation park"	4 (one included)	MOLISE, O. (2017). A1. 3 Good practice guide and benchmarking guidelines on ecosystems of byproduct and energy exchanges.
26/5/2020	Netherlands OR dutch OR holland "sustainable business site"	12 (four included)	Pellenbarg, P. H. (2002). Sustainable business sites in the Netherlands: a survey of policies and experiences. *Journal of Environmental Planning and Management*, *45*(1), 59-84. Louw, E. (2017). Implementing Sustainable Business Estates in Netherlands: A Confrontation Between Theory and Practice. *Advancing Sustainability at the Sub-National Level: The Potential and Limitations of Planning*, 127. Effting, S. H. J. (2009). *The added value of sustainable business sites*.

26/5/2020	Netherlands OR dutch OR holland "sustainable business sites"	70 (2 included)	Bontje, M. (2004). Sustainable new economic centres in European metropolitan regions: A stakeholders' perspective. *European Planning Studies*, *12*(5), 703-722.
26/5/2020	Netherlands OR dutch OR holland "eco industrial sites"	38 (no new papers included)	
26/5/2020	Industrial symbiosis Netherlands OR dutch OR holland "eco industrial sites"	37 (no new papers included)	
26/5/2020	allintitle: green park netherlands OR dutch OR holland	0	
26/5/2020	Netherlands OR dutch OR holland "eco innovation parks"	54 (no new papers included)	
26/5/2020	Netherlands OR dutch OR holland "green industrial park"	31 (none included)	
26/5/2020	Netherlands OR dutch OR holland "green industrial parks"	18 (none included)	

26/5/2020	Netherlands OR dutch OR holland "integrated industrial park"	42 (none included)	
26/5/2020	Netherlands OR dutch OR holland "integrated industrial parks"	39 (none included)	

A2. Results of Scorpus

Relevant papers about EIPs and EIPs as symbiosis networks			
Date	**Keywords**	**Number of hits**	**Papers included**
26/5/2020	TITLE-ABS-KEY (eco AND industrial AND parks AND Netherlands)	7 (no new included)	
21/7/2020	TITLE (symbiosis AND networks)	134	Simboli, A., Taddeo, R., & Morgante, A. (2014). Analysing the development of Industrial Symbiosis in a motorcycle local industrial network: the role of contextual factors. *Journal of cleaner production*, *66*, 372-383. Yap, N. T., & Devlin, J. F. (2017). Explaining industrial symbiosis emergence, development, and disruption: a multilevel analytical framework. *Journal of industrial Ecology*, *21*(1), 6-15. Bacudio, L. R., Benjamin, M. F. D., Eusebio, R. C. P., Holaysan, S. A. K., Promentilla, M. A. B., Yu, K. D. S., & Aviso, K. B. (2016). Analyzing barriers to implementing industrial symbiosis networks using DEMATEL. *Sustainable Production and Consumption*, *7*, 57-65. Wang, Q., Deutz, P., & Chen, Y. (2017). Building institutional capacity for industrial symbiosis development: A case study

			of an industrial symbiosis coordination network in China. *Journal of Cleaner Production*, *142*, 1571-1582. Herczeg, G., Akkerman, R., & Hauschild, M. Z. (2018). Supply chain collaboration in industrial symbiosis networks. *Journal of cleaner production*, *171*, 1058-1067.

Relevant papers about mixed industrial parks and sustainable business parks			
Date	**Keywords**	**Number of hits**	**Papers included**
21/7/2020	ALL (“sustainable business parks’)	8	ATWA, S. M., IBRAHIM, M. G., & SALEH, A. M. (2017). Green business parks towards sustainable cities. *WIT Transactions on Ecology and the Environment*, *214*, 9-19. Bontje, M. (2004). Sustainable new economic centres in European metropolitan regions: a stakeholders' perspective. *European planning studies*, *12*(5), 703-722. Le Tellier, M., Berrah, L., Stutz, B., Audy, J. F., & Barnabé, S. (2019). Towards sustainable business parks: a literature review and a systemic model. *Journal of cleaner production*, *216*, 129-138.
27/7/2020	TITLE-ABS-KEY (“mixed industrial parks)	3	Lambert, A. J. D., & Boons, F. A. (2002). Eco-industrial parks: stimulating sustainable development in mixed industrial parks. *Technovation*, *22*(8), 471-484. Maes, T., Van Eetvelde, G., De Ras, E., Block, C., Pisman, A., Verhofstede, B., ... & Vandevelde, L. (2011). Energy management on industrial parks in Flanders. *Renewable and Sustainable Energy Reviews*, *15*(M4H), 1988-2005. Corder, G. D., Golev, A., Fyfe, J., & King, S. (2014). The status of industrial ecology in Australia: Barriers and enablers. *Resources*, *3*(2), 340-361.

27/7/2020	ALL (“sustainable business sites’)	44	Bontje, M. (2004). Sustainable new economic centres in European metropolitan regions: a stakeholders' perspective. *European planning studies*, *12*(5), 703-722.
29/7/2020	TITLE-ABS-KEY (“sustainable industrial parks)	6	None included
29/7/2020	TITLE-ABS-KEY (“sustainable business site)	3	Pellenbarg, P. H. (2004). Parkmanagement as a tool for careful industrial land-use planning. *Journal of Environmental Planning and Management*, *47*(M4H), 503-516. Snep, R., Van Ierland, E., & Opdam, P. (2009). Enhancing biodiversity at business sites: What are the options, and which of these do stakeholders prefer?. *Landscape and Urban Planning*, *91*(1), 26-35.

B. List of EIPs in the Netherlands in 1999

Friesland
1 Heerenveen/Heerenveen-Zuid

Groningen
2 Groningen/Milieuboulevard Groningen
3 Delfzijl/North Refinery Delfzijl CA

Drenthe
4 Beilen/Ossebroek
5 Wijster/Tweesporenland(VAM)
6 Emmen/Veenoord

Overijssel
7 Kampen/Haatland 7
8 Zwolle/Hessenpoort
9a Deventer/Colmschate Noord
9b Deventer/Bedrijvenpark A1
9c Deventer/Bergweide
10 Hengelo/Westermaat-Noord 2

Flevoland

11 Emmeloord/Ecobedrijvenpark
12 Lelystad/Noordersluis
13 Lelystad/Ecobedrijvenpark
14 Almere/De Vaart

Gelderland
15 Apeldoorn/De Kar/Ecofactorij
16 Zutphen/De Mars
17 Barneveld/Harselaar-West
18 Arnhem/Kleefse waard
19 Arnhem/Business Park Arnhem
20 Arnhem/Koningsplei
21 Arnhem/IJsseloord 2
22 Arnhem/Nijmegen/MTC Valburg

North Holland
23 Alkmaar/Boekelemeer Zuid fase 1
24 Heemskerk/De Trompet
25 IJmuiden/Business Park IJmond
26 Zaanstad/Westzanerpolder
27 Zaanstad/Achtersluispolder
28 Zaanstad/Hembrugterrein
29 Amsterdam-Noord/Cornelius Douwes terrein
30a Amsterdam/Lutkemeer
30b Amsterdam/Westpoort-Afrikahaven
31 Hoofddorp/Transpolis Schiphol Airport
32 Schiphol/De Elzenhof

South Holland
33 Europoort/INES-CEATON
34 Rotterdam/Truckpark Waalhaven
35 Rotterdam/Spaanse polder

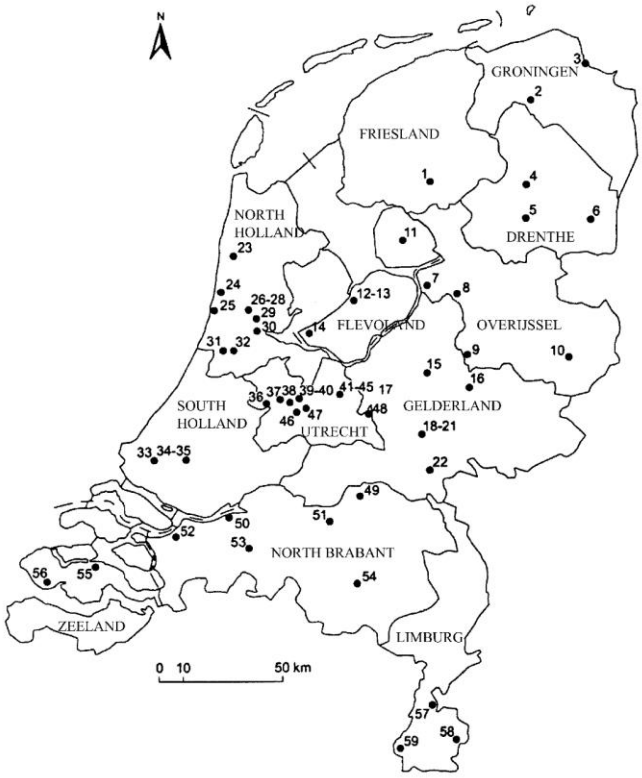
Utrecht
36 Woerden/Kantorenstraat
37 Harmelen/Glastuinbouw Harmel
38 Vleuten-deMeern/Ouden Rijn
39 Utrecht/Leidsche Rijn
40 Utrecht/Lage Weide
41 Amersfoort/Isselt
42 Amersfoort/De Hoef
43 Amersfoort/Calveen
44 Amersfoort/De Wieken
45 Amersfoort/Vathorst
46 Nieuwegein/Het Klooster
47 Houten/De Bark
48 Veenendaal/De Batterijen

North-Brabant
49 Oss/Moleneind

50 Moerdijk/Moerdijkse Hoek
51 Den Bosch/De Rietvelden
52 Dinteloord/AgroIndustrieel Complex
53 Breda/De Krogten
54 Eindhoven/De Hurk Zeeland
55 Goes/De Poel, Goes-Zuid
56 Middelburg/De Mortier

Limburg
57 Sittard/Fortuna Park
58 Heerlen/Aken/Avantis
59 Maastricht/Beatrixhaven
Obtained from Bakker et al. (1999) (as cited in Pellenbarg, 2002)

C. Map of EIPs in the Netherlands in 1999



D. Findings on the discarded parks recommended by experts

D1. Moerdijk in North Brabant

It is a brownfield development project that started in 1998 with a focus on sustainable production processes (Massard et al., 2014) and the exchange of energy and raw materials (P. Pellenbarg, 2002).

The park has an area of 120 hectares available for companies in the chemical or chemical-related business in the heaviest environmental category. Other companies in the heaviest environmental category are also allowed in the park (Port of Moerdijk).

In 2009, a project called Sustainable Connections started. The ambition of the project is the accomplishment of the exchange of heat between companies, improvement of permit procedures, supply residual heat and CO2 to nearby greenhouses and increase job opportunities. Governmental organisations (the port authority of Moerdijk, the municipality of Moerdijk, the province of Noord-Brabant, the department of waterways and public works) and the Business and Industry Circle Moerdijk are collaborating to construct the pipeline infrastructure to circulate energy (heat), CO2 and water around the whole EIP. Part of the infrastructure is built, but it is still in progress (Spekkink & Boons, 2016).

Another initiative emerged in 2011 which aims for sustainable development in the region, specifically to have a sustainable port and industrial area. This initiative has the objective of monitoring the environmental performance, the exchange of knowledge among participants in the park, the improvement of water loops, and communication with the environment of the park (such as addressing to neighbor complaints) (Spekkink & Boons, 2016).

Today, the Shell refinery works as an anchor and is the core of the park. Exchanges happening include Montell using ethene and other gases from the refinery, and the refinery using waste products from Montell. Kolb uses ethene oxide as a raw material from the refinery. There is also AZN, a waste incinerator that supplies steam and electricity to the Shell refinery, steam to a power plant, and steam to a truck washing activity. Besides, a biogas producer supplies CO2 for pigment manufacture. Basell also gets raw materials from Shell, and Shell delivers carbon dioxide to glass horticulture (Massard et al., 2014; P. Pellenbarg, 2002).

The success of this park is attributed to the active participation and will to invest of the tenants and the active participation of the entrepreneurs' association that has a coordinator role to communicate information (Massard et al., 2014).

The port authority also has the role of coordinator. The port authority acts as the developer, manager, and operator of the park and the port. They also assure the quality of the park and port in the present and future (Port of Moerdijk).

D2. Chemelot in Limburg

Chemelot is an industrial park that focuses on high chemistry and new materials. The area of the park is of 800 hectares (Chemelot, 2020c).

It is located in the southern region of the Netherlands where the mines of Geleen were located. Today, DSM N.V. (Dienst der StaatMijnen) is a global science-based company that focuses on health, nutrition, and materials with sustainability as one of their core values. Chemelot is the industrial site of DSM as well as the organisation that services the industrial area (Vliek,2011).

Chemelot contains R&D centers, pilot and demonstration factories, large scale chemical manufacturing industry, start-ups, and SMEs. Until 2002, all the factories and R&D centers were part

of DSM. At the moment there are more than 150 companies and institutions at the park, where 60 of them are factories (Chemelot, 2020e).

Regarding sustainable collaborative activities, Chemelot is involved in flow exchange and utility sharing making production processes greener. Factories exchange and recycle residual flows of energy (Chemelot, 2020d).

There is also a collaboration of about 30 industrial companies that produce petrochemical and plastic products involved in operations to reduce the use of raw materials, repurpose waste, and keep efficient operations (Headrick, 2018).

The Utility Support Group is the company in charge of the utilities of the park. USG provides the purchase, production, distribution, and sale of technical gas, water, and electricity, steam, nitrogen, instrument air and compressed air (Chemelot, 2020f). The park also houses a heat and power plant, a steam plant, and a wastewater treatment plant (Chemelot, 2020b).

For 2025, Chemelot wants to become the safest, sustainable, and competitive chemical site in Europe by focusing on a sustainability transition of the production processes and the final products (Chemelot, 2020a).

D3. GreenPark Venlo in Limburg

This is a green office and educational park located in Greenport Venlo installed after the Floriade horticultural event was finalized (Doorn, Stimac, & Schik, 2013). The park houses office-based companies and knowledge-intensive institutes mainly operating in the agro-sector (food, flowers, fresh production). Space in the park is also destined for services including facility management and leisure such as wellness, fitness, sports facilities, catering services, and a conference center (GreenPark, n.d.).

Greenpark Venlo is inspired by the Cradle-2-Cradle design, which focuses on sustainable production, operation, and disposal to make products 100% recyclable and use wastes as raw materials (Doorn et al., 2013).

All of the elements of Venlo GreenPark are developed and designed guided by sustainability, based on reusing raw materials to make 100 % recycled products (GreenPark, n.d.).

D4. M4H (MerweVierhavens) in Rotterdam

The M4H is an area of an old port being transformed into a new city district by the municipality of Rotterdam and the Port of Rotterdam Authority. There are pioneering and traditional manufacturing companies and companies in the circular manufacturing industry. Besides the manufacturing industry, there is also space for housing, catering and other functions. (M4H, n.d.).

The main objective is to transform the area into a centre for innovative manufacturing by housing large corporations and start-ups. The area is expected to attract knowledge institutes and corporations which foster innovation. It is expected that the M4H becomes a leader in experiments focusing on CE in Rotterdam (van Slobbe, 2019).

D5. Buiksloterham in Amsterdam

This is a project aiming for circular neighborhood development in Amsterdam for socioeconomic development, and wellbeing. The project started in March 2015 (Buiksloterham, n.d.).

The stakeholders have a shared vision of a transition to a circular city. The targets are in having full renewable energy supply, make the city sewer free by collecting rainwater and treating wastewater, using shared vehicles, constructing circular buildings and material management,

The environmental plans of Buiksloterham for 2034 include:

- Being energy self-sufficient with a renewable energy supply.
- Have nearly a 100% circular material flow.
- Have nearly 100% od resources recovery from wastewater
- Have zero emission in local mobility (Gladek, van Odijk, Theuws, & Herder, 2015)

D6. Waarderpolder, Haarlem

This business park houses more than 1100 companies in 2.5 km2, with 14500 employees. More than 100 are manufacturing companies. SMEs include companies from different sectors such as printing, packaging production, pharmaceutical, or a beer brewery.

The park looks for a sustainable supply of energy with solar panels, wind turbines, and sustainable heat. Besides, the park seeks to develop more green areas to capture CO2 (Waarderpolder, n.d.-a).

Collaboration is essential at the park. The Industrial Ring Haarlem (which represents the entrepreneurs of the park) has been working with the municipality for some years. This has had an impact on aiming for circular entrepreneurship and innovative manufacturing (Waarderpolder, n.d.-b).

For mobility, the park has shared bicycles (Waarderpolder, n.d.-c)

Even though the park is conscious about CE, a survey made by the Haarlem municipality to 34 manufacturing companies showed that there are no residual flows from production processes that can be used as raw materials by other companies in the park because currently, companies need high-quality raw materials. However, there are opportunities for other types of wastes, like collective waste flows (coffee cups, plastics, office waste, cardboard and paper, and wood) individual bulk waste (mixed materials and wastewater), or individual waste (concrete, used nets) (Bosch, Driessen, ten Wolde, Dekkers, & van der Linden, 2017).

D7. Lage Weide in Utrecht

This is one of the oldest business parks in the Netherlands. In the beginning, the park housed industrial entrepreneurs and construction companies. Now, the entrepreneurs, government, and research institutions focus more on finding logistics and distribution solutions.

The park is 216 hectares and has more than 900 companies. The companies' sectors are very diverse, including distribution centers, construction companies, transport companies, utility companies, demolition waste processing companies, collective business buildings, IT, and startups addressing sustainability and energy transition distribution (Lage Weide, 2020).

D8. Brainport campus Eindhoven

This park is a place to accelerate high tech manufacturing. Parties involved in the high-tech supply chain can work together on innovation and production. The park has a state-of-the-art environment to work and learn, including resources like clean rooms, flexible manufacturing areas, warehouses, and advanced facilities.

Several facilities can be shared such as clean rooms, meeting rooms, storage, warehousing, and a restaurant. Services like cleaners, IT, security, and a joint pool of flex workers can also be shared. Technologies and processes like 3D printing, measurement systems, fiber-optic internet, server rooms, stock control, logistics, quality control, and waste processing will also be used together (Brainport Eindhoven, n.d.).

D9. Cosun Beet Company (previously Suiker Unie)

Cosun Beet is a sugar producer company that is heavily concerned about sustainability and is taking a step to an energy transition. The company has invested in several sustainability initiatives during the last years, focusing on green energy. Now, Cosun Beet Company is the biggest producer of green gas in the Netherlands.

This company that has 4 factories in the Netherlands and wants to accomplish circularity by treating its own waste and creating green gas. Their goal is to accomplish complete circularity. Cosun Beet has accomplished to process the sugar beet residual flows by using biomass digesters to produce energy in the form of biogas. Residues remaining after digestion are used as fertilisers for farmers' fields which closes the supply chain loop.

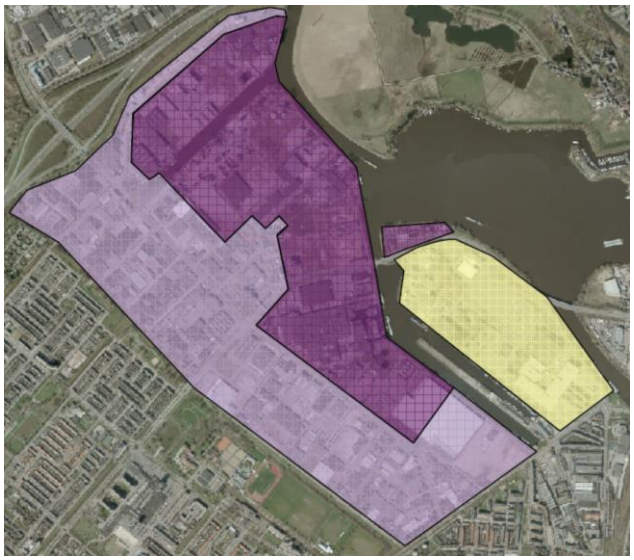
Biogas is then upgraded to green gas and transferred to the national gas transmission network, feeding at least 20,000 households a year. A part of the green gas is used at the companies' factories, cutting the consumption of natural gas by 10% a year.

The company has four wind turbines in one of the factories and is looking to have another factory to operate entirely on solar power soon (Cosun Beet Company, n.d.).

D10. De Rietvelden in Den Bosch

De Rietwelden is the largest business park in 's-Hertogenbosch with 250 hectares, and 459 companies. The construction of the park started in the 1930s, with the largest part built in the 1950s.

The park has two divisions, one for SMEs with a medium environmental category (2 to 4) , and one for more large-scale and water-related companies with a heavier environmental category (2 to 5) (Municipality of 's-Hertogenbosch, 2009; Municipality of 's-Hertogenbosch, n.d.). SMEs are located west of the dark purple area, and large heavy industries are located in the east of the light purple area as shown in the next figure.



Subareas of De Rietvelden park (Municipality of 's-Hertogenbosch, 2009).

The park has 13% of industry companies, 38% belong to retail, 29% to the services sector, and construction and other services 7% (Municipality of 's-Hertogenbosch, 2009).

Some of the large companies present in the park are Heineken, Benier (machines) Sigma Coatings (paints), Tyco Electronics, among others.

A business association (RiVu) of De Rietvelden and de Vutter parks was created in the late 1990s formed by companies and the municipality. With the association in place, the project Sustainable Revitalization RIVU started. This project aims to improve the economic results, environmental impact, and efficient use of space in the park.

The association has been in charge of restructuring and solving problems in the park. Good results have been achieved with the involvement of entrepreneurs, the state, and the province. The improvements in the park have attracted private investments, new constructions, and several redevelopment projects (Municipality of 's-Hertogenbosch, 2009).

D11. Oosterhout

No relevant information found

D12. Zwolle

No relevant information found

D13. Table with a more detailed criteria for the non selected cases.

Eco-industrial park	Presence of production facilities	Presence of collective synergy 1: Exchange of materials and flows	Presence of collective synergy 2: Utility sharing	Presence of colleciive synergy 3: Joint provision of services	Relevant secondary literature?	Size (hectares)	Number of companies	Tine of implementation	Front-runner?	Sources
Chemelot (Former DSM site) in Limburg	Yes	Yes (residual energy flows are exchanged)	Yes (There is shared purchase, production, distribution and sale of technical gas, water, and electricity, steam, nitrogen, instrument air and compressed air. There is also a wastewater treatment plant.)	Not found	Yes	800	150+	2002	Yes	www.chemelot.nl
De Rietvelden in Den Bosch	Yse	Not found	Yes. (There is a collective facility that supplies water, energy and power and a wastewater purification installation that produces biogas)	Not found	Yes	250	459	1950s	Yes	(Municipality of 's-Hertogenbosch, 2009) (Eilering & Vermeulen, 2004)
Moerdijk in North Brabant	Yes	Yes (Exchange of ethene, gases, steam and electricity and other raw materials)	Yes (co-makership of energy)	Not found	Yes	120	400	1998	No	(Massard et al., 2014) (Pellenbarg, 2002) (Spekkink & Boons, 2016) https://www.portofmoerdijk.nl/media/1182/brochure-industrial-park.pdf
Greenpark Venlo	No	Not found	Not found	Not found	No	Not found	Not found	2012	No	https://web.archive.org/web/20150518040444/http://www.venlogreenpark.nl/en/venlo-greenpark/locating-to-venlo-greenpark
M4H in Rotterdam	Not found	Not found	Not found	Not found	No	Not found	Not found		No	www.m4hrotterdam.nl
Buiksloterham in Amsterdam	No	No	No	Yes (shared vehicles and shared collection and management of waste)	No	Not found	Not found		No	www.issuu.com/delvalandscape/docs/circular buiksloterham_eng_full_repo
Waarderpolder in Haarlem	Yes	A report in 2017 said there were not complementary matches between companies.	Not found	Yes (shared bicycles)	No	250	1100 (100 manufacturing)	Over 100 years ago	Yes	www.waarderpolder.nl
Lage Weide in Utrecht	Yes	Not found	Not found	Not found	No	216	900+	1945. Investments in 2007.	No	www.lageweide.nl
Brainport Industries Campus in Eindhoven	Yes	Not found	Not found	Yes. Several facilities can be shared such as clean rooms, logistics, quality control, and waste processing will also be used together.	No	Not found	Not found	Created since 1945. Investments made in	No	www.brainportindustriescampus.com
Cosun Beet Company (previously Suiker Unie)	Yes	This is mainly a circular company that has 4 factories in the Netherlands and wants to accomplish circularity by treating its own waste and creating green gas. They also treat their waste water, have wind turbines, and solar panels	Not found	Not found	No	Not found	4 factories	Created since 1945. Investments made in 2007.	Yes	https://www.cosunbeetcompany.com/
Oosterhout	Not found	Not found	Not found	Not found	No	Not found	Not found	Not found	No	Not found
Zwolle	Not found	Not found	Not found	Not found	No	Not found	Not found	Not found	No	Not found

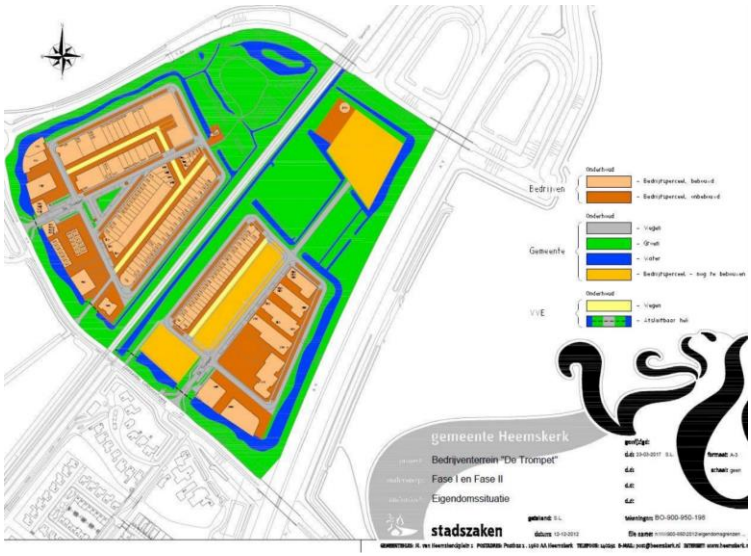
E. Findings on the selected cases that had to be changed

E1. De Trompet in Heemskerk

This mixed industrial park of 18 hectares started in 1992 (Eilering & Vermeulen, 2004), becoming a pioneer in sustainable business parks in the Netherlands. This park is used by municipalities and institutions as a reference and example for the development of sustainable business parks (Voogd & Bunnik, 2003). This park is a sustainable and environmentally friendly park (BIZ, 2017).

The park was initiated by the municipality with the help of consultancies and their technical and process knowledge (Voogd & Bunnik, 2003). Now, the park has 120 companies (Techneco, n.d.) with the first companies joining until 2001. The long period for this is due to the lack of expertise in sustainability by the organisation and the efforts needed to implement sustainability in practice. The objective of the park is to reduce CO2 emissions by 50% compared to a common industrial park. It also focuses on other sustainability themes such as water, energy, transport, raw materials and waste, and planning quality (Eilering & Vermeulen, 2004). Now, all the buildings of the park are heated and cooled by a collective source (Techneco, n.d.).

The park contains B2C and B2B companies, production companies, collective buildings for entrepreneurs, and offices (BIZ, 2017). The map of De Trompet can be seen in the next figure.



De Trompet map (BIZ, 2017).

According to Eilering & Vermeulen (2004) the park had a low ambition, with sustainable measures mostly targeted only at individual companies. The measures were carried out, but not all sustainability targets were achieved (in 2004).

Some of the sustainable activities accomplished include (Voogd and Bunnik, 2003):

- There is a biological purification system for water
- Energy-saving at the building level and sustainable energy generation achieving more than 50% CO2 generation at the building level (heat pumps in combination with an aquifer, solar panels).

According to Voogd and Bunnik (2003) several success factors determined the success of the park:

- The physical environment of the park (the possibility of using aquifers)
- The period of the development (attention to sustainability, growth of energy market)
- Creation of an agreement between the municipality and official organisation (a clear division of responsibilities)
- Decision-making made by the organisation (establishing ambitions, objectives, conditions)
- The enthusiasm of people and organisations involved
- Effective communication

The board of the Business Investment Zone (BIZ) association does the park management and represents the interests and initiatives of the entrepreneurs in the park. The BIZ cooperates with the municipality and the entrepreneurs to work in the quality of the park. In the coming years, it is aimed to achieve a collective purchasing of resources (De Trompet, n.d.).

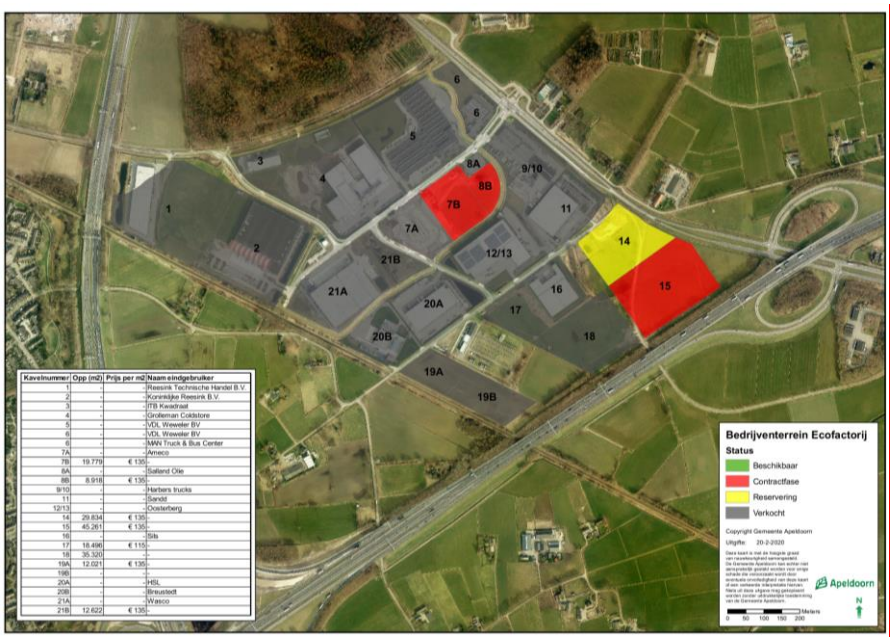
The BIZ has the objectives of keeping the maintenance and safety of the park. The activities carried out by the BIZ association include elaborating an action plan (activities, budget, a charge per entrepreneur, organisation), creates support among entrepreneurs, and makes agreements with the municipality about what is the role of each one for the park development, applies for subsidies (such as the one from the municipality) and collect investments of entrepreneurs (ParkTrust, n.d.). The BIZ does other activities such as publishing newsletters, organising meetings (at least once a year), regular consultations with stakeholders and municipality of Heemskerk, making annual reports and plans (Business Investment Zone Board, 2017). The BIZ also arranged the contracts for the implementation of solar panels, and collective security and telecom services (Voogd & Bunnik, 2003).

The park also requires an internal organisation to monitor and help with the implementation of other activities of BIZ (Business Investment Zone Board, 2017).

E2. Ecofactorij in Apeldoorn

This park was created in 1998 and has 75 hectares (Pellenbarg, 2002). Efficiency and sustainability are two themes that are essential for the park (Bedrijnventerrein Ecofactorij, 2020b). When created, the park had high ambitions of achieving industrial symbiosis and utility sharing but a low performance (in 2004 none of the proposed measures had been carried out). The objective of the park is to run entirely on non-fossil fuels, have at least 75% of the water produced sustainably, and minimize waste flows (Eilering & Vermeulen, 2004).

The park is destined for large-scale firms in the production sector or logistic services (each using 3 hectares or more) that comply with ecological targets set by the municipality of Apeldoorn that is the developer of the park (Pellenbarg, 2002; SenterNovem, 2004). The park can be described as a mixed industrial park that houses companies up to environmental impact category 4 (Eilering & Vermeulen, 2004). According to the figure below, there are 15 companies in the park with space for more.



Map of Ecofactorij (Bedrijnventerrein Ecofactorij, 2020b).

The park has a system for counting ecological points for the tenant companies. The companies need to mandatorily comply with some conditions included in the “location package” and get extra points if they take extra measures voluntarily included in the “plus package”. The “location package” demands collective firm transport systems, car-pooling, and joint waste removal. The “plus package” includes the reuse of waste materials or waste-water or the collective use of energy. More points mean lower land prices, higher subsidies and priority to settle on the park (Pellenbarg, 2002).

Other ecological targets include the production of renewable energy (solar panels and biomass), use sustainable building materials, energy-efficient buildings, saving energy, establishing a green environment, reusing rainwater, and reducing mobility (Atwa et al., 2017; Pellenbarg, 2002). One of the most important elements is sharing utilities for the supply of energy and water. There are plans (in 2002) for using an existing incineration plant as a source of biogas (Pellenbarg, 2002).

Recently, the park has implemented new technologies to achieve more sustainability. A smart grid has been developed by the companies at the park. It consists of an electricity grid designed for the purchase and delivery of electricity to the grid in a smart way. This means that peaks in electricity demand are avoided and result in less cost (Bedrijnventerrein Ecofactorij, 2020a).

The park management is organized by an association formed by all entrepreneurs in the park. The companies and municipality are part of the board (SenterNovem, 2004).

The park management consists of three different independent activity groups: a management unit (in charge of paving, sewerage, greenery and water, lighting, street furniture, signs), a facility centre (joint purchase of items, childcare) and a utility centre (energy facilities, water, waste separation) (SenterNovem, 2004).

Every company participates in the cooperative for the park management aiming for sustainable solutions beneficial for participants and the park. At the moment, the focus is on implementing solar

panels on the companies' roofs so the surplus can be supplied to the nearby residential areas (Bedrijnventerrein Ecofactorij, 2020a).

Eilering & Vermeulen (2004) remark that the park had a top-down decision-making process, which harmed the support from local NGOs. Some parties even started legal proceedings against the local authority. The undesired outcome could have probably been avoided if these parties were involved in the decision-making process.

F. Interview questions with expert to define case studies

Question 1: Who are the actors that have a relevant role in the development of an EIP in the Netherlands?

Question 2: What is the process and phases that a business park goes through to transform into an EIP in the Netherlands?

Question 3: Which are the front-running eco industrial parks that are leading in terms of collective industrial synergies (industrial symbiosis, shared utilities, or joint provision of services) in the Netherlands?

Question 4: What kind of collective industrial synergies are happening in these front-running mixed industrial parks?

Question 5: Are there any key players that had a crucial role in the successful implementation of collective industrial synergies at these front-running parks?

Question 6: What are the most important factors for the successful implementation of collective industrial synergies in a business park?

Question 7: What are the biggest barriers to the implementation of collective industrial synergies in a business park?

Question 8: What is the role of technology for the implementation of collective industrial synergies at the business parks in the Netherlands?

Question 9: What elements need to be improved at the park level in the Netherlands to make the implementation of collective industrial synergies more effective?

Question 10: What elements need to be improved at the institutional level in the Netherlands to make the implementation of collective industrial synergies more effective?

G. Interview questions with selected respondents for the different cases

G1. Interview questions for park management

This questionnaire was applied to:

- Program manager (InnoFase)
- Corporate Contact Officer (InnoFase)
- Director (IPKW)
- Partner at Van de Bunt Consultancy (Biopark Terneuzen)
- Partner at Van de Bunt Consultancy (Biopark Terneuzen)
- CEO of TransForum (Biopark Terneuzen)
- Assistant professor and researcher (Biopark Terneuzen)

Introductory Questions

1. Can you shortly introduce yourself and explain how your work relates to eco-industrial parks?
2. What was the formation process of InnoFase in general terms?
3. Who were the most relevant actors in this process?
4. Why do you think InnoFase is so successful?

Vision and Ambition

5. What is the sustainability vision of the InnoFase?
6. How was this vision developed and refined?
7. What is the ambition of the park?

Decision-making

8. How are decisions at InnoFase made?
9. Do you have certain criteria that the new companies need to meet to join the park?

Projects at the Park

10. How were opportunities for new more sustainable options and projects identified? Who participated in the identification?
11. What factors do you consider were the most determinant for the success of the synergies?
12. What were the major challenges or barriers to achieving the synergies between companies?
14. Which projects have been unsuccessful?
15. What were the biggest reasons for the failure of these projects?
16. How does the context of the park influence the creation of new projects?
17. Do you think policies supported the development of the park?

Closing Questions

18. What would you change about the government to make the park more sustainable and circular?
19. What do you think that needs to change at the park level to make it more sustainable and circular?
20. Do you know any other contacts that I can speak to? Any other relevant persons that work in companies in the park that are involved in synergies, persons that work in the municipality of Duiven or other government agencies related to InnoFase?

G2. Questions for companies

This questionnaire was applied to:

- Plant Manager at AVR (InnoFase)
- Process Manager at the Rijn & Ijssel Water board (InnoFase)
- Director at Primco (InnoFase)
- Communications & Marketing Officer and Project Manager at Veolia (IPKW)
- Project manager at Save Plastics (IPKW)
- Operational manager at the Mobility Innovation Center (IPKW)

Introductory questions

1. Can you shortly introduce yourself and explain how your work relates to eco-industrial parks?
2. What was the formation process of cooperation between the company and the EIP?
3. Why do you think the park is so successful?

Vision and ambition

4. What is the sustainability vision of the company?
5. Was the vision of the company somehow modified or aligned with the vision of the park?

Decision-making

6. How are the decisions in the park made?
7. Does the company have any role in the decisions the park makes?

The situation at the park

8. In what initiatives aiming for more sustainability and circularity is the company involved inside the park?
9. What was the formation process of the exchanges of residues between the companies?
10. How were opportunities for more sustainable options and projects identified? Who participated in the identification?
11. What factors do you consider were the most determinant for the success of these projects?
12. What were the biggest challenges or barriers to achieving these projects?
13. Was the company involved in any projects aiming for more sustainability and circularity inside the park that were unsuccessful?
14. What were the biggest reasons for the failure of these projects?
15. What do you think about the context formed by the park? Does it impact the formation of synergies or cooperation between companies?
16. How have policies and regulations affected the creation of synergies at the park?

Closing questions

17. What would you change about the institutional level (e.g government, universities) to support the implementation of new synergies between the tenants in the park?
18. What do you think that needs to change at the park level to foster the implementation of more synergies in the park?

19. Do you know any other contacts that I can speak to? Any other persons that work in park management, companies that are involved in synergies in the park, or that work in the municipality of or government agencies that are involved in the development of the park?

G3. Questions for the municipality

This questionnaire was applied to:

- Municipality of Arnhem (IPKW)

Introductory questions

1. Can you shortly introduce yourself and explain how your work relates to eco-industrial parks?
2. Why do you think IPKW is so successful?

Vision and ambition

3. What is the sustainability vision of the municipality of Arnhem? Do you have a plan for it?
4. How was this vision developed?

Decision-making

5. Is the municipality involved in any decisions that are made at IPKW? How?

The situation at the park

6. What is the role of the municipality of Arnhem at IPKW?
7. How does the municipality support new sustainable and circular projects at the park? How do you choose which ones to support?
8. In what sustainable initiatives aiming for more sustainability and circularity is the municipality involved at the park?
9. What was the formation process of the cooperation between the municipality and the park?
10. How were opportunities for these more sustainable options and projects identified? Who participated in the identification?
11. What factors do you consider were the most determinant for the success of these projects?
12. What were the biggest challenges or barriers to achieving these projects?
13. Has the municipality been involved in any projects aiming for more sustainability and circularity at the park that were unsuccessful?
14. What were the biggest reasons for the failure of these projects?

Policies and regulations

15. How have policies and regulations affected the creation of synergies at the park?
16. What policies or regulations have been imposed to support or incentivize new sustainable and circular initiatives?
17. How do you deal with old regulations that hamper the development of more sustainable practices?

Closing questions

18. What would you change about the institutional level (e.g government, universities) to support the implementation of new synergies between the tenants in the park?

19. What do you think that needs to change at the park level to foster the implementation of more synergies in the park?
20. Do you know any other contacts that I can speak to? Any other persons that work in the municipality or government agencies that are involved in the development of the park?

H. Consent Form

Information sheet for the graduation project of Carlos Valladolid, MSc Delft University of Technology

Purpose of the research

The purpose of this research is to find how to facilitate the implementation of synergies in front-running parks at the park level and institutional level in the Netherlands. The findings are useful for Dutch managers of firms, park managers, management bodies and local policymakers to know where to focus their efforts on the innovation process for the more likely success of projects aiming for sustainability in Dutch business parks.

Scientifically speaking, the project gives empirical novelty about the state-of-the-art of eco-industrial parks in the Netherlands and a better understanding of the enabling and constraining factors for the success or failure of the projects that aim for sustainability involving the cooperation of different actors.

Benefits and risks of participating

The participants will receive the final research report for their contributions.

As a risk, the participant and the company they work in could experience adverse consequences if critical information given could be linked back to them. However, critical information shared will stay anonymous. Only the information such as the position and years of experience will be used in the study to guarantee anonymity. Besides, the participants will be consulted about what information given can be used and what needs to be left out.

Procedures for withdrawal from the study

Participating in the research project is voluntary and you can withdraw your participation at any time by informing the researcher.

Whether any personal information about the participant will be collected, processed and how and for what purpose; the right of the participant to request access to and rectification or erasure of personal data

The information from the participant that will be collected by the researcher includes name, position, years of work experience. This information is collected to validate the relevance of the contribution of the participant to share their experiences and contribute to the study. Besides, the email address will be used as a communication platform between the researcher and the participant.

Usage of the data during research, safeguarding personal information, maintaining confidentiality and de-identifying (anonymising) data, controlled access to data, especially in relation to data archiving and reuse, ways of dissemination, data archiving and possible publishing

The interviews will be video-recorded digitally to enable the making of text transcripts. This gives the researcher the possibility to analyse the data collected in detail. The transcripts will be anonymised but using the position and years of experience as a reference. The recordings will not be shared with anyone else outside the study team formed by the researcher and two TU Delft professors.

The anonymised results of this research will be published in the TU Delft repository for future research and learning purposes.

Retention period for the research data, or if that is not possible, criteria used to determine that period and contact details of the data protection officer in the institution

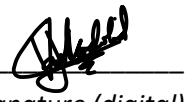
The recordings will be destroyed after the research project has ended.

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated ____or it has been read to me and I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
I understand that taking part in the study involves a video-recorded digital interview used to transcribe the information for further analysis and that the recording will be destroyed at the end of the project.	☐	☐
Risks associated with participating in the study		
I understand that taking part in the study involves the following risks: The participant could experience adverse consequences if critical information shared is linked back to them.	☐	☐
Use of the information in the study		
I understand that information I provide will be used for the research report and potential publications.	☐	☐
I understand that personal information collected about me that can identify me such as my name will not be shared beyond the study team.	☐	☐
I agree that my information can be quoted in research outputs without using my name.	☐	☐
Future use and reuse of the information by others		
I give permission for the anonymised transcripts that I provide to be archived in the TU Delft repository so it can be used for future research and learning.	☐	☐

Signatures

		_____
Name of participant	*Date*	*Signature (digital)*

I have accurately provided the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands what they are freely consenting.

Carlos Valladolid		
Researcher name	*Date*	*Signature (digital)*

Study contact details for further information: Carlos Valladolid, +31612766814, c.e.valladolidcalderon@student.tudelft.nl

I. Cross-case analysis summary

Factor	InnoFase	IPKW	Biopark Terneuzen
Vision and ambition	InnoFase is a brownfield project started by the municipality of Duiven. The municipality had the ambition to transform the area into a park as symbiotic as possible. Kalundborg was visited by the program manager, and it became an inspiration for InnoFase. The vision of the project was developed collaboratively between the governmental authorities and companies in the area. Apparently, there is no future map of how the park will look.	IPKW started by a family as a private brownfield project, aiming to become the most sustainable park in the Netherlands by 2025. IPKW does not want to become as symbiotic as Kalundborg because the park is not entirely industrial. They want to become more like a campus. The vision was formed by the family individually. There is a future map that visualizes the park ten years ahead.	Biopark Terneuzen is a brownfield project idea initiated by the Province of Zeeland. The idea of making an EIP was born in part when they visited an existing eco-park in Canada. Their ambition is to use one plant's waste streams as raw materials by another, focusing on the agricultural industry. The vision and ambition were developed collaboratively between the governmental actors and the companies. A map showing all the possible ideal stream connections was developed between the involved actors.
Location specific physical features	Companies in the park attract other companies if some cooperation is possible with their waste products. Distance between companies is short.	All companies in the park focus on innovation and energy transition. Not every company has waste flow because there are some small companies, consultancies and laboratories. However, there are shared utilities such as a power plant and a wastewater treatment plant where every building is connected to. There is a short distance between companies.	Companies' waste flows are complementary to each other production processes. There is a short distance between the companies that participate in exchanges. An exchange of biomass between the greenhouse and Nedalco did not happen because they were too far from each other and it was too expensive to make the connection.
Location-specific social features	There is a collaborative culture at InnoFase. Companies communicate with each other at periodic meetings. Knowledge is shared during these meetings, where problems are solved jointly, and updates of current projects are exchanged. Therefore, members of the park are aware of each other activities and processes. Interactions between companies have created trust. However, before the municipality intervened, companies were not even aware of what was happening in their surroundings. Sometimes there are understanding problems with universities.	At IPKW, there is a collaborative culture. There is constant joint problem solving and knowledge sharing between the HAN and companies. The cooperation between the HAN and companies is crucial for the development of new projects. There is constant communication between Veolia, park management and the companies and the HAN. However, it seems that companies are not aware of what is happening at every one of the 90 companies at the park, especially what is happening at the smaller companies. Companies seem to only focus on their core business without looking at their surroundings except when park management or Veolia suggests a new project. The presence of trust was not explicitly mentioned.	There is a collaborative culture in whole Zeeland because people tend to know each other, not only at Biopark Terneuzen. Several meetings were held where companies were updated each other about the state of current projects and new ideas. Problems were solved jointly and knowledge was shared at meetings. Trust was also developed during these meetings. Before the project started, companies only focused on their core business. Thanks to a consultancy they looked at the surrounding companies and their processes. There were also some understanding issues between universities and companies due to the difference in a scientific and practical way of working.

Factor	InnoFase	IPKW	Biopark Terneuzen
Business-specific features	The municipality and every company at the park want to become more sustainable and contribute to circularity. Companies are big-sized and generate a large amount of residues. In some cases specific exchanges have failed because there is not enough residue to make a profitable exchange. Companies are disposed to make long-term investments. The municipality and every company have an entrepreneurial mind and goals. Companies are capable of making huge investments However, a Every company is industrial and has an environmental category 4 or 5. Companies are willing and enthusiastic about exchanging streams. 4PET is the company that acts as the "spider in the web" and is connected to several companies and exchanges several streams.	Park management and every company located at the park want to contribute to circularity and an energy transition. There are some big industrial companies, but also some small startups that do not have production processes. Only big industrial companies with a high volume need for utilities are connected to the heat network. A smaller company struggled to receive waste streams from other companies. The park owners are disposed to make long-term investments in infrastructure such as pipes without a soon revenue. The owners, Veolia and the companies have an entrepreneurial mindset. The park management can make huge investments for projects like the biomass boiler, mainly because everything is reinvested in the park. There are some international industrial companies, but there are also small startups and companies with no waste flows, such as consultancies or laboratories that only focus on R&D. Parties involved in IPKW are enthusiastic about the projects and willing to perform better. Veolia is "spider in the web" company that is connected to every company in the park and supplies them any needed stream.	Actors involved at the park have a sustainable vision want to make their processes more sustainable. Companies were already developing some projects separately to become more sustainable before Biopark started. The greenhouses and companies that participate in exchanges are big-sized. Therefore, they have a huge amount of waste. However, some flow exchanges failed because the volume of waste generated was smaller than expected. Companies, the consultancy, and TransForum had an entrepreneurial mind. The municipality and the province did not. Companies are financially capable. Besides, there was considerable financial support from subsidies. Every company has some industrialized production process. Willingness and enthusiasm were present about the Biopark Terneuzen project.
Proposed measures	The municipality initiated the whole park project. Today, they also suggest new project initiatives. The newest one is to create an energy hub. Research institutions were more involved during the first years of development by finding new opportunities for exchanges. Today they still contribute with findings but less than before. Companies have technical experts that look for possible connections.	Research institutions contribute to new projects, such as finding new uses for recycled plastic. Opportunities for waste stream reuse such as heat are found by Veolia because they supply utilities to every company at the park. Park management also contributes with new proposals such as collecting wood, plastic, and organic waste from tenants at the park to reuse.	The opportunities for most of the exchanges were identified by a consultancy. Research institutions contributed with feasibility studies of the links identified by the consultancy. Some opportunities for stream exchanges, such as Yara giving their CO2 to the greenhouses, were identified by the companies themselves.

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Organisation of decision-making	The municipality makes decisions about which company to sell the plot at the park. Companies are the ones that decide if participating in an exchange or not. There is a task force formed by plant managers, the municipality, the province and the mayor that meets around three times a year. The task force is an informal cooperation and participants are comfortable with it. Having all the decision-makers together at the meetings has helped to develop new stream exchange projects. An obstacle for exchanges has also been that governmental bodies such as the Water Authority have a slower decision-making process than private companies. The decision-making process becomes harder when actors outside the park are involved. Also, when projects involve more stakeholders such as the surrounding community, there are more interests and the implementation process is slower and harder.	The owners of the park make any significant decisions because they own the buildings and the ground. However, some decisions are made collaboratively with Veolia because they own the power plant and the water treatment plant and are the utility providers. The owners have the freedom to operate and make decisions without approval from other parties because it is a private project. This also allows them to make decisions and take action in the short-term. Companies choose which projects to join. For example, they decide if joining the heat network or not. Different decision-making models are also seen with research institutions such as the HAN because they depend on municipal and provincial grants to participate in some projects.	There was a steering committee led by Zeeland Seaports that guided the course of the project. Zeeland Seaports decided which companies could be located at the park. TransForum could also intervene if they believed the project was not going in the right direction. The decisions to make the connections were made by the companies involved. Some obstacles were found when combining everyone's ideas and interests and putting them together into a project.
Policy instruments/Facilitator	The municipality acts as a facilitator and is crucial for InnoFase. The municipality is in charge of enabling the context for stream exchanges to happen. They are in charge of stimulating the companies inside to interact with other companies, helping companies look at their surroundings, initiating new project ideas and removing burdens such as maintenance of infrastructure and helping companies to get permits.	Park management is the facilitator. They organize events for companies to interact and also come with new project ideas. Park management also supports companies to accomplish their projects. Because Veolia, the utility provide, knows all the flows going in and out of companies, they can help companies by suggesting more environmentally friendly solutions by reusing flows. Veolia also does technical management and maintenance for the buildings at the park.	Van de Bunt was key in the planning phase. They acted as a facilitator by finding possible stream connections and convincing companies to join the project. Van de Bunt had to leave the project after the planning phase, and then the performance of the project declined. Zeeland Seaports is the other facilitator. They contributed with enabling the context, creating and enabling relationships, informing people, organizing meetings.

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Policy instruments/Regulations	Regulations are mainly a barrier for InnoFase. Even though regulations forced companies to pursue more sustainable processes, regulations were described as barriers because they lag behind innovations. As a public body, the Rijn & IJssel Water Board must comply with European regulations and cannot get streams from other companies. They need to tender instead. An exchange opportunity failed because of this. There is a requirement to have a "not a waste status" to receive waste from another company. Getting this permit can take years. Also, there is not a clear framework and guidelines for how to get this permit. InnoFase is also constrained by a Natura 2000 area that is closeby. Therefore, they cannot implement new activities at the park because nitrogen emission limits are surpassed.	Regulations were also mentioned mainly as a barrier because innovations go quicker than regulations. Nevertheless, regulations have also caused companies to take more sustainable alternatives such as the implementation of the biomass boiler. The inefficiency and lack of flexibility in permit processes were also highlighted. The government was qualified as changeful. The government supported biomass and granted subsidies for biomass projects. Now the government is against biomass. Because a Natura 2000 area also surrounds IPKW, they also struggle with nitrogen regulations and implementing new industrial activities.	Regulations also forced companies at Biopark Terneuzen to make their processes more sustainable to reduce their CO2 emissions. Biopark was also affected by a change in the government's stance toward biomass. When the government stopped supporting biomass, the amount of subsidy was considerably reduced. This decision made a biofuel factory get canceled as they depended on the subsidy money.
Policy instruments/Park policies	The municipality only accepts companies that contribute to circularity and IS and an environmental category 4 or 5. With these categories, companies generate more waste and allow more synergies. The municipality is strict with its selection. These policies were held even during the difficult times during the 2008 economic crisis.	IPKW is also strict with its selection policies. Only companies that have a sustainability theme and focus on cleantech are located at IPKW. The new tenants are selected between the owners of IPKW and the companies at the park by using a balloting system. If companies are not complementary to the park, they are not considered.	Zeeland Seaports only accepted companies that fit into the park's concept and contributed to circularity and bioeconomy.
Policy instruments/Other policies	Subsidies were highlighted as important in order for companies to develop more projects. It was suggested that more subsidies should be given to help companies build the infrastructure needed to exchange flows because it is very expensive. Synergies have helped to promote the park. The complete name of the complex is Synergy park InnoFase. The name and the ongoing synergies help the municipality to attract companies and sell the ground.	Companies at IPKW have benefited from governmental subsidies for research in circular economy. The HAN also gets considerable subsidies for new research. The biomass boiler was supported in great measure by a governmental subsidy. Also, a recent subsidy was given by the province of Gelderland for an innovation lab project called Connectr. The name of being an EIP also helps IPKW have more companies that want to be located at the park. Governmental promotion for IPKW has helped considerably to improve their image as well. Promotion in synergy projects has also helped new cooperations related to plastic recycling to happen. When companies realize the benefits of using plastic waste to create new products, they also want to cooperate.	TransForum invested two euros for every euro invested by a company which functioned as a magnet for companies to join and was a motor for the entire project. TransForum's money was used mainly for research. The Province of Zeeland and the European Union also gave a subsidy for the development of the project. These subsidies were used partly for infrastructure. However, a biofuel plant was not built because the government did not give Nedalco the initially planned subsidy. The name of Biopark Terneuzen created more unity for the project and made it more attractive for companies to join. The province of Zeeland, the municipality of Terneuzen and Zeeland Seaports also helped in propagating the project.

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Economic features	Having a business case is the priority for companies at InnoFase when a new opportunity for an exchange is identified. A business case is more important than sustainability. Every participant that participates in synergies gets some benefit. The companies get profit, more sustainable processes, and the municipality can sell the land easier because synergies make the park more attractive. Companies that participate in an exchange of streams have a low risk of failure, meaning that if the resource supplier fails, there is another option to get the resource. Hence, their processes do not risk stopping. A pipe for exchanges was not implemented because the risk of not profittng from the investment was too high.	Companies at IPKW also highlighted a profitable business case as crucial. Profits are needed to make innovations in processes. Companies at IPKW cooperate with other companies because they get a mutual advantage.	The main driver to create Biopark Terneuzen was economic. Besides, interviewees also highlighted the importance of having a business case when making an exchange of streams. Companies joined the project when they realized that they could benefit from it. Also, companies at Biopark have no risk of stopping their processes. Streams like heat and CO2 can be easily obtained from another source if the main supplier company fails.
External context	No new interesting projects were created at InnoFase during the economic crisis of 2008. InnoFase has become more successful in the last years partly because companies and society are more aware of sustainability and circular economy.	Companies at IPKW notice that a lot of attention is put on sustainability and circular economy by companies and society, which is favorable for the creation of more synergies. Markets are perceived as unfavorable for any transition because they change too slowly. Public opinion is harming IPKW. There are many groups against biomass and hence against the biomass boiler at IPKW. However, more support was asked for startups for their initial phases.	Companies at Biopark Were hit by the economic crisis of 2008. Many greenhouses could not be installed in the area as planned initially. The unfavorable market conditions contributed to the biofuel factory going bankrupt. Sustainability became more important in society when Biopark Terneuzen was developed. The public opinion towards unsustainable processes and waste generation pushed companies to think of more sustainable alternatives such as exchanging flows. The public opinion towards biofuels contributed to the government changing its stance towards bioeconomy projects, hence reducing the subsidy for biofuel projects. Nedalco's biofuel factory was not built.