PlanMiljø
ELLEVEJ 5 ØSTRUP
3670 VEKSØ
WWW.PLANMILJOE.DK

POLICIES SUPPORTING INDUSTRIAL SYMBIOSIS IN THE BALTIC SEA REGION

Authors: Nina Lander Svendsen, Simon Claësson Kaarsberg and David Watson

BALTIC INDUSTRIAL SYMBIOSIS

Interreg Baltic Sea Region

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND

EXECUTIVE SUMMARY

Industrial symbiosis (IS) specifies constellations where industries, utilities and other stakeholders utilise each other's resource and side-streams in a co-dependency and with mutual benefits. Industrial symbiosis can play a role in a circular economy and can offer significant resource efficiency and climate benefits. Policies can, if appropriately designed, create the right framework conditions for industrial symbioses to emerge and thus unlock the potential of IS. This project has been carried out by PlanMiljø for the Interreg Baltic Sea Region project. Baltic Industrial Symbiosis explores what policy measures that either directly or indirectly affect the establishment and viability of IS in selected countries surrounding the Baltic Sea – Denmark, Finland, Norway, Poland, Sweden and the Russian Federation. The report then identifies what more can be done by national, regional and local governments to promote IS in the region. The study has been carried out through a literature review and interviews with experts and policymakers from all six countries.

The study finds that, with the exception of Finland and Poland, national governments have not explicitly addressed industrial symbiosis at a strategic level. Both Finland and Poland include IS in their circular economy strategies. National circular economy strategies and policies have been adopted in the region in recent years, but these do not in general recognise the potential of IS. In the Russian Federation and Poland, the focus on CE tend to be limited to targets, whereas in the Nordic countries the governments offer funding and to a varying degree capacity- and relation building measures that are indirectly in support of IS.

A number of functioning industrial symbioses do exist in the region, particularly in the Nordic countries, but many of these have been established by businesses without direct government assistance. In these cases, government may have had an influence, but has not been the initial driver. These frontrunners of IS have subsequently acted as centres for learning and capacity, and in many cases, this bottom up-development has later been supported and developed further by governmental authorities.

Industrial symbiosis should be included in national circular economy strategies to increase awareness and to ensure national measure in support of IS. Likewise, the agenda on resource scarcity and on climate change offer great potential to promote IS as a tool to ensure resource efficiency and decrease the carbon footprint from production.

In the Nordic countries, some environmental regulations are perceived by practitioners as hindering industrial symbiosis and the circular economy. Insecurity about regulation can also inhibit investment in IS. Environmental regulation in the region needs to be assessed to ensure that it is not inhibiting the recirculation of resources, and in general governments need to support the interpretation of regulation. In addition to long-term funding and supportive regulation, governments can play a key role in establishing a mapping of all side-streams to assist in the identification of potential exchanges.

In the Nordic countries, local and/or regional policies in direct support of IS are typically found in the region or municipality within which an IS cluster has already been established. There are also examples of business development activities that support industrial symbiosis. The local actors with mandate to support IS constitute a great potential to support companies in IS activities ranging from capacity building, screenings and network facilitation. At the regional and local level, only one policy in support of IS could be found in the Russian Federation and Poland respectively. IS is in general inhibited in these countries by a lack of cooperation and trust between businesses. Here, local and regional governments would do well to focus on information and network building to create a culture of cooperation among companies.

BALTIC INDUSTRIAL SYMBIOSIS
Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

The following concrete recommendations are made for policy to support IS:

1. Communicate the potential of IS in order to put industrial symbiosis on the national political agenda as part of the focus on circular economy
2. Include industrial symbiosis in national circular economy strategies
3. Place the responsibility of promoting IS with a single government agency
4. Offer long-term funding ear-marked for industrial symbiosis
5. Create incentives for industrial symbiosis through taxes and subsidies
6. Identify and remove regulatory barriers where this does not compromise environmental protection
7. Increase regional or local level capacities to support industrial symbiosis and inform on the possibilities of IS when in dialogue with businesses
8. Support companies in carrying out screening of side-streams
9. Build up a national digital platform mapping the side-streams of all companies
10. Establish a national network on industrial symbiosis
11. Facilitate match-making of companies that can potentially constitute an IS
12. Increase coordination between national and local levels of governance

Content

1 BACKGROUND AND OBJECTIVES

National, regional and local governments in the Baltic Sea Region[1] are becoming increasingly aware of the need to achieve circular economies. Yet, the concept of industrial symbiosis (IS) has received little attention politically even though it offers a great potential to contribute to the circular economy and achieve a higher resource efficiency within industry.

Box 2: Baltic Industrial Symbiosis (BIS) project (2019-2021)

The BIS project aims to promote industrial symbiosis across the Baltic Sea Region by establishing peer-to-peer exchange among practitioners representing 13 different organisations and led by the Symbiosis Center Denmark. The project is supported by the European Regional Development Fund through Interreg Baltic Sea Region, Norwegian funding and Russian funding. The project consists of four stages:

1) To accelerate symbiotic business development through identifying and establishing new business opportunities as well as to build capacities and carry out pilots.
2) To build capacity to develop IS through investigations, IS designs and institutional set-ups and an executive training program
3) To map policies for industrial symbiosis to feed into a platform for policy learning
4) A roadshow to inspire municipalities in the Baltic countries to pursue IS[3].

We understand industrial symbiosis as achieved *when at least three different entities are involved in exchanging at least two different resources*[2]. These resources can be products or by-products - such as waste material, energy and water - but the exchange is only considered symbiotic when it is a two-way distribution (Thomsen et al. n.d.).

Many functioning examples of industrial symbioses can be found across the Baltic Sea Region. The degree of public authority involvement in, or influence on, these initiatives varies. Some symbioses have been planned top-down from scratch or through retrofitting of existing industrial parks. Others have been developed bottom-up by several companies in response to opportunities to save expenses for sourcing energy, materials or to reduce waste management costs. This is most common for the symbioses in the Baltic Sea Region (Tao et al. 2019). In these circumstances, public authorities can have supported the process directly by facilitating cooperation between companies, have offered capacity development or the development of databases on resource streams. Alternatively, they may have stimulated the development indirectly through favourable waste, resource and/or energy regulations, economic instruments or other policy instruments.

Policies can act as enablers of, but also as hindrances to industrial symbiosis. As industrial symbiosis includes several material streams, IS is often subject to many different policies – such as regulations on waste, energy and water – that together constitute a major policy complex for the industrial symbioses to navigate in.

The objective of this project is to map local, regional and national policies that support, or alternatively that inhibit, industrial symbiosis across selected countries in the Baltic Sea Region. The geographical scope includes Denmark, Finland, Norway, Poland, Russia and Sweden. Estonia, Latvia and Lithuania are not included in the study. The project has been commissioned by the Baltic Industrial Symbiosis (BIS)

[1] The Baltic Sea Region is defined within the context of EU's Interreg Programme as comprising Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Poland, Russia and Sweden.
[2] https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/TO6_policybrief_Industrial_symbiosis_final_IK_CLEAN.pdf

project that aim to promote industrial symbiosis in the Baltic Sea Region and is carried out by PlanMiljø with input from the project partners. Please see Box 2 for a description of BIS[3].

The mapping has been carried out through surveys with IS initiatives, academic experts and policymakers. The report does not claim to be comprehensive with respect to all policies that indirectly affect IS positively or negatively. Rather, we have included all policies that have been named by respondents to our survey as having an effect. Moreover, the scope of the report does not include European policy, although in the European member states EU policy can have a strong bearing on IS. Examples of relevant EU policy include the waste directives, the eco-design directive, the strategy on circular economy and Horizon 2020 funding and regional funding. European policy has been covered in a parallel study (Lybæk et al. 2019).

This mapping concludes in recommendations to inspire policymakers on how they can support industrial symbiosis. The report also identifies commonalities in policy challenges and thus potentials of interregional cooperation in the Baltic Sea Region.

2 APPROACH

2.1 Scope of policies and government action under consideration

We define and limit *"policies supporting Industrial Symbiosis"* by presenting a typology that will constitute as our analytical framework. We understand policy that support Industrial Symbiosis as *a combination of policy tools issued by governmental authorities to support and effect industrial symbiosis* (Verdung 2010). This definition highlights three relevant aspects of our policy mapping that need to be clarified: the role of various levels of government, the aim of supporting and implementation of IS reflected in strategies and overarching policies and lastly relevant (both positive and negative) policy instruments and tools.

2.1.1 Levels of government

In this study we limit ourselves to policies and initiatives issued by governmental authorities and not initiatives launched by private actors. In our understanding of governmental authorities, we distinguish between three political levels including national, regional and local governmental authorities. The mandate of each level as well as the interplay between the three levels (or in some cases only two) differ across the countries in the Baltic Sea Region, as does their intensity of activity in supporting IS.

2.1.2 Strategies and overarching policies

The upper level of the policy hierarchy is represented by strategies and overarching policies, which include objectives to support and implement IS. These strategies may be focussed on green growth, resource efficiency or circular economy or some other broad policy theme, but include chapters, goals, targets or indicators that are intended to directly promote IS. Such strategies can be found at national, regional or local level.

In this process, we pay attention to the policy context that is formed by national and regional traditions, the relation between state, market and society and the ideology and priorities of the governmental authority. The societal and business context can likewise affect policy development (Borrás & Edquist 2013).

[3] https://symbiosecenter.dk/project/bis/

There may also be overarching strategies that *indirectly* affect IS. An example might be a digitalisation strategy that enables the information across partners in an industrial symbiosis, but which did not have IS in mind. These indirect policies are only included if a respondent has drawn our attention to them as being of relevance.

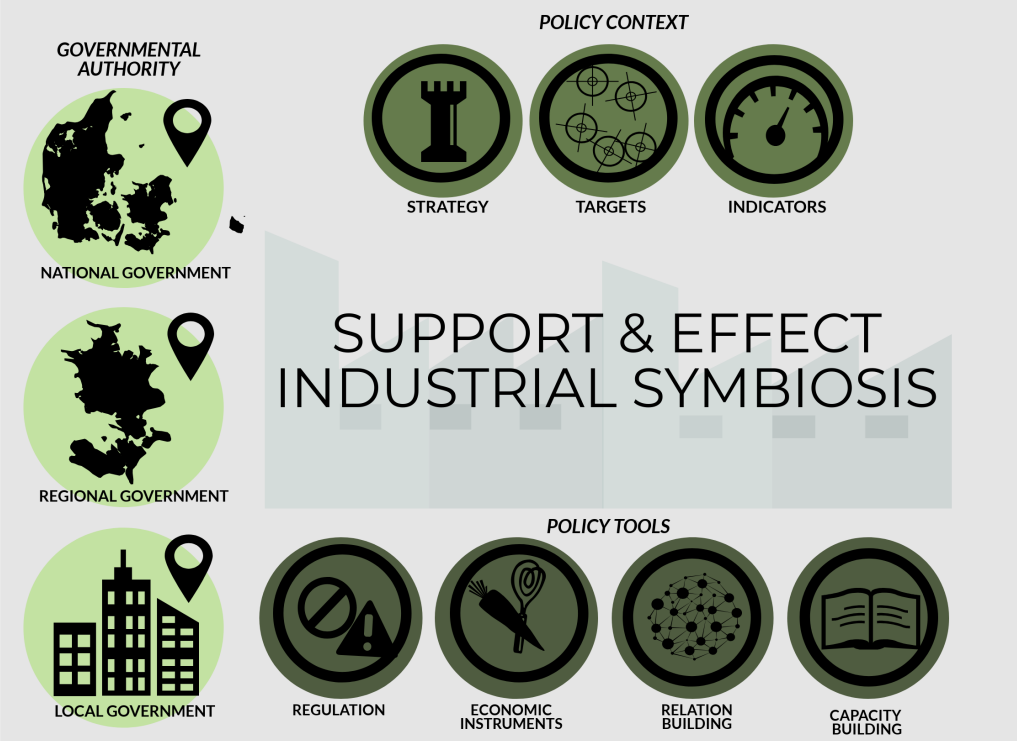

Figure 1: Analytical framework for analysis (own making based on the deduced analytical framework)

2.1.3 Policy tools

Policy tools represent concrete measures used to implement policy objectives and targets in strategies, although they can also stand alone. We identify four types of policy tools including regulation, economic and market instruments, relation- and capacity building instruments (Verdung 2010). The first type of policy is regulation, which include laws, rules and directives that are obligatory and where disobedience often will be sanctioned. The second type of policy is economic and market instruments such as incentives, where public authorities discourage or promote certain behaviour by creating economic negative (e.g. taxes) or positive incentives (e.g. subsidies). The third and fourth category includes soft policies, which are characterised as being voluntary and non-coercive.

2.1.4 Analytical framework

When mapping policies supporting industrial symbiosis in each of the six countries, we thus apply the analytical framework provided in Figure 1. This analytical framework further functions as a way to compare across the countries on the selected parameters. In the comparative analysis, we identify commonalities in policy challenges, and we carry out a gap analysis to scrutinise if the performance of IS policies match their potential.

2.1.5 Definition of industrial symbiosis

The term IS is a clear reference to the natural sciences where symbiosis is understood as biological co-dependency through the exchange of natural resources. There are widespread applications of the concept, however in both literature and practice there seems to be some disagreement on what can be considered to be industrial symbiosis. For the purposes of this report we understand industrial symbiosis as an exchange of products or by-products (incl. residues and waste materials) between several economic entities with the aim to utilise these in a processing industry (Thomsen et. al. 2019). We thereby make a distinction between industrial symbiosis and cascade utilisation.

Applied concepts

Industrial symbiosis: *"An industrial symbiosis is understood as an exchange of products or by-products (incl. residues and waste materials) between several economic entities with the aim to utilize these in a processing industry. A symbiosis has to be an exchange of products or by-products and one-way distribution is not considered symbiotic. Mere buyers and sellers of products and by-products can thereby not participate in the symbiosis but can facilitate it."* (Thomsen et al. 2019: 3)

Cascade utilization: "*When a by-product from company A is converted into a product by company B it is considered cascade utilization."* (Thomsen et al. 2019: 3).

Eco-industrial clusters: complexes of units connected by shared energy supply, logistics, assets and expertise used for among other things processing, recycling and managing waste (applied by the Russian Ministry of Industry and Trade)

What are considered as resources in this context? With Chertow's definition from 2000 IS has been defined as the exchanges of physical materials such as water, energy or by-products between diverse and traditionally separate organisations in mutually profitable transactions. In this paradigm, geographic proximity and collaboration were argued to be the most important prerequisites (Chertow 2000). This is the definition we will use for this report. Exchanges of knowledge and other non-material resources are not considered in this report as representing IS, even though IS definitions that do include such aspects does exist (e.g. see Lombardi & Laybourn 2012).

3 METHODOLOGY

We have identified policies that support industrial symbiosis through a desk study and through interviews with experts and policymakers working with IS. Below we describe how we have carried out both desk study and interviews as well as the limitations of the current study. Due to the wide range of policies that can potentially include references or relevance to IS, and also due to language challenges, in particular in the Russian Federation, Poland and Finland, we did not attempt to carry out a comprehensive desk study but relied for the most part on national experts to identify relevant policy.

3.1 Desk study

The conducted desk study was carried out in two parts.

The aim of the **first part** was to gain sufficient knowledge from academia regarding the concept of IS, ranging from discussions on its definition to assessments on how it generally develops in certain circumstances with different levels of influence from policies. In this part, we limited ourselves to asses 20 papers on IS, and therefore tried to focus our review on main authors on the subjects and other conducted literature reviews. To wrap up this part of the desk study we furthermore discussed some of the issued pointed out in the literature with experts from Roskilde University, Denmark. The insights from these activities became the foundation for the interviews that were later conducted as the main activity for gathering information. More specifically, this initial desk study resulted in a list of policies that can potentially support industrial symbiosis (see Table 1). The list is not exhaustive, but rather intended to show the range of policies in support of IS.

The **second part** of the desk study was focused on case studies, strategies and general policies that support IS. Few policies focus solely on supporting industrial symbiosis, but rather include industrial symbiosis as a sub-goal or perhaps indirectly affect IS without specific intent. We started this part of our desk study by searching for general policies that support IS, using our list of policy tools presented in Table 1. In the identification of policies relevant for IS in each of the countries, we were much dependent on the project partners, who we asked to identify policies that support industrial symbiosis in their home country. We then looked into the policies they pointed out to be relevant.

TABLE 1: POLICIES SUPPORTING INDUSTRIAL SYMBIOSIS	
TYPES OF POLICY TOOL	**EXAMPLES OF POLICY TOOLS**
Strategy	· Industrial symbiosis · Circular economy · Bio-economy · Waste management · Resource efficiency · Green growth
Regulation	· Land planning/zoning with emphasis on IS · Environmental regulation such as emissions control · Removal of regulatory barriers · Streamlining and clarification of end-of-waste criteria and definitions · Better waste segregation · Standardisation of secondary materials · Internal market for material resources · Food safety regulations (particularly important for bio-resources)
Economic incentives	· Taxes and charges e.g. landfill fees · Subsidies (implementation or removal) · Funding (e.g. IS earmarked) · Removing market barriers · Does quality/accessibility of public infrastructure enter here? Investments in infrastructure that enables sharing of energy/water/materials could perhaps be a way in which public authorities could facilitate IS.
Relation building	· Establish or facilitate clusters, networks or public-private partnerships · Code of conduct
Capacity building	· Gather and share knowledge e.g. feasibility studies · Support research · Build technical capacities · Create awareness through campaigns, talks, workshops etc. · Planning instruments

3.2 Interviews

We invited selected BIS project partners to participate in an interview. We also used these experts to identify and connect us to other experts and policymakers working with industrial symbiosis relevant policy using a snowball method. We strived for equal coverage across the BSR countries as well as across political levels. The goal was to achieve a minimum of three interviews per country with one of these representing policymakers. Table 2 identifies the experts and policymakers that we interviewed.

TABLE 2: OVERVIEW OF INTERVIEWEES

COUNTRY	ORGANISATION	NAME	BIS PARTNER?
Denmark	Symbiosis Center Denmark, Kalundborg Municipality	Nina Alkærsig Jensen & Per Møller	✓
	Kalundborg Symbiosis	Lisbeth Randers	✓
	Ressource City, Næstved Municipality	Michael Elgaard	✓
	The Danish EPA	Nanna Rørbech	
Finland	DigiPolis	Tiina Poutinen	✓
	Nordregio	Jukka Teräs	Associated partner
	Regional Council of Lapland	Mika Riipi	
Norway	Eyde Cluster	Christophe Pinch	Associated partner
	Trøndelag County Council	Lilian Strand	✓
	THAMS industrial cluster	John Kåre Solem	
Poland	Gdansk University of Technology	Joanna Mioduska	✓
	Mineral and Energy Economy Research Institute	Joanna Kulczycka	
Sweden	The Paper Province Economic Association	Magnus Persson	✓
	Swedish Agency for Economy and Regional Growth	Gunilla Thorstensson	✓
	Linköping University	Mårten Wiktor	✓
Russian Federation	St. Petersburg State Geological unitary Enterprise "Specialised firm "Mineral" (SC Mineral)	Natalia Bobyleva	✓
	ICSER Leonitief Centre	Elena Belova	
	Committee for Environment in St. Petersburg	Dmitry Krutoy	

Interviews were carried out either through Skype or via physical meetings at a BIS partner meeting held in Kalundborg in the last week of August 2019. Interviews were guided by an interview guide that included questions on policies, cooperation between government hierarchies, capacity within government and industry plus enablers and barriers of IS. The interview guide can be found in the appendix. The interview guide was sent to the informants prior to the interview. A few respondents provided their answer in written form.

3.3 Limitations

The mapping includes policies that both directly aim to support industrial symbiosis and policies that indirectly either negatively or positively affect BIS. However, our literature search was not comprehensive

and in particular policies that indirectly help or hinder IS are limited to those that were mentioned by interviewees. As industrial symbioses vary in terms of which side streams they include - water, energy, materials - they will be affected by many different types of regulation. The form of regulations varies across the BSR countries. Therefore, we cannot generalise, but rather report on specific policies as examples.

Furthermore, it is important to note that IS are influenced by many factors and we cannot conclude objectively on the actual impact of a specific policy. Rather we communicate how the experts and initiators of IS evaluate the varying importance of policies in supporting or inhibiting IS.

3.4 Presentation of results

The results of the mapping are presented for each of the six countries. This is followed by a discussion of common findings and a list of recommendations/considerations for policymakers wishing to promote IS.

4 DENMARK

4.1 Prevalence of Industrial Symbioses

Denmark is in professional circles known for the Kalundborg Symbiosis (KS), which was formed in 1961 long before the concept of IS was established. KS is one of the leading symbioses in the world in terms of numbers of both companies and resources being exchanged counting 9 organisations and 24 different streams. KS has been a driver in Denmark to create awareness of the potential and business case of industrial symbiosis as well as collecting and sharing knowledge and experience on IS. Today, exchanges of resources are common in Denmark. A number of these have developed into true industrial symbioses[4].

4.2 Overview of supporting strategies and policy instruments

4.2.1 National level

Strategies

The current government took office in June 2019 and has not yet initiated any policies that directly focus on supporting industrial symbiosis. Nonetheless, circular economy is one out of five priorities of the current Ministry of Environment and Food. Likewise, the recently elected Social Democrat government is very ambitious in its climate goals, targeting that Denmark should reduce its GHG emissions by 70% in 2030 compared to 1990-levels. To realise this target, Denmark is facing a structural transition.

The previous centre-right government (2015-2019) established an Advisory Board for Circular Economy in 2017, which led to a national Circular Economy Strategy (2018)[5]. The CE strategy does not address industrial symbiosis explicitly. However, all Danish stakeholders report that the CE strategy has contributed to put circular economy and resource efficiency on the agenda in the business environment, which is a first step towards IS. They thus regard the CE strategy as having a positive influence. Also, the business industry supports the CE strategy and recognises the potential of CE as a business case. The preceding centre-left government from 2011-2015 launched a national waste prevention strategy "*Denmark without Waste II, Waste Prevention Strategy*" (2015)[6], which clearly indicated that waste should be regarded as a resource.

[4] https://groenomstilling.erhvervsstyrelsen.dk/symbioser-i-danmark
[5] https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Cirkulaer_oekonomi/Strategi_for_cirkulaer_oekonomi.pdf
[6] https://eng.mst.dk/air-noise-waste/waste/denmark-without-waste-ii/

Regulation
No national regulation is identified as focusing directly on CE or IS. Emissions controls and environmental performance indicators can indirectly be in support of IS as IS potentially can reduce GHG emissions from production and strengthen companies' environmental performances.

Economic incentives
In Denmark the most prominent economic incentives are taxes, levies and funding. Charges on the disposal of waste fractions and residuals are identified as negative incentives for IS as they force firms to rethink their material flows while giving advantages to firms who can minimise their wastes. The yield of waste tax is revenue in the Finance Act and is administrated by local tax and customs. Currently (2019) the tax on disposal of waste is 475 DKK (€ 63) per tonne[7]. Wastewater is taxed depending on its composition.

With respect to funding possibilities, there is no funding specifically earmarked for industrial symbiosis. However, there are several funding possibilities including Environmental Development and Demonstration Program (MUDP)[8], Green Development and Demonstration Program (GUDP)[9], the Innovation Fund and the Regional Fund. MUDP, is handled by the Danish Environmental Protection Agency (DEPA), has been running since 2010 and has invested roughly 90 million DKK (€ 12 million) each year in the development of technical innovation. MUDP supports projects within six themes including circular economy with a focus on prevention and reuse of resources and the environmental impact of the industry, where IS can be supported. MUDP has previously supported IS-projects such as the water exchange in Kalundborg[10]. GUDP is targeting the food sector, but might be relevant for some side streams in an IS. The innovation fund finances development of research and technology that support growth and employment in Denmark. Lastly, the regional fund is supporting innovation and energy- and resource efficiency in SMEs.

One stakeholder points out that funds in general have too short a time horizon (typically maximum of three years), to allow the establishment of an IS.

Relation- and capacity building
The Ministry of Education and Research initiated an "*Innovation Network Programme*", which funds 17 innovation networks, which also receive at least half of its funding from members. The networks aim to build bridges across companies and knowledge institutions. Some of these innovation networks have an interface with circular economy[11]. The Lifestyle and Design Cluster is funding "circular economy in SMEs" (2018-2020), thereby supporting the development or implementation of circular business models in SMEs[12].

The Danish Business Authority of the centre-left government from 2011-2015 issued a *"Green Industrial Symbiosis" (GIS)* initiative in which they funded a Green Task Force[13] of technical experts that screened companies for possibilities of passing and taking over resources between companies in each region (2013-2015). When companies were matched in a potential symbiosis, they could apply for money to

[7] https://www.fm.dk/publikationer/2019/finansloven-for-2019
[8] https://ecoinnovation.dk/om-mudp/baggrund/
[9] https://mst.dk/erhverv/groen-virksomhed/groent-udviklings-og-demonstrationsprogram-gudp/
[10] https://www2.mst.dk/Udgiv/publikationer/2015/07/978-87-93352-50-6.pdf
[11] https://ufm.dk/forskning-og-innovation/samspil-mellem-viden-og-innovation/viden-netvaerk-og-kommercialisering-til-virksomheder/klynger-og-innovationsnetvaerk/innovationsnetvaerk
[12] https://ldcluster.com/projektet-coe-smv-har-fundet-sine-foerste-deltagere/
[13] https://www.rm.dk/api/NewESDHBlock/DownloadFile?agendaPath=%5C%5CRMAPPS0221.onerm.dk%5CCMS01-EXT%5CESDH%20Data%5CRM_Internet%5CDagsordener%5CVaekstforum%202015%5C05-03-2014%5CAaben_dagsorden&appendixId=63725

support a symbiosis project. The initiative was carried out in cooperation with the regions and technical experts.

The initiative further included the development of a database, where companies could register their excess resources. The business authority carried out a survey that showed that two out of three companies having participated in the programme were interested in entering a symbiosis cooperation, indicating the great potential of such a program.

However, the participants experienced that the implementation phase was challenging and slow, and it was concluded that for future initiatives it would be beneficial to also support companies in the implementation process (NordRegio 2015: 29). Indeed, some stakeholders concluded that the GIS sowed the seeds for Industrial Symbiosis in the companies, but the grant was removed before the policy proved its success. The same government initiated a taskforce commissioned to identify regulatory barriers for resource efficiency in private companies (2014)[14]. However, there was a change in government before any of the identified barriers could be tackled.

4.2.2 Regional level

The business promotion system was reformed in Denmark on January 1st, 2019 such that regions (Regioner) no longer have the mandate nor the funds to support regional business development. This has been transferred to national and local level. Thus, the regions' mandate to support industrial symbiosis has also been removed.

One informant reported this move as a major blow to IS since the regions have traditionally played a key role in business development and have supported IS. The Region of Zealand for example, included IS in its *"Regional Growth and Development Strategy"* (2015-2018)[15], where the region had a goal that more than 200 companies should work with symbiosis and resource efficiency measured by a decrease in energy and material use[16]. As a part of this strategy, the region in 2015 established the Symbiosis Center Denmark (DSC) in its current constellation with the aim that DSC eventually should be independent from the region. The establishment of DSC has proved to be a very efficient policy as DSC is initiating a range of projects supporting IS and is functioning as the knowledge centre on IS in Denmark. The region further contributed with funding such as "*Sustainable Bottom Line*"[17] a programme now in its second phase that assists companies in increasing their energy- and resource efficiency.

4.2.3 Local level

In Denmark, the municipalities are responsible for waste management and supply. The municipalities either own or co-own a part of waste management- and supply companies. One local policymaker notes that this structure creates good possibilities for the municipalities to support industrial symbiosis. That being said, the municipalities do not always keep close control with the waste- and supply companies. Besides waste management and supply, the municipalities possess a range of tools they can apply to support industrial symbiosis including public procurement, planning, communication and business promotion. However, municipalities are limited in their financing opportunities as they must not create unequal competition. Furthermore, the municipalities are officially prohibited from providing consultancy services. However, they can facilitate processes with screenings, interviews or reports – activities that are

[14] https://groenomstilling.erhvervsstyrelsen.dk/task-force-oeget-ressourceeffektivitet
[15] https://www.regionsjaelland.dk/Udvikling/Documents/Den%20regionale%20v%C3%A6kst-%20og%20udviklingsstrategi%2017.03.15(slve).pdf
[16] https://www.regionsjaelland.dk/Udvikling/Documents/Den%20regionale%20v%C3%A6kst-%20og%20udviklingsstrategi%2017.03.15(slve).pdf
[17] https://www.gate21.dk/baeredygtig-bundlinje-2/baeredygtig-bundlinje-1/

closely related to consulting and can support enterprises in identifying what type of advisory services are needed.

Strategies
All municipalities include sustainable development and environmental targets in their strategies, a few include circular economy, and even fewer address industrial symbiosis. The municipality of Kalundborg uses the Kalundborg Symbiosis strategically to strengthen the brand of the city, to create jobs and support growth. The municipality more specifically aims to strengthen their position in cleantech and the pharma-medical sector through cluster development, symbiosis and innovation[18].

Likewise, the municipality of Næstved in their business strategy addresses their "*Resource City*" - a green industry cluster - and their newly established knowledge centre on circular economy, where companies can receive help to realise circular business models. Næstved aims for the Resource City to act as a pioneer on circular economy and further states that Næstved will support innovation, entrepreneurship and growth through sustainable solutions and local business promotion. Næstved further aims to bring forward the network across industry companies in the municipalities to exploit synergies and to strengthen the cooperation across educational institutions and companies[19].

Capacity- and relation building
With the reform of the business promotion system (Erhvervsfremmesystem), five *inter*-municipal business hubs were established. The objectives of these business hubs are to create growth and business development and to gather the municipalities' efforts on business promotion in these inter-municipal business hubs. These business hubs offer among others guidance on Corporate Social Responsibility (CSR) and can choose to offer courses or advisory services in CE and IS[20].

Besides the five inter-municipal business hubs, a range of other business networks exist around in Denmark, of which some place specific focus on sustainability including circular economy. These include Gate21[21] and Network for Business Development in Northern Denmark (NBE)[22]. The organisation of these business networks varies. Some hubs are associated with several municipalities, some just one. Some have a membership structure where companies, waste companies and public organisation are members. Likewise, some of these aim at sustainable business development, some at innovation and one – the Symbiosis Center Denmark - focuses on industrial symbiosis in particular. Regardless of the organisation of the business networks or business hubs, these tend to be quite efficient in supporting business development as they have a good understanding of and relation to the companies in their regions. In addition, one informant points out that the business hubs tend to be more agile and more innovative than the municipalities.

The policy tools - that the business hubs, networks and clusters can make use of to support circular economy and industrial symbiosis - are especially relation and capacity building and funding. Capacity building is pursued through screenings, business models as well as testing and implementing technologies, whereas relation building is pursued through networks and match-making facilitation. Funding is either provided through project funding or through an appropriation from a governmental authority. Examples of such funding includes "*Residue to Resource*"[23], where companies were assisted in increasing their

[18] http://kp2017.kalundborg.dk/Virksomhed_og_job/Hovedpolitik_for_virksomhed_og_job.aspx
[19] https://www.naestved.dk/Erhverv/Erhvervsstrategi.aspx pp. 5-6
[20] https://www.kl.dk/media/18854/rammeaftale-om-erhvervshusene-2019-2020.pdf
[21] https://www.gate21.dk/om-gate-21/
[22] https://nben.dk/
[23] https://symbiosecenter.dk/en/project/residue-to-resource/

resource efficiency and to anchor symbioses in the local environment. Many of these business hubs work on a project basis and are dependent on funding from larger funds.

Box 3: "Residue to Resource" (2015-2018)

Symbiosis Center Denmark (DSC) initiated the project "Residue to Resource – Green Business Models for SMEs", which helped companies in six Danish municipalities to develop and implement sustainable business plans with a high resource efficiency. Furthermore, some of these companies were offered a symbiosis cooperation with other companies. The project was funded by the EU regional fund, the affiliated municipalities, DSC and the Technical University of Denmark (DTU).

The project helped to place focus on resource efficiency in the companies and further screened the possibilities of utilising side streams from companies as inputs to the production in other companies or utilities. More concretely, over 100 companies were screened, and 50 companies were selected to receive a technical development plan. 30 companies received funding for consultancy to develop a green business model while 10 were offered funding for developing a green business model for industrial symbiosis.

4.3 Coordination and capacities across vertical levels of government

The policy "*Green Industrial Symbiosis*" (GIS) reflects that the government *can* play an essential role in putting industrial symbiosis on the agenda. GIS likewise reflects that the government can play a key role in funding industrial symbiosis projects. At the moment, the national government is not placing focus on industrial symbiosis and the funding possibilities are not in favour of industrial symbiosis, even though some funds - MUDP in particular - can and have funded IS projects.

At the local level, the different business hubs have a more practical approach and thus pose a great potential to offer companies capacities- and relations building in support of CE and IS.

The municipalities and the national government can push forward the IS agenda by initiating strategies that aim to support IS and ensure funding.

As the regions no longer have mandate to support industrial symbiosis, the important coordination is between the national and the local level. The representative from the Danish EPA informed that they are planning to enter into dialogue with the business hubs, to whom they will inform on the possibilities of applying for MUDP. Apart from this meeting the coordination on IS is generally poor between national and local government.

Summing up, both national and local level have a role of play in the support of IS. Currently, the most proactive actors are specific municipalities and business hubs.

4.4 Key success factors

Experts identified the following key success factors:

- Technology and the know-how on IS as a key factor in support of the spread of industrial symbiosis in Denmark.
- The Kalundborg Symbiosis has had a significant effect, promoting industrial symbiosis in and outside Denmark.
- Symbiosis Center Denmark (DSC) has contributed to the promotion of the Kalundborg Symbiosis and IS in general. DSC has initiated several projects in support of IS.

- The focus on environmental output control initiated by the governmental authorities in the 1970s has played a key role in pushing forward the environmental agenda including resource efficiency in companies.
- The high trust between public and private partners as well as the low hierarchical level in companies have likewise been a key enabler of industrial symbiosis in Denmark.

4.5 Key obstacles

According to practitioners, environmental regulation on waste, energy and water can also hinder industrial symbiosis. A Taskforce identifying regulatory barriers for resource efficiency in companies in 2015 concluded that waste regulations are a significant obstacle[24]. Regulation on waste is aiming to ensure the right management, prevent dumping and hinder the leak of harmful substances to the environment. Informants commented that this was entirely necessary but could be streamlined to better support IS while not compromising the protection of the environment.

The businesses included in the Taskforce assessment claimed that the definition of waste, rules for transboundary transport, municipalities' waste practices, taxes on NOx and waste heat and the limitation values for the content of phosphorus in wastewater sludge act as a barrier for using waste as a resource. These regulative barriers cause either higher cost for the companies sometimes resulting in an unattractive business model, higher administrative costs or inhibit the transfer of waste to resources[12].

In general, practitioners claim that regulations are more of a barrier than a support. With respect to energy, the Heat Supply Act puts taxation on recovered energy and sets a price cap. The aim of this policy is to avoid making a business case of generating extra surplus heat. However, it limits the return on investment and creates a payback time for heat recovery beyond the acceptable time horizon for private actors, and thus acts as an important barrier to IS. With respect to water, the taxes on the use of water do not create incentives for reuse. According to one interviewee there are even examples of symbiosis initiatives that could not be executed due to the tax structure, which ruin the business case. The Danish EPA acknowledges that some environmental regulations can conflict with industrial symbiosis, but it is a balance as the regulation is there for a purpose e.g. for environmental protection. The EPA expects to evaluate the environmental regulation in the coming years as a result of the ambitious climate goals of the current government.

One policymaker associated with a local municipality points to the barrier of too little communication between both civil servants and policymakers and between the environmental and business policy areas. Firstly, civil servants working with IS often possess expert knowledge on the matter, which should feed into the development of effective policies. However, politicians are rarely aware of the potential of IS and the communication between the civil servants and politicians is poor. Secondly, environmental- and business policies are not cooperating adequately, but are often separated. When working with industrial symbiosis there are gains to be made both within environment and business theme areas, thus an integrated policy on IS would be a strength. Overall, incentives for promoting cross sectoral cooperation are missing.

4.6 What more is needed?

The following recommendations have been made by interviewees:

[24] https://groenomstilling.erhvervsstyrelsen.dk/sites/default/files/media/rapport_niras_endelig.pdf p. 68

- National political commitment to industrial symbiosis is lacking. The national government should include industrial symbiosis in its strategy on circular economy to create awareness of the possibilities of IS. Such a strategy should lead to economic incentives for IS including long-term funding ear-marked IS and a tax-structure that creates incentives for companies to recycle or circulate their side streams.
- Create a digital platform that maps all resource streams of companies and supply companies to enable the identification of possible IS collaborations
- A few municipalities and business hubs are already working with circular economy and industrial symbiosis, but there is potential for others to follow suit. Earlier projects show that facilitating a process of screening, matchmaking and assistance on implementation are key steps in an IS process. Furthermore, a neutral facilitator among the business cooperation can be an advantage.
- Ensure greater coordination between national and local initiatives on IS
- Create a national network on IS to ensure experience and knowledge sharing.

5 FINLAND

5.1 Prevalence of Industrial Symbioses

Industrial symbiosis is widespread in Finland, where more than 600 companies exchange more than 4500 resource streams (FISS, 2015). Finland is thus identified as a country with a high level of development of IS (SYMBI, 2015: 9). Many of the symbioses are within the forestry sector, paper industry and mining sectors. The term industrial symbiosis is known by the public since circular economy and industrial symbiosis are high on the political agenda.

5.2 Overview of supporting policies

5.2.1 National government

Strategies

Finland aims to be a world pioneer on circular economy and was the first country in the world to have a strategy for circular economy: "*Leading the Cycle: Finnish Roadmap to a Circular Economy 2016-2025*"[25]. The strategy includes the support of industrial loops, which is understood as utilising secondary raw materials as side streams to avoid waste production in the most efficient way possible. The CE strategy is intended to be reviewed and updated regularly. The first update came in 2018. Where the first version of the roadmap focused on growth and innovation, the second version addresses national government, municipalities, companies and cities and includes 25 recommended concrete actions[26]. The government is recommended to cooperate on CE across all ministries. The Finnish Innovation Fund (SITRA) was responsible for the first CE Strategy and the subsequent update and has applied an inclusive stakeholder approach.

The circular ambitions are also reflected in the national waste management plan *"From Recycling to a Circular Economy"* (2018-2023)[27], which aims at organising waste management in support of the circular transition. IS is mentioned in the strategy as part of the circular economy. One action to support IS and

[25] https://www.sitra.fi/en/projects/leading-the-cycle-finnish-road-map-to-a-circular-economy-2016-2025/
[26] https://www.sitra.fi/en/projects/critical-move-finnish-road-map-circular-economy-2-0/
[27] http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/160889/SY_01en_18_WEB.pdf?sequence=1&isAllowed=y

CE is to ensure centralisation of waste treatment, making sure that these can easily be reached logistically. The plan also includes the implementation of IS in the construction sector in a few urban regions.

Some of the Finnish waste regulation is born out of EU requirements, but Finland tends to be more ambitious than the EU at least in some areas. That being said, Finland is still far from reaching the EU's recycling targets for municipal waste (65% for municipal waste in 2035[28]: Finland is aiming to recycle 55% of municipal waste by 2030[29]), thus several initiatives have been adopted to raise the recycling rate and strengthen recycling markets, raising the amounts of collected wastes, voluntary agreements for the construction sector and better waste data[30].

Regulation
Newer regulation pays more attention to the circular economy by encouraging the exchange of side streams. In 2020, the national government of Finland will launch a new waste act that requires all SMEs, which are using local waste management services, to report their side streams on the digital marketplace called "*Materiaalitori*" (see Box 4). By visualising side streams, companies can easily find buyers and sellers of certain secondary resources.[31]. The platform is thus developed to match companies and identify potential symbiosis. The platform is provided by the Ministry of the Environment and maintained by the sustainable development company, Motiva. This new waste act is targeting SMEs dependent on the supplementary waste management service offered by the municipalities while larger companies have to make their own.

Box 4: Materiaalitori

Materiaalitori is a digital platform that enable the exploitation of side streams and thus offering a recycling market that can increase the value of recycled materials. Organisations and companies can report their side stream, location and waste management services, which enable others to search or receive notifications for particular side streams at specific locations. The platform is provided by the Ministry of Environment and maintained by Motiva.

In 2020, all SMEs that today receive waste management services from the municipalities, will be obliged to register side streams that exceed 2000 EUR in value, on this platform. In 2021 this requirement will also include municipal waste companies.

The Materiaalitori is to accelerate the circular economy and industrial symbiosis and thus to maintain the value of materials in the cycle for as long as possible.

Capacity- and relation building
In 2013 SITRA established the Finnish Industry Symbiosis System (FISS), which amongst other things includes capacity- and relation building among the regions and disseminates new knowledge. See Box 5 for a detailed description.

Economic incentives
Within the waste regulations, landfill taxes and high gate fees for solid waste disposal sites encourage recycling to lower the fees per tonne (Nordregio 2015: 33). In 2016 the landfill tax reached 70€ per

[28] https://ec.europa.eu/environment/circular-economy/index_en.htm
[29] https://tietokayttoon.fi/julkaisut/raportti?pubid=URN:ISBN:978-952-287-644-7
[30] https://tietokayttoon.fi/julkaisut/raportti?pubid=URN:ISBN:978-952-287-644-7
[31] https://www.motiva.fi/en/solutions/material_efficiency/materiaalitori

tonne[32]. The Finnish Innovation Fund (SITRA) offers funding for project contributing to a carbon-neutral circular economy and capacity for renewal. The Ministry of Economic Affairs and Employments provides discretionary government transfers reaching €2 million in 2018 and another €2 million in 2019[33]. Furthermore, the Ministry of the Environment currently promotes bio-economy through programs such as the Wood Building Programme (2016–2021)[34] while the Ministry of Agriculture and Forestry up until June 2019 has been funding projects experimenting with nutrient recycling[35] - both initiatives that are closely related to the circular economy agenda.

One regional policymaker states that they are in dialogue with the national government to ensure steady funding looking forward. The government of Finland should navigate between different priorities and even though they have expressed circular economy and IS as a policy objective, according to the regional policymaker, they still need to be pushed to maintain IS on the funding agenda.

Business Finland (merge of Finpro and Tekes) has several initiatives to attract foreign investments in business innovation and research. Business Finland among others has a program of circular ecosystems. They thus have gathered 30 million euros to support CE[36]. Business Finland is part of Team Finland that together with a range of ministries and agencies are service companies with responsibility for business advice, internationalisation and funding.

Box 5: Finnish Industry Symbiosis System (FISS)

SITRA established the now paused Finnish Industry Symbiosis System (FISS) in 2013, which was managed by the development company Motiva. FISS was an operational model and tool to support industrial symbiosis. FISS consisted of a regional network, a method of supporting businesses in IS and a resource database. Through the regional network, the regional actors were equipped to promote IS among the regional companies. Moreover, the network ensured exchange of knowledge and experiences across the regions. FISS further offered methods to support businesses in IS that consisted of workshops activating businesses, network facilitation and supporting implementation of IS. Lastly, the resource database "*SYNERGie*" gathered information on resource data to identify synergies across companies and to monitor progress. FISS succeeded in creating strong regional cooperation and build capacities in the regions to support businesses in moving towards IS.

Despite these successes, the network is no longer active due to lack of funding[37].

5.2.2 Regional

Strategies

At the regional level, Finland has two types of regional actors: The regional councils that facilitate municipal cooperation within the region and the Centres for Economic Development, Transport and the Environment (ELY) that function as the extended arm of the government. The ELYs have the mandate to support business development, infrastructure and natural resources and can thus play a key role in the

[32] https://www.ymparisto.fi/en-US/Consumption_and_production/Waste_and_waste_management/Waste_charges_and_taxes
[33] https://tem.fi/en/discretionary-government-transfers-for-circular-economy-investment-and-development-projects
[34] https://www.ym.fi/en-US/Land_use_and_building/Programmes_and_strategies/Wood_Building_Program
[35] https://mmm.fi/ravinteetkiertoon
[36] https://www.businessfinland.fi/en/whats-new/blogs/2019/bio-and-circular-finland-program-accelerates-new-climate-smart-solutions-in-circular-economy/
[37] http://www.industrialsymbiosis.fi/what-is-fiss-and-industrial-symbiosis

funding of CE and, in some instances, industrial symbiosis. The high national prioritisation of CE is also reflected at regional level, where most ELYs have a strategy that includes CE.

In the region of Lapland, the circular economy is so essential that it is included in all regional strategies regardless of their theme. In the "*Strategic Priorities for International and Smart Specialisation 2018-2022*"[38], Lapland aims to be the leading expert on circular economy in part by supporting industrial symbiosis. The region of Tampere likewise includes circular economy as a part of its smart specialisation strategy (Nordregio 2019).

Regulation
The regions are responsible for land-use plans, which they can design to support industrial symbiosis. Lapland has so much space that it is not a problem to find a place for companies to place their production. Rather land-use plans can support the logistics such as railroad protection to make it easier for the companies to exchange side streams. In a large country as Finland, logistics are key to support IS.

Economic incentives
The regions play a key role in funding the public sector's research and development. They cannot fund private companies, but they can lobby on a national and European level to ensure funding looking forward. The contact between regional and national level is close in Finland implying that the regional government has direct access to ministers.

Capacity- and relation building
The regions have the mandate to offer advice to companies on business development and thus IS. In some cases, they provide practical advice directly. In other cases, they support the municipalities or other stakeholders in providing advice and in the more practical implementation of IS and circular economy. The regions are also functioning as a bridge between stakeholders and municipalities. The regions are in close contact with the municipalities to coordinate their activities. Moreover, the regions have a role in communicating the potential of industrial symbiosis through strategies and their general work.

5.2.3 Local level

Strategies
Some municipalities have strategies that include circular economy. The municipality of Kemi has in their strategy "*Green Kemi*" a target of ensuring progress towards circular economy. Yet, the term of industrial symbiosis is not applied, despite Kemi funding several activities promoting IS, as described below.

Economic incentives
The municipalities can fund projects that support business development and thus industrial symbiosis. The municipality of Kemi provides 50% funds for the technology park of DigiPolis[39], the other 50% is funded by projects.

The municipality of Nokia likewise own the ECO3 platform[40] - a business area of bio and circular economy. The municipality has played a key role in initiating the ECO3 platform both by funding and by providing the space (Nordregio 2019).

[38] http://www.lappi.fi/lapinliitto/c/document_library/get_file?folderId=1483089&name=DLFE-21423.pdf
[39] https://www.digipolis.fi/en/front-page
[40] https://eco3.fi/en/eco3/

Capacity- and relation building
Economic development is increasingly becoming a task for municipalities in Finland. It is quite common for the municipalities to outsource this task to development companies that support capacity- and relation building. An example of this is DigiPolis that manages the technology park of the same name in Lapland. DigiPolis promotes innovation, technology, research as well as they place focus on circular economy and industrial symbiosis. DigiPolis is working closely together with Kemi, the Regional Council of Lapland, local universities and companies in the region.

The municipality of Kemi, Lapland's University and DigiPolis have established an industrial circular economy centre (2017)[41] with the mission to make Lapland the leading area for bioeconomy and CE in the Arctic. The centre supports companies to develop circular business models, facilitating networking across companies and operators, promoting pilots and collecting technical information. Furthermore, the centre leads the Finnish Network for Eco-Industrial Parks that consist of 10 parks, development companies and other IS stakeholders. The network shares good practices and is currently developing a circular operating model based on their respective experiences. The idea is that this operating model can be used by other parks who want to develop IS.

5.3 Coordination and capacities across vertical levels of government

One informant identified the strong vertical coordination across local, regional and national governments as a key advantage within circular economy and innovation. The reason why Finland has such a strong vertical coordination is cultural and historical. Finland is quite young as a nation and thus has developed rapidly, whereby innovation and cooperation across stakeholders became an integrated part of the political practice.

At national level – via SITRA in particular - circular economy and industrial symbiosis enjoys particular prioritisation ensuring a broadly public understanding of the business models that CE and IS offer. SITRA has been appointed as a key driver of industrial symbiosis in Finland due to its CE projects and funding opportunities. Furthermore, the national level has initiated several networks that ensure coordination and exchange of knowledge. Lastly, the national level is ensuring essential funding for CE/IS to succeed. Having said that, it is appointed that even more funding is necessary in order for Finland to reach a circular society. The coordination within the government has been inadequate but is addressed by the latest roadmap towards CE.

The regions also play a key role in funding, creating awareness and ensuring infrastructure. Yet, the actual implementation of CE/IS supporting companies in practice are either done by municipalities or outsourced to development companies.

5.4 Key success factors

Interviewees identified the following key success factors in the development of IS:

- The high national political commitment to circular economy, including the industrial loop, has been a key enabler for industrial symbiosis in Finland. CE and IS are recognised politically as tools to create growth, innovation and jobs while ensuring resource efficiency and low GHG emissions. The high commitment is reflected by the objective that Finland wants to be a pioneer on CE.

[41] https://www.lapinamk.fi/news/Finnish-centre-for-industrial-circular-economy-to-be-established-in-Kemi-/vacczxgl/7400aabd-9647-4c7f-afda-e4bd52f4b941

- The Finnish innovation fund, SITRA, has been the author of the two inclusive roadmaps on CE and has moreover initiated and financed several activities to support IS. SITRA has ensured the continuous focus on IS, while involving other important stakeholders.
- SITRA initiated the Finnish Network for Eco-Industrial Park (FISS), which is no longer in operation, but has previously proved very efficient in sharing knowledge across stakeholders.
- Digital platforms such as Materiaalitori for side streams and Maapösi for building materials are also contributing to accelerating industrial symbiosis by making it possible to identify potential exchanges of side streams.
- The Circular Economy Centre placed in Lapland is a flagship for circular economy and also a driver for industrial symbiosis through business development and network facilitation.

5.5 Key obstacles

Even though the national waste plan addresses circular economy, companies still point to waste regulation as a barrier to circular economy. These barriers include the specification of by-products, waste transport, time limit of three years for utilisation of waste and the ownership of waste[42].

Moreover, the technologies are there, but need to be tested and demonstrated. In order for that to happen funding for pilots are key. National funding can be found, but it is not adequate to achieve the circular transition. Logistics can also be a challenge as some companies are placed far from each other, it thus becomes important to establish infrastructure that support exchange of resources.

One stakeholder identified the lack of awareness and priorities in the businesses as a key barrier. The companies are often busy with their core business and do not prioritise industrial symbiosis. As IS is getting more attention - also as an attractive business model - more businesses are gradually becoming more positive of prioritising IS. Local development agencies should also be better at communicating to businesses that they are willing to provide support.

5.6 What more is needed?

The interviewees made the following recommendations for improvements in conditions for IS:

- There is a need for piloting and testing of new technologies to support industrial symbiosis funded by national government
- Smaller companies need incentives to engage in IS as they tend to prioritise their core business
- Local development companies should promote themselves to companies and support the companies in IS activities
- Companies perceive some waste regulation as a barrier, but it is often due to lack of knowledge. The companies could thus use help to interpret the regulation
- Waste management companies could apply a more holistic approach and strengthen their activities in support of IS
- The infrastructure can be improved to ensure exchange of side streams.

[42] Circular- and Bioeconomy Centre (2019). *Challenges of industrial circular economy*

6 NORWAY

6.1 Prevalence of Industrial Symbioses

There exist only a few industrial symbioses in Norway, and they tend to be initiated bottom-up by private companies (CONCITO 2018: 15). Industrial symbiosis has not received much attention politically with a few regional exceptions. The IS initiatives are primarily concentrated around the large process industries in Norway, including the Arctic Cluster in the North, Thamsklyngen in Mid-Norway, Herøya in Telemark, and Eyde cluster in the South of Norway. The support of IS in Norway tends to be through business and innovation support. There is thus a great potential for expanding IS in Norway, with the greatest potentials within the energy sector and the process industry, which has placed focus on circular economy.

The Eyde cluster[43] is an example of an industrial symbiosis within the process industry in the area Sørlandet. The cluster has carried out several IS projects, which have resulted in the exchange of non-ferrous metals and by-products from these. The cluster began as a regional triple helix project including the Adger University, the industry and the regional government. The cluster is gathered around innovation, research and development, but it also focuses on circular economy and symbiosis. The cluster today functions as a national centre of expertise on IS due to their experience.

Arctic Cluster Team (ACT) [44] gathers the process industry in northern Norway. ACT aims to be a pioneer in a sustainable transition ensuring compliance with the Paris Agreement through increasing innovation and improving competitiveness. 14 of the cluster participants are located within a shorter distance from each other constituting the "Mo industry park". The Artic Cluster Team is financed by the municipality of Nordland, Norwegian Industry, NCE Eyde, Innovation Norway in Nordland, NHO and Centre of the Northen Area.

The industrial Green Tech (IGT)[45] emerged from three industrial networks in the region of Telemark. IGT is the largest concentration of process industry in Norway and constitutes more than 20% of the total greenhouse gas emissions in Norway. IGT aims to be the first climate neutral region and thus to contribute to Norway's obligation to reduce CO_2-emissions by 40% in 2030. In order to pursue this, the cluster promotes circular economy and industrial symbiosis.

Lastly, the Industrial area of Øra[46] also aims to become climate neutral. The businesses and public authorities in the area have received financial support to carry out projects and activities that will reduce carbon emissions. The Øra Industrial area has among others initiated a material resource bank to facilitate IS.

The Thams cluster[47] is another newer example. The Thams cluster is aiming to establish an innovative and collaborative industrial symbiosis that gives the companies a competitive advantage.

[43] https://www.eydecluster.com/no/kompetanseomraader/circular-economy/
[44] https://arcticclusterteam.no/
[45] https://industrialgreentech.com/om-igt/
[46] https://www.dagsavisen.no/demokraten/vil-gjore-industriomradet-ora-klimanoytralt-frevar-far-millionstotte-1.1540872
[47] https://www.thamsklyngen.no/om-thamsklyngen/

6.2 Overview of supporting policies

6.2.1 National

Strategies

In June 2017 the government in Norway issued a White Paper on circular economy, but this strategy received extensively critique from industry and NGOs claiming that the strategy was basically a waste framework program in another format. The Ministry of Climate and Environment is currently in the process of developing an updated roadmap to circular economy which is expected to be published in 2020[48].

Norway also has a strategy for green competitiveness that includes circular economy, where the objective is to use resources more efficiently and thus strengthening the business sector's green competitiveness[49]. Likewise, the bio-economy strategy *"Familiar Resources - Undreamt of Possibilities" (2016)* is addressing CE[50]. Norway's waste programme also includes circular economy and includes some elements on industrial waste. It is the Norwegian climate targets that have been driving the focus on Norway's sustainable development. The Norwegian government aims to be a low carbon society reducing GHG emissions by 80-95% in 2050 compared to 1990[51].

The Ministry of Trade, Industry and Fisheries has established "*Process 21*"[52], which recommends how the process industry can reduce its emissions by 2050. Circular economy is recognised as one tool in this process and an expert group on circular economy has been established. This expert group is expected to make recommendations on how the industry can carry out a circular transition of the process industry and is expected to include recommendations on industrial symbiosis.

Regulation

The environmental regulation in Norway is mostly focused on avoiding pollution, which can hinder reuse in many instances. The regulation does not place focus on material loops. However, in 2002 the EU landfill directive (1999/31/EF) was implemented in Norway resulting in increased costs for disposal and the closure of many landfills[53]. The costs related to landfill is still increasing according to this regulation. Furthermore, landfilling of biodegradable waste was banned in 2009[54]. Industrial companies can bypass the law by landfilling waste on their own sites, but this is expensive, and companies would rather find alternative strategies for their waste streams. This is regarded a strong incentive for IS.

Economic Incentives

Landfill taxes and high fees for establishing new landfills are significant incentives for companies to develop means for the prevention of or recycling of wastes through CE/IS business models.

With respect to funding, Innovation Norway and research funds have been supporting IS. Innovation Norway functions as the state's and the regions' tool to realise business development all over the country (Miljødepartementet 2013). Of key significance, Innovation Norway has managed an innovation cluster programme from 2015 (see box 6), which aims to create sustainable innovations. The programme

[48] https://www.regjeringen.no/en/aktuelt/the-norwegian-government-steps-up-the-efforts-to-turn-waste-into-resources-and-reduce-marine-litter/id2558322/
[49] https://www.regjeringen.no/contentassets/4a98ed15ec264d0e938863448ebf7ba8/t-1562b.pdf
[50] https://www.regjeringen.no/contentassets/5b2dc02e8dd047adba138d7aa8b4dcc1/nfd_biookonomi_strategi_engelsk_uu.pdf
[51] https://climateactiontracker.org/countries/norway/
[52] https://www.prosess21.no
[53] https://miljostatus.miljodirektoratet.no/tema/avfall/avfallshandtering/deponering-av-avfall/
[54] https://www.avfallnorge.no/hva-jobber-vi-med/deponi

offers long-term funding and is thus very well designed to support industrial symbiosis. The Norwegian cluster programme has been identified as a key enabler of IS by all informants from Norway.

SIVA - an agency for industrial growth - is supporting industries including building, owning and developing infrastructure for industry start-ups and research environments[55]. SIVA has the mandate to develop industrial parks, and they have e.g. contributed to the development of Norwegian Innovation Clusters (NIC) and Norsk Katapult[56].

Capacity- and relation building

The capacity- and relation building supported by the national government tend to focus on the support of innovation - such as Innovation Norway and Siva. The cluster programme (see Box 6) thus offers advisory services as well as they facilitate knowledge sharing across clusters.

Box 6: Norwegian Innovation Cluster (NIC) (2014-ongoing)

The cluster program NIC offers competency based and financial support of clusters that are nationally and internationally competitive in their business area. NIC is led by Innovation Norway in cooperation with Siva and the Research Council and financed by the Ministry of Trade, Industry and Fisheries and the Ministry of Local Government and Regional Development.

The objective of NIC is to increase the collaborative development in a cluster, to build up expertise and to create innovation and, thereby, increase the value creation in industry and trade.

The NIC program consists of four levels targeting new and immature clusters (Arena), established clusters (Arena Pro), clusters being National Centres of Expertise (NCE) and lastly clusters with Global Centres of Expertise (GCE).

NIC is identified as a key driver of IS as it supports innovation, cooperation across stakeholders and offer long term funding[57].

Moreover, Siva has initiated the regional business hub programme (2011-2022)[58] that aims to create wealth, growth and innovation on the business sector. The business or innovation hubs are responsible for the businesses in the region where they are placed. The hubs support innovation and there are examples of business hubs supporting circular economy such as the business hub in Orkdal's regions, which has further played a key role in the establishment of the Thams cluster[59].

6.2.2 Regional

Strategies

The local and regional governments will be subject to a structural reform that takes effect in 2020. The regions will among others continue to have the mandate to support infrastructure, environment and climate and business development, and on business development they will get more responsibility than before the reform[60]. The regions are identified as key actors in supporting business development due to its closer relation to the business environment and educational institutions. Accordingly, the regions are essential in supporting IS and have been important in implementing resource efficiency (EEA, 2016).

[55] https://siva.no/om-oss/?lang=en
[56] https://norskkatapult.no/ & https://siva.no/om-oss/
[57] https://www.innovationclusters.no/english/
[58] http://v4dp610i86t3v9gxdj0cbh10-wpengine.netdna-ssl.com/wp-content/uploads/2015/03/programbeskrivelse-inkubator.pdf
[59] https://www.nasjonalparkhagen.no/om-naeligringshagen.html
[60] https://www.regjeringen.no/no/tema/kommuner-og-regioner/regionreform/oppgaver-til-nye-regioner/id2628105/

Several regions have included CE in their regional plans and three directly promote IS. Aust- og Vest-Agder Region has a consultation process underway for its Regional Plan up to 2030 which will include elements of industrial circular economy. From 2020 the region will, as a consequence of this priority, employ a full-time CE specialist. The Regional Plan includes objectives on setting up industrial ecosystems and allocating resources to the growth of these.

The region of Trøndelag also includes circular economy as a priority in its Strategy for Value Creation and Innovation[61]. The region writes in this strategy that the potential of innovation is to develop cooperation, business models and technologies that exploit resources as long as possible in the value chain. The region points out that infrastructure, mobilisation of businesses, facilitation of cooperation, funding, contributing to major development projects and procurement are some of the tools, they can apply to realise their objectives.

The Region of Nordland identifies itself in their introduction paper "*Introduction to Nordland*"[62] as the future region of opportunity for circular economy and economic growth. Moreover, the region addresses recycling of side streams and by-products in the Mo Industrial Park[63], where the Arctic Cluster is located; the Arctic Cluster is an IS including several process industry actors. The region aims to support innovation and strengthen clusters and networks[64].

The region of Østfold has supported the establishment of a Norwegian Centre for Circular Economy at the industrial area Øra in Fredrikstad. The region includes circular economy as part of their strategy for bioeconomy, where one out of three objectives is to ensure a resource efficient use of biomass by combining value chains, sectors and knowledge institutions in a circular economy[65].

Regulation
The regions have been successful in identifying brownfield sites as sites for industrial symbiosis. However, it is the municipalities who are responsible for land use planning. Vertical coordination on land use planning is essential and has been implemented in some regions but far from all.

Economic incentives
The regions can fund not-for-profit projects on IS, as Trøndelag has done. They can for instance finance infrastructure that is in support of resource exchange across companies. The regions also play a key role in helping clusters or corporations apply for both national and European funding. Innovation Norway have developed a support programme for businesses addressing circular economy, a programme which also will support IS development.

Capacity- and relation building
The regions and the regional business hubs provide both capacity- and relation building in order to promote business development. The region of Trøndelag facilitates relation building by matching businesses and relevant stakeholders including Innovation Norway and Siva as well as directly facilitating networking activities among companies. To build capacities in the regional companies, Trøndelag offers advisory services.

[61] https://www.trondelagfylke.no/globalassets/dokumenter/naring/vedtatte-versjon-14.12.2017-strategi-for-innovasjon-og-verdiskaping-for-trondelag-1.pdf
[62] https://www.nfk.no/_f/p34/i3e5f3b63-d682-471f-ac3c-e1fb0170cd27/introduction_to_nordland_0518_korr_1.pdf
[63] https://www.mip.no/en/mo-industripark/
[64] https://www.nfk.no/_f/p34/if7a0e349-8d24-464f-8c32-3b82d1bf11f4/vedtattft15oktris.pdf
[65] https://www.ostfoldfk.no/naringsliv/planer-og-analyser/strategi-for-biookonomi/

There are also examples of regions carrying out screening or mapping of flows of material waste to identify IS potentials. For example, the region of Trøndelag played a key role in the recent establishment of the Thams cluster[66], contributing financially and with competencies. They identified the potential of Thams through a mapping of waste resources and side streams. Having identified this potential, they facilitated relevant companies to meet and discuss potential cooperation, which led to the Thams cluster. The regional actors in Trøndelag moreover, identified the unlocked potential of universities' knowledge on IS. They facilitated that students from the Norwegian University of Science and Technology (NTNU) could take summer jobs, where they applied their knowledge on IS and built up capacities. NTNU is the largest technical university in Norway and offers a master's degree in industrial Ecology.

6.2.3 Local

Strategy

Climate and environmental targets are a key priority for many Norwegian municipalities. This was emphasised even more strongly in the local elections of September 2019, where the reduction of GHG emissions and climate mitigation was one of the key election issues. This strong green focus is likely to lead to further policies supporting circular economy. In Oslo, for example, circular economy is a focus in waste management and in a strategy for sustainable consumption. However, Oslo does not focus on industrial symbiosis.

The municipalities can choose to support business development, yet it is not mandatory. The municipalities either outsource business development activities to innovation agencies or manage it themselves, but it requires a certain size to do that. The municipalities in general seem more likely to support CE and IS through climate strategies rather than through business development. The municipalities are further responsible for waste management. Smaller waste parks "civil amenity centres" can provide a good opportunity for IS at a local level.

According to interviewees, no municipality in Norway directly addresses industrial symbiosis nor circular economy in business. Despite this, municipalities have some potential tools to promote IS including business development, area planning that can be devoted to IS or business parks and logistics and public procurement.

6.3 Coordination and capacities across vertical levels of government

Innovation Norway and Siva ensure coordination between the national and regional/local level through regional offices and business hubs. Implying that in the area of innovation and business development, coordination across political levels tend to be quite strong. Likewise, both the national government, Siva, Innovation Norway and the regions do have capacities to support IS. However, it is only a few regions that are using their capacities.

6.4 Key success factors

Stakeholders identified the following key success factors in the development of IS:

- The organisation for business development and innovation being led by Innovation Norway ensures good funding possibilities for IS clusters and facilitation of collaborations between academia, private and public sector

[66] https://www.thamsklyngen.no/om-thamsklyngen/

- Norwegian Innovation Cluster (NIC) is a collaborative development programme that builds up capacities and ensures long-term funding. Both the Eyde cluster, the Arctic Cluster and the Thams cluster receive funding from NIC and identify the programme as very important
- An effective ban on use of landfill by business has been identified as an important driving factor for IS
- A few regions and business hubs are playing an important role in building competencies and relations
- The companies have been a driving force initiating industrial symbiosis bottom-up

6.5 Key obstacles

There is some disagreement amongst stakeholders as to whether knowledge and competences on IS exists in sufficient quantities. One policymaker felt that the knowledge is missing but other informants disagreed stating that the knowledge is there, but not being used. This might indicate that the knowledge is missing in government authorities but can be found in other more specialised institutions such as in academia and in certain clusters.

There is in general a low awareness of circular economy and IS in particular in part due to a silo mentality in government authorities. The many potential benefits of IS are not communicated clearly enough, and that is key to raising awareness among both politicians and the society in general. Strengthening climate policy offers a great opportunity to promote IS as a tool.

The lack of awareness of concrete synergies where by-products can be utilised can also be improved through big data. The data on resource use and waste generation in companies is not being gathered centrally at the moment, but offer a great opportunity to realise the potential of IS.

Norway has a complicated geography that can challenge the logistics being important for the resource exchange between companies due to high transportation costs.

Lack of comprehensive end-of-waste criteria for industrial waste is also identified as an obstacle by industrial stakeholders.

6.6 What more is needed?

Stakeholders made the following recommendations for strengthening IS-support:

- The national government should include industrial symbiosis in their coming roadmap on circular economy to create awareness of the business opportunity that IS offers companies
- Siva and Innovation Norway should exploit their important positions within business development and innovation to support industrial symbiosis more directly
- Siva co-owns more than 100 business hubs and should put an emphasis on circular economy and industrial symbiosis
- Good examples – such as Thams and Eyde cluster - need to be better disseminated
- Municipalities should take part in the support of IS through public procurement

7 POLAND

7.1 Prevalence of Industrial Symbioses

No industrial symbiosis, according to our definition of the term, has been identified in Poland. Nonetheless, there are examples of exchange of side streams between companies such as between the two public companies Lotos Groups and Grupa Azoty Puławy. The maturity to implement IS is low in Poland compared to the Nordic countries (SYMBI 2015: 9). Circular economy is a rather new concept in Poland, which is put on the agenda by the EU and the common European targets towards circular economy. According to one stakeholder, the national government of Poland has been foot-dragging on the green transition due to the country's large reserves and high exploitation of coal. However, the government recently presented an energy plan that includes increases in energy efficiency and in renewables[67]. Likewise, Polish industries work with resource efficiency and reuse of waste due to economic incentives. Lack of awareness on IS is still present.

7.2 Overview of supporting policies

7.2.1 National

Strategy

In January 2018 the" Roadmap *for Transformation in the Direction of a Circular Economy*" was submitted for interministerial consultations, as a result of a multi-stakeholder process initiated by the Minister for Economic Development in 2015 and the establishment of an interdepartmental team called "*Closed Circuit Economy Unit*" in June 2016[68]. In September 2019, the roadmap was approved by the Polish government. This roadmap covers industrial production, sustainable consumption, bio-economy and new business models. IS is mentioned as a green business model, although emphasis is put on circular economy more widely. This strategy is expected to have a positive influence on the development of a framework for promoting IS.

Capacity- and relation building

In 2010 the European Commission accepted the "*Strategy Europe 2020 – Strategy for Smart, Sustainable and Inclusive Growth*", which obliged Poland to prepare a strategy for smart specialisation. The overall aim of the European strategy has been to identify smart specialisation in specific countries with the biggest geopolitical potentials, allowing for the concentration of investments in research and development. The Polish strategy for smart specialisation has one chapter specifically dedicated to circular economy, wherein IS is mentioned but only in the context of recirculating water from municipal and industrial systems[69].

On the web platform National Smart Specialisation or "*Krajowa Inteligentna Specjalizacja*" it is furthermore described how The Ministry of Entrepreneurship and Technology are undertaking networking activities funded by EU initiatives. Specific thematic partnerships are established within three categories, one of which is a thematic platform focusing on energy. Within this platforms, two regions; the Małopolski and Łódzki region are engaged in projects centred around interregional cooperation on innovative use of

[67] https://www.gov.pl/attachment/376a6254-2b6d-4406-a3a5-a0435d18be0f
[68] https://www.gov.pl/web/przedsiebiorczosc-technologia/rada-ministrow-przyjela-projekt-mapy-drogowej-goz & https://strategyforum2019.eu/documents/810774/2291961/No+time+to+waste.+Unlocking+the+circular+potential+of+the+Baltic+region.pdf/bf58b8e2-1cad-486f-bd95-f3cd00185771
[69] https://www.gov.pl/attachment/ce982d48-f0c8-4532-90ef-a6094c2097b2

non-food biomass[70]. This platform could potentially support the development of biogas projects and other projects utilising waste streams, however there are no such examples as yet. It is also expected that the National Smart Specialisation will help companies grant public aid in compliance with EU law[71].

7.2.2 Regional

Strategy

During 2016 to 2021, Poland is participating in the 1.6 million € SYMBI project alongside six other EU countries with the overall aim of promoting IS and circular economy. Through this project, the Malopolska Regional Operation Programme was developed for the Malopolska region, containing initiatives that are expected to promote IS. A specific object from this programme is "*Investments in the Area of Waste Management Aimed at Increasing Waste Management Efficiency and Meeting the EU Requirements*"[72]. Mention of IS in the programme is primarily used in the context of efficient water usage.

7.2.3 Local

Capacity- and relation building

On the local level there have been some initiatives for developing economic zones and industrial parks. In Krakow (also in the Malopolska region) one example is the Krakow Technology Park consisting of 350 enterprises. Here, businesses are responsible for waste incineration, and some of the surplus heat goes to central heating in Krakow. The park is not an example of IS, but the example demonstrates that there are clusters of industries in Poland that might be moving towards IS as they are already within close geographical distance[73].

Box 7: The SYMBI project

The SYMBI project[74], funded by Interreg Europe, has completed its first phase aimed at exchanging experiences and building capacities for IS in Poland. In this phase the project completed a comparison analysis, investment mapping and catalogue of good practices. The second phase will proceed into late 2020 and in this phase good practice will be promoted regionally by "eco-experts" – capacities from industries that have successfully implemented circular economy principles and are now hired to consult other companies. Through the SYMBI project regional strategies will be developed and the project is also expected to influence overall national targets.

7.3 Coordination and capacities across vertical levels of government

Regarding waste management, the government is making plans to take away the mandate to develop waste plans from the regions and put this responsibility on to the municipalities in a new waste act come into force in June 2021. Currently, each region defines strategic targets in waste prevention through these strategies. The act ensures unification across municipalities, which will benefit industrial symbiosis.

7.4 Key success factors

Stakeholders identified the following existing factors that can promote IS in Poland in coming years:

[70] https://www.smart.gov.pl/en/circular-economy-water-fossil-raw-materials-waste/description-of-the-specialization
[71] https://strategyforum2019.eu/documents/810774/2291961/No+time+to+waste.+Unlocking+the+circular+potential+of+the+Baltic+region.pdf/bf58b8e2-1cad-486f-bd95-f3cd00185771
[72] https://www.interregeurope.eu/symbi/
[73] http://www.kpt.krakow.pl/en/about/about-kpt/
[74] https://www.interregeurope.eu/symbi/

- In 2012 the Waste Act provided a legal distinction between waste and secondary resources. Until this act was approved, no clear distinction between waste and secondary resources was made. Although the Waste Act has made it easier to utilise by-products, high levels of bureaucracy are still experienced regarding the use of another company's waste streams.
- The Waste Management and Recycling Cluster (WMRC)[75] is a cluster for collaboration between 90 members created in 2011. Besides facilitation collaboration the cluster also supports knowledge and technology transfers and innovation management. The cluster is identified as a potential key actor for facilitating a transition towards IS.
- Another key promotion factor is a mechanism for subsidising investments in the field of environmental protection and water management. Sixteen regional funds issue fees and fines targeted at industries with negative environmental externalities, while the income from these activities are used to subsidise investments preventing environmental pollution. One of the critical instruments which apply the polluter-pays principle and also provides incentives for better resource efficiency is a landfill fee.
- More actions on resource efficiency and circular economy are being taken by the national government including waste regulation, plan on energy and the circular economy, which is expected to improve the conditions of IS looking forward.

7.5 Key obstacles

Within the private sector, our interviewees indicated that there is a limited tradition for exchanging resources among companies. Rather, it is common to establish a subsidiary when there is an opportunity to reuse secondary resources. In general, it seems that companies prefer not to share data, resources and knowledge related to their production. Since cooperation and trust are key prerequisites for IS, this is considered a key obstacle regarding the implementation of IS.

Our interviewees also point out that national top-down legislation is usually not received very well from industry in Poland. They argue that rather than imposing legislation onto companies, promotion and positive incentives might be a better way for the facilitation of IS in Poland. Within certain industries, circular economy principles are considered as potential barriers if they result in new legislation. One reason for this could be the lack of business cases and knowledge of alternative business models.

Finally, the lack of clear legislative frameworks supporting IS will hinder further development of the concept. Even though circular economy strategies are expected to have a positive influence on the concept, these strategies do not include concrete targets towards IS sufficiently.

7.6 What more is needed?

Stakeholders made the following recommendations for strengthening IS-support:

- There is a need for the development of a better legislative framework for supporting IS. In such a framework, clear definitions and economic benefits of implementing IS should be clearly stated and supported by more economic incentives than just landfill fees. These incentives should

[75] https://new.klasterodpadowy.com/klaster-2/koordynator-klastra/

include positive incentives, as these are easier to implement considering traditions and culture in Poland.

- There is a need for platforms for exchanging information and building competences. Since there is no tradition for IS and since circular economy is still a fairly new concept, there is a strong need for good practice examples and case studies in a Polish context, proving the feasibility and benefits of the concept. An IS platform could serve such a purpose. The SYMBI project and National Smart Specialisation are platforms that already fulfil this need to some degree, and it could be beneficial to use the resources and experiences from these projects for developing a dedicated platform for IS.

8 RUSSIAN FEDERATION

8.1 Prevalence of Industrial Symbioses

Stakeholders could not identify any concrete examples of IS in the Russian Federation. Waste management still primarily utilises the lowest level of the waste hierarchy model namely landfill. In general, there are many issues related to waste management, which have only recently been addressed politically.

In May 2018 the president signed a decree on national goals and strategic objectives of the Russian Federation, where environmental issues are addressed specifically. Among other things, there are goals to build 200 waste processing installations and reduce the number of unauthorised landfills which currently stands at 17 000, compared to only 5 500 authorised landfills including 1 000 municipal solid waste landfills[76]. Furthermore, there are targets to increase the recycling of packaging and waste by producers to 10-30%. Currently only 5-7 % of waste is recycled while 90% goes to landfill (unauthorised and authorised). These issues derived from poor waste management are increasingly receiving much public attention.

8.2 Overview of supporting policies

8.2.1 National

Strategy

Even though there are no examples of IS in the Russian Federation, cascade utilisation and the development of eco-industrial clusters are increasingly receiving attention. The Ministry of Industry and Trade is introducing the concept of Eco Industrial Parks (EIP) through the "*Strategy for the Development of Industry for Processing, Recycling and Disposal of Production and Consumption Waste for the Period up to 2030*", which was adopted by the Order of the Government of the Russian Federation No. 84-P on January 25, 2018. In this strategy, the definition of EIP has similarities to the definition of IS through its emphasis on closing loops on secondary materials.

According to this strategy, eco-industrial parks or "Eco-techno parks" are complexes of units connected by shared energy supply, logistics, assets and expertise used for among other things processing, recycling and managing waste[77] (see also Box 9). This definition hence includes socio-technical aspects of cooperation, which is not something that the definition of IS as adopted in this report emphasises. However,

[76] https://www.nederlandwereldwijd.nl/binaries/nederlandwereldwijd/documenten/publicaties/2019/09/05/factsheet-on-waste-management-in-russia/Waste+management+20190726+FINAL.pdf
[77] https://rulaws.ru/goverment/Rasporyazhenie-Pravitelstva-RF-ot-25.01.2018-N-84-r/

other more comprehensive definitions of IS, such as the one adopted by the Journal of Industrial Ecology in 2012, has similarities with eco-techno parks in the way that socio-technical aspects such as the sharing of expertise, data, assets and logistics are also considered to be part of IS (Lombardi & Laybourn 2012).

If the targets on the development of eco-industrial parks are successful, these clusters could create some of the prerequisites for further development of the maturity towards IS as is support collaborations across companies, which is a prerequisite for IS. The strategy includes a target of the establishment of 12 eco industrial parks in 2020, 30 in 2025 and 70 in 2030.

Today there are 12 clusters in the St. Petersburg and Leningrad region, which build their work and communication with respect to circular economy principles in regard to recycling, green consumption and efficient resource usage. We have not been able to clarify if cascade utilisation or IS is taking place within the 12 clusters. The further development of these projects into IS largely depends on a consistent development of the regional legal framework conditions.

8.2.2 Regional

Strategy

The Russian Federation has a federal legal system, meaning that power is divided between national and state governments. There are seven federal districts in the Russian Federation, each containing several regions, and each administered by a governor. Asymmetrical federalism is practiced, meaning that some regions are more autonomous than others[78].

The decision on the location of the above-mentioned eco-techno parks will be made by the regional authorities on the basis of applications from potential investors. Currently in nine regions territorial waste management schemes have been approved, which provide platforms for the creation of nine new eco-industrial parks.

Capacity- and relation building

The St. Petersburg Cleantech Cluster has been operating since 2014 promoting best available technologies (BAT) and ecological modernisation of production. Here, capacities for IS are being developed alongside relation-building activities and the promotion of clusters. One output from this organisation is the state programme of St. Petersburg, with the main goal of promoting innovative technological development of industry. The organisation is not run entirely by the government but is partly funded through state programmes.

Box 8: Eco-techno parks

The "*Strategy for the Development of Industry for Processing, Recycling and Disposal of Production and Consumption Waste for the Period up to 2030*" promotes eco-techno parks. The strategy has currently resulted in 12 industrial clusters and aims for 70 clusters in 2030. As circular economy principles are incorporated into the strategy, these clusters could arguably create a foundation and raise the matureness for IS projects.

According to a representative from the Ministry for Industry and Trade in the Russian Federation, the eco-techno parks are a way to facilitate the transition towards a green economy by creating a system for interregional cooperation and the reduction of waste and landfilling. The Ministry of industry and Trade predict that the development of these parks will increase the level of waste processing up to 70-80%.

[78] http://www.consultant.ru/document/cons_doc_LAW_44571/

8.3 Coordination and capacities across vertical levels of government

There are no political organs dedicated to IS and, therefore, it is likely that the individual regions will be the main drivers for IS, such as it is seen through the local self-governance of St. Petersburg. According to the Russian Constitution, matters related to among other things the use of natural resources, environmental pollution control and waste management are regulated at both the federal and the regional level. At the federal level regulation consists of codes, laws and subordinate regulations approved by the Russian Government and governmental agencies. These regulations are then supplemented further at the regional level.

The Ministry of Industry and Trade has already been mentioned as being a potentially important driver for some positive incentives for IS. Another ministry that can have influence on the negative incentives (fees, tariffs, taxes etc.) is the Ministry for Natural Resources which is the authority within environmental protection and the main authority administering the governmental policy. The Federal Environmental, Industrial and Nuclear Supervision Service is the federal policymaker for matters related to technological supervision. Here, integrated environmental permits are issued through local offices, setting waste disposal limit for certain facilities[79].

8.4 Key success factors

Stakeholders identified the following existing factors that can promote IS in the Russian Federation in coming years:

- In 2016 landfilling of wastes containing useful recyclable components was prohibited by law. With the number of unauthorised landfills, it is unlikely that this law will be complied with, however, it represents an important part of a legislative framework
- In the regions, territorial waste management schemes have been approved, which can potentially provide the basis for the establishment of industrial symbiosis
- The first step towards IS has been taken with the focus on eco-industrial parks and clusters
- Public awareness towards circular economy has increased much since an unpopular waste collection reform was introduced in January 2019 deeming waste from Moscow to be stored in facilities across the country. In more than 26 of the Russian Federation's regions there were protests with participation by up to 30 000 people at any one protest[80]

8.5 Key obstacles

Compared to the other countries assessed in this paper, the Russian Federation scores lowest in maturity in terms of developing the right framework for the promotion of IS. Politically, there are other priorities that come first, such as implementing efficient waste management systems.

The lack of clear framework conditions, both financially and in terms of regulation is a strong barrier for companies that might consider IS as a business model.

[79] https://uk.practicallaw.thomsonreuters.com/w-013-5609?transitionType=Default&contextData=(sc.Default)&firstPage=true&bhcp=1
[80] https://strategyforum2019.eu/documents/810774/2291961/No+time+to+waste.+Unlocking+the+circular+potential+of+the+Baltic+region.pdf/bf58b8e2-1cad-486f-bd95-f3cd00185771

The lack of tradition for close and co-dependent cooperation between traditionally separated companies creates a social barrier for innovation. Trust and cooperation are often mentioned in literature and interviews as a prerequisite for IS, and it seems that existing cultural norms might not cope very well with this need. However, there might be other cultural barriers as well such as public consciousness and preparedness for products produced from secondary resources etc.

The most polluting industry in the Russian Federation is the mining industry which made up 94% of all industrial waste in 2018[81]. Even though there has been implemented a mining extraction tax, there are few incentives to reduce waste streams. Mining waste varies from harmless to hazardous and in general, much of it has little economic value. This has been mentioned as a barrier, although Finland has demonstrated that IS is feasible within mining industries as well.

Another already mentioned obstacle is the lack of control on land filling. With 17.000 unauthorised landfills, it is difficult to create sufficient negative incentives on landfilling. This obstacle is expected to sustain since targets to close unauthorised landfills are very unambitious. Specifically, there are targets to close 76 unauthorised landfills in cities by 2021 and 191 by 2024, which compared to the total prevalence of unauthorised landfills are very low numbers[82]

According to 2018 results of the Corruption Perception Index from Transparency International, the Russian Federation ranked 138st place out of 180 countries with a score of 28 relative to the highest score of 88. This results in difficulties in among other things financing modernisation and attracting foreign funding.[83] Likewise, the high level of corruption antagonises trust.

Finally, there is a lack of coordination between regulative institutions on environmental protection. Here, the various regulations are often contradicting and there is an existence of several tautologies which results in less effective regulation of taxes and subsidies. However, it is estimated that 80% of all the Federation's environmental legislative acts have never actually been used (Vitálišová, Borsekova & Blam 2016).

8.6 What more is needed?

Stakeholders made the following recommendations for strengthening IS-support:

- There are steps that need to be taken before the Russian Federation can be considered mature for IS. Before focusing on IS there might be a potential in firstly exploring the opportunities for circular economy more generally.
- There is a strong call for an overall strategy with clear definitions. It is likely that an overall strategy towards circular economy that includes IS is the best way forward, instead of focussing on IS isolated.
- It is unlikely that relation-building tools such as match-making and speed dating will have the same effect as in the Scandinavian countries, because there is still the lack of tradition for this kind of co-dependent cooperation. Alternative steps for enhancing the maturity towards IS would be developing examples of good practice in the context of the Russian Federation

[81] https://www.gks.ru/folder/11194
[82] https://www.nederlandwereldwijd.nl/binaries/nederlandwereldwijd/documenten/publicaties/2019/09/05/factsheet-on-waste-management-in-russia/Waste+management+20190726+FINAL.pdf
[83] https://www.transparency.org/cpi2018

through focused funding and consulting activities. Furthermore, corporations that implement IS should be integrated within a global network of environmentally responsible companies.

- Incentives structures need to be consequential. Environmental regulation systems need to be developed and strengthened while funding must be provided for corporations that develop IS projects. Funding to stimulate R&D is critical, as the academic tradition within CE needs to be enhanced over the coming years.

9 SWEDEN

9.1 Prevalence of Industrial Symbioses

Industrial symbiosis is not on the national political agenda in Sweden, yet Sweden has more than 35 examples of industrial symbioses[84]. Many of the industrial symbiosis in Sweden have emerged from the integration of heat and energy production and the establishment of biorefineries (NordRegio 2015 p. 39).

This was the case for the industrial symbiosis in Lidköping[85], where, among others, a combined heat and power plant, a grain-based bio-refinery and a biogas plant circulate grain residues, organic waste, fly ash and residual heat for mutual benefit. Likewise, in Norrköping, where the symbiosis is more complex also exchanging organic residues, heat, carbon dioxide and gardening and construction materials and others[86].

9.2 Overview of supporting policies

9.2.1 National

Strategies

Sweden does not have a national strategy for circular economy, but the previous government established a delegation for circular economy in 2016 that is still active. The objective of the CE delegation is to analyse and propose instruments to support CE, which in the first place has resulted in a report with suggestions on actions to support CE[87]. The delegation is currently developing a strategy on circular economy due to be released during spring 2020, but it is not expected to include industrial symbiosis directly. This CE strategy is a good starting point to create awareness of the potential of CE.

Sweden has focused more on the sustainable development goals with "*Agenda 2030*", where first a delegation was established, which has delivered a roadmap towards the 2030 Agenda[88]. This amongst other included circular economy as a focus area.

Regulation

In 2002 burnable waste was banned on landfilling and in 2005 this was followed by a ban on all organic wastes[89]. This has been in support of circular economy and IS as it forces companies and waste companies to figure out ways to reuse or recycle their waste.

[84] www.industriellekologi.se/symbiosis/index.html
[85] http://www.industriellekologi.se/symbiosis/lidkoping.html
[86] http://www.industriellekologi.se/symbiosis/lidkoping.html
[87] https://www.regeringen.se/49550d/contentassets/e9365a9801944aa2adce6ed3a85f0f38/fran-vardekejda-till-vardecykel-2017_22.pdf
[88] https://sustainabledevelopment.un.org/content/documents/16033Sweden.pdf
[89] https://www.naturvardsverket.se/Documents/publikationer/620-1249-5.pdf p. 22

According to the Energy Mapping Act, larger companies are obliged to carry out energy mappings of their operations every four years and smaller companies could apply for funding to carry out energy screening until April 2019[90]. The data and knowledge of energy use create incentives to increase resource efficiency.

Economic incentives
Landfill, energy and emissions taxes are creating incentives for CE (NordRegio 2015). Likewise, emissions trading between industries is also having an effect[91].

There can also be found different funding possibilities, although none of these addresses IS directly. Sweden's innovation agency, Vinnova, offers funding earmarked to circular economy, cluster support through the programme of VINNVÄXT[92] and RE:Source[93] and funding of projects that are in support of innovation[94]. Also, the Swedish Agency of Economic and Regional Growth through different green funds[95] is also supporting CE projects. Lastly, the Swedish Energy Agency offers funding for industries with negative GHG emissions[96].

Capacity- and relation building
The Swedish Agency for Economic and Regional Growth supports the project "*Innovation Sync*" [97] that aims to increase knowledge exchange on EU projects across the Swedish regions and between the regional and the national level. Some of these projects are about circular economy.

9.2.2 Regional

Strategies
Swedish regions have few *mandatory* tasks that function to support industrial symbiosis. The main task of the regions is to manage the healthcare sector. If the regions choose to support IS, it is on a voluntary basis. The 21 regions in Sweden can voluntarily choose to support business development if it is not-for-profit but it is the municipalities who are responsible for promoting business development and not regions. The regions are together with the municipalities responsible for infrastructure development[98]. The regions of Östergötland and Kalmar have, however, used mobility strategies to support biogas production from organic waste by requiring public transport to use biogas as fuel.

Most of the regions have strategies on sustainable development. For example, Skåne's Climate and Energy Strategy[99] recognises the potential of achieving resource efficiency through industrial symbiosis. Skåne states the importance of collaboration between businesses, municipalities, energy companies and other important actors. The role of Skåne rather seems to be to pool resources across municipalities in a common regional cooperation. Skåne further states that it will promote circular economy to ensure a

[90] https://www.energimyndigheten.se/energieffektivisering/jag-arbetar-med-energieffektivisering/energikonsult/for-dig-som-utfor-energikartlaggningar/
[91] https://www.lansstyrelsen.se/download/18.2e0f9f621636c84402734c0d/1528979328191/Klimat-%20och%20energistrategi%202018.pdf p 55
[92] https://www.vinnova.se/m/vinnvaxt/
[93] https://www.vinnova.se/m/strategiska-innovationsprogram/resource/
[94] https://www.vinnova.se/e/vinnvaxt-2019/vinnvaxt-2019-fullstandig-ansokan/
[95] https://tillvaxtverket.se/finansiering/for-foretag.html
[96] https://www.energimyndigheten.se/utlysningar/industriklivet--stod-till-minusutslapp/
[97] https://tillvaxtverket.se/eu-program/innovationssynk.html
[98] https://www.vannas.se/default.aspx?di=2056
[99] https://www.lansstyrelsen.se/download/18.2e0f9f621636c84402734c0d/1528979328191/Klimat-%20och%20energistrategi%202018.pdf p 55

better management of resources. Procurement is another tool that the regions can apply to support industrial symbiosis.

The regions can voluntarily choose to support research, innovation and infrastructure and through that support industrial symbiosis. The region of Värmland has the strategy "*Research and Innovation Strategy for Smart Specialisation*"[100] in cooperation with the Academy for Smart Specialisation that includes the University of Karlstad, companies, social actors, funders and entrepreneurs. This strategy includes forest-based bioeconomy and advanced manufacturing as two out of five areas, where Värmland can become internationally competitive. The strategy encompasses several projects that support resource efficiency, innovation, research and knowhow. The strategy aims for the region of Varmland to supplement investments to achieve a bio-based economy with various degree of IS[101].

Economic Incentives
The regions can support not-for-profit projects such as research. The Region of Värmland is doing this through several projects as presented in their smart specialisation strategy as described above[102].

Special national investments have been made during the years 2015-2019 to stimulate small and medium-sized companies in order to work systematically and structured with energy issues and to increase competences. These include the Company Network for Energy Efficiency, Regional Nodes, Energy Coaches and Incentives for Energy Efficiency[103].

Capacity- and relation building
The region of Skåne has offered the municipalities to participate in the project "*Circular Skåne*" (2019-2021) [104], where the municipalities' capacities on circular procurement and promotion of circularity in the business environment are built up. The project is financed by Skåne and the Swedish Agency of Economic and Regional Growth. In general, the regions are important to ensure cooperation among the municipalities in their region.

9.2.3 Local

Strategies
Municipalities have the mandate to ensure environmental protection, co-owning water supply and waste management companies, city planning and business development and as a result the municipalities possess responsibilities of several areas, where they in theory can support IS. One policy maker roughly estimates that in 2019, 20 out of 300 municipalities are working with industrial symbiosis and it is continuously becoming more widespread. Often the municipalities use circular economy or industrial symbiosis as a tool to reach climate- or environmental targets. That is the case in the municipality of Malmö. Malmö has in their "*Vision 2040*" an objective to promote the interests of IS by exchanging knowledge and experiences as well as the objective of a sustainable and integrated city where city, harbour and industry are all included in the urban planning. Likewise, Malmö looks at how energy, logistics and waste can be managed to support IS[105].

[100] https://www.kau.se/files/2017-09/Strategy%20Smart%20Specialisation%202015-2020.pdf
[101] https://www.regionvarmland.se/globalassets/global/utveckling-och-tillvaxt/naringsliv-forskning-innovation/vris3.pdf
[102] https://www.kau.se/files/2019-03/ENGPosterutst_Broschyr_A5_181207_LOW.pdf
[103] https://www.lansstyrelsen.se/download/18.2e0f9f621636c84402734c0d/1528979328191/Klimat-%20och%20energistrategi%202018.pdf
[104] https://mplusext-hr.unikom.se/welcome-sv/namnder-styrelser/kommunstyrelsen/kommunstyrelsen-2018-08-14/agenda/kortinfo-cirkulara-skanepdf?downloadMode=open
[105] http://industrialsymbiosis.se/wp-content/uploads/2018/12/5_Linköpings-universitet_Murat-Mirata.pdf

Many clusters and projects are associated with municipalities, but it is not the municipalities that have initiated them. It is rather the companies themselves or energy companies being the initiators, which are owned by municipalities, but independent in their actions. The municipalities are rather working on the dissemination of information on IS. That being said, the municipality has in many circumstances created incentives for industrial symbioses through their environmental policies.

According to one stakeholder, in Lidköping, the municipality increased the demand of district heating and further reduced the amount of waste landfilled creating incentives for IS. In Norrköping, it was also a district heating system that was a driver as well as using waste and biomass as fuels. For the IS system in and around Helsingborg (including the Industry Park of Sweden – IPOS), the objective of the municipality of Helsingborg of having a heat production free from fossil fuel in 2020 was essential to create the incentive[106].

Regulation
Existing district heat systems established through local development plans and investments are identified as enablers of IS in Sweden. The district heating systems were initiated by municipalities and are today mostly managed by municipality owned companies (Werner 2017). On the other hand, one expert from Norway points out that district heating and incineration of waste can be a barrier for more circular handling of waste implying that district heating shall not be seen as a 'tool' to promote industrial symbiosis today, but rather be seen as a previous enabler of IS in Sweden.

Urban planning can in general be a strong tool for promoting IS. The City of Malmö is planning to make use of urban planning for this aim but have, as yet, not progressed so far with these plans.

Economic incentives
Municipalities can solely issue income taxes and thus not use taxes to create incentives for certain behaviour. With respect to funding, the municipalities can only support not-for-profit projects economically.

Capacity- and relation building
The City of Malmö experienced a great support from both the local community and politicians on climate priorities, which opened the door to promote IS as a tool to reach the city's climate targets. With this support it became more accessible to raise funding and prioritise IS internally. Additionally, the industrial symbiosis in the harbour of Malmö functioned as a showcase that convinced many different stakeholders on the potentials of IS. The City of Malmö uses this "good practice" to inform on the potential of IS in their meetings with companies. The main tool of the City of Malmö municipality is to create awareness of IS. In the municipality, an increasing number of municipal units are working with industrial symbiosis and a structure and workflow is under development that intends to continuously identify and support IS development opportunities among existing as well as new operations in the area.

Another tool that municipalities can apply, as pointed out by the region of Skåne, is energy and climate counselling, which has been part of the municipality's task since 1998[107].

[106] www.industriellekologi.se/symbiosis/index.html
[107] https://www.lansstyrelsen.se/download/18.2e0f9f621636c84402734c0d/1528979328191/Klimat-%20och%20energistrategi%202018.pdf

Box 9: Restrictions on wastewater emissions lead to an industrial symbiosis

The process industry in Sötenas was restricted in emissions of wastewater from local fish production. The processing industry was facing increased demand but could not increase their production due to these restrictions on emissions. The municipality was afraid that their largest industry would be forced to leave the area. To create incentives for the producer to stay, IS was considered. The idea was first raised by a director of one of the local processing industries but was supported by the municipality.

An industrial symbiosis was established, where the wastewater is converted to purified water and fertilisers. Likewise, the organic residual products are used to produce biogas, which is used for electric power and hot water. Sötenas has established a symbiosis centre with six civil servants that support business development through industrial symbiosis[108].

9.3 Coordination and capacities across vertical levels of government

In Sweden, the municipalities have been the most important in promoting industrial symbiosis. They have through ambitions on waste management, energy efficiency and corresponding environmental targets created incentives for IS. The initiatives are often taken from the energy companies, but municipalities have often taken part of the IS and actively supported these. Many municipalities work with circular economy and a smaller share also work with industrial symbiosis mostly through capacity- and relation building.

The regions can through voluntary tasks choose to support IS. At least four regions are actively promoting industrial symbiosis through projects funded either nationally or by the European Commission. The regions can play a key role through their energy offices as well as taking the role in bringing together the municipalities to collaborate and exchange knowledge on IS. Skåne has facilitating thus inter-municipal cooperation in the region.

The national level has not put any direct focus on industrial symbiosis. Yet, they do offer some funding. The Swedish network for Industrial and Urban Symbiosis initiated by the University of Linköping ensures some coordination. However, the network only meets once a year, and further lack both a physical place and funding.

9.4 Key success factors

Stakeholders identified the following key success factors in the development of IS:

- A problem-solving culture and an open business culture with culture to work together across companies
- The great focus on resource efficiency and climate activities in Sweden both politically and within the community have been in favour of industrial symbiosis
- The University of Linköping has performed key work to support IS in Sweden. All informants recognise the importance of the university in supporting IS. The university communicates the potential of IS. Most of the information to be found on IS in Sweden is thus provided by them: for example, an analysis of enablers and barriers of IS in Sweden[109]. They are educating students in IS and sending them out to clusters to advise and build capacities. The university has further built up a national network on IS

[108] http://www.symbioscentrum.se/vuxenutbildning.4.1f39350415fe315b1ac103bd.html and http://circulareconomy.se/industriell-symbios-cirkulara-floden-av-restmaterial/

[109] http://www.industriellekologi.se/symbiosis/index.html

- Regional requirements for the use of biogas in public transport has led to biogas production from organic waste, which have developed into industrial symbiosis.

9.5 Key obstacles

A national focus on IS is lacking. The environmental regulation is further characterised as being inflexible and can sometimes work against industrial symbiosis. A lack of streamlined end-of-waste criteria limits the utilisation of waste materials as side-streams.

A plant can in Swedish law only have one owner. This creates some barriers to investment sharing and output sharing by IS partners. The companies in the symbiosis will thus be characterised as “owner” and “producer”, where taxes on energy still need to be paid.

9.6 What more is needed?

Stakeholders made the following recommendations for strengthening IS-support:

- A national strategy on circular economy that includes industrial symbiosis to create broader awareness of IS and its potential
- Assess the current environmental regulation to ensure that the regulation is not acting as a barrier of industrial symbiosis.
- The Swedish network for Industrial and Urban symbiosis should receive funding to ensure coordination across stakeholders working with industrial symbiosis
- Regions can ensure experience sharing across the municipalities in the region, as Skåne has done.

10 COMMONALITIES IN POLICY CHALLENGES

In this section we will carry out a gap analysis to identify commonalities in policy challenges across the Baltic Sea Region. Here we place focus on the potential of IS in each country by looking at each of the four types of policy tools; regulation, economic incentives and relation and capacity building.

First, however, we discuss the political commitment as it is the precondition for establishing a policy infrastructure in support of IS. The Nordic countries possess the potential to create good framework conditions for IS, what is missing is rather the political will and priority to do so. That priority has been seen in Finland, and previously in Denmark, which has effectively been in support of IS. In Poland, the focus on resource efficiency and circular economy is rather new, implying that the structure for industrial symbiosis first needs to be established. That is also the case in the Russian Federation, to an even higher degree, where corruption and poorer institutions is challenging IS.

10.1 Political commitment

In Denmark, little attention is given to industrial symbiosis at national level. More resources are allocated to the broader agenda of circular economy, which indirectly is in support of IS. A previous government carried out initiatives in support of IS including Green Industrial Symbiosis. This reflects how the commitment to industrial symbiosis is dependent upon the priorities of the national government in power.

A similar picture of industrial symbiosis is found in Norway and Sweden, where IS is not present on the national political agenda. Both countries are in the process of developing strategies on circular economy. Norway has several national initiatives in support of research and development that support CE indirectly, while Sweden's initiatives on resource efficiency has supported IS.

IS is high on the Finnish national political agenda as reflected in the national target of being a circular pioneer where the industrial loop is also included. The political support of IS in Finland implies that more resources are allocated to support both circular economy and IS, but still more can be done to support business and facilitate IS collaborations.

The government of Poland has just begun to look at the circular economy and recently developed its first circular economy strategy, where IS is mentioned as a possible business model. The strategy is not accompanied by any actions that support IS. However, a "*Closed Circuit Economy Unit*" has been established to support a circular transition.

In the Russian Federation, the political commitment to sustainable development and circular economy is in general low. The Federation has through the last two decades faced economic and social challenges, which have not been in favour of environmental policies. The maturity on IS is characterised as low, which is among others indicated by the fact that the Russian Federation disposes most of its waste in landfills – often unauthorised. The national government has issued targets on increasing recycling rates.

The generally low political national commitment towards IS across the BIS countries can be reasoned by low awareness of the economic and environmental potential of industrial symbiosis. Finland – and the Finnish Innovation Fund SITRA in particular - has to a larger degree succeeded in communicating the potentials of CE and IS.

The political commitment varies at the local and regional level. Local political commitment is often motivated by the existence of an IS or a dense industry in the local area. In Denmark, it is primarily the municipalities and business hubs that support IS. whereas in Norway it is rather the regions and regional business hubs. In Finland and Sweden both municipalities and regions support IS. In Poland and Russia, there are no local initiatives and only one regional initiative in each country as far as we know.

Recommendation 1: Communicate the potential of IS in order to put industrial symbiosis on the national political agenda as part of the focus on circular economy.

In order to put IS on the agenda, the great potential of IS and the good examples need to be communicated. Stakeholders can lobby through communication and awareness raising. Internationally, both resource scarcity and climate change have increasingly received more attention. IS can be identified as a tool to reach targets on climate change and resource efficiency in each of the BIS countries.

To pursue circular economy, the more circular loops including refusing consumption, reduction of waste and reuse should be prioritised, which can be archieved through circular designs of products. Industrial symbiosis should not be at the expense of more circular solutions and should neither results in lock-ins narrowly focusing on industrial symbiosis.

Target group: Policy-makers and stakeholders

Recommendation 2: Include industrial symbiosis in national circular economy strategies

Concrete targets for IS should be included in national circular economy strategies or roadmaps. In countries such as Poland and Russia, where circular economy has had less breakthrough, it might also be beneficial to introduce IS along with the introduction of circular economy as a wider framework or strategy. However, IS has many prerequisites that needs to be targeted in such a framework, and it is important that the concept of IS is unfolded and that relevant policy measures and targets are included.

Target group: National governments

Recommendation 3: Place the responsibility of promoting IS with a single government agency

The Finnish success with creating awareness on industrial symbiosis and circular economy is partly due to the Finnish Innovation Fund Sitra, which has been able to create persistent attention on CE. A similar structure in the other Baltic countries can be considered to ensure long-term awareness. In both Norway and in Denmark, stakeholders point out that IS is sometimes falling between two chairs: handled by both the Environment- and Business area.

Target group: National governments

10.2 Economic incentives

Industrial symbiosis needs investment and long-term funding. The motivation to support IS can be a reduction in material resource use combined with an increase in innovation and economic growth.

With the exception of Finland, no funding that is directly earmarked for IS can be found. The national governments of Denmark, Norway and Sweden all offer funding possibilities, but these are rather focused on innovation or the broader agenda of the circular economy and are often too short-term to allow establishment of a functioning self-sufficient IS.

In the Russian Federation and Poland there are some financial measures that provide indirect incentives for IS, but no funding is directly targeting IS. In the Russian Federation, the only financial instrument identified that could potentially benefit IS is a reimbursement possibility for expenses for investment in technological development in the field of environment. Poland also provides some funding through the smart specialisation programme that could potentially benefit IS, but there are no examples of this yet.

Private investments can further be attracted through branding and lobbyism carried out by authorities.

Recommendation 5: Create incentives for industrial symbiosis through taxes and subsidies

There is a need for attractive and stable market conditions for private sector investments in industrial symbiosis. Therefore, it is important to create both long-term carrots and sticks to encourage companies to participate in an IS. Sticks can be provided through relatively high landfill and incineration taxes, pay-as-you-throw schemes, landfill bans of various waste streams etc. while carrots can be provided through subsidiaries or direct funding for certain projects. Such incentives should favour higher and penalise lower waste hierarchy options.

Target group: National governments

10.3 Regulation

In Finland, newer environmental regulation is in support of the circular economy and thus often also industrial symbiosis, yet more can be done to ensure that the regulation is in favour of IS. In Denmark, Norway and Sweden, there are environmental regulations that sometimes conflict with industrial symbiosis. There is thus a task in evaluating the environmental regulation and balancing this between the aims of circular economy and other environmental objectives.

In all the Nordic countries, structural changes due to a green transition are likely to result in an assessment of current policies to ensure it is aligned with the political ambitions. Poland and the Russian Federation have not formulated the same structural ambitions. However, sometimes the uncertainty on regulation can act as a barrier in both the Russian Federation and Poland.

Recommendation 6: Identify and remove regulatory barriers

Review environmental control and regulation to see where it conflicts with industrial symbiosis. Identify opportunities for streamlining regulations such that they better enable IS without leading to additional environmental pollution risks.

Often IS is a cross-departmental matter as companies utilizing side streams might be influence by strict waste regulation etc. It can be beneficial to establish governmental departments entirely dedicated at both administrating IS specific regulation and at orientation companies in the legislation. In Denmark there has been examples of cross-ministerial task forces established with the sole purpose of clarifying which taxes had negative influence on material efficiency and IS (NordRegio 2015).

Target groups: Legislative apparatus within the areas of waste in particular, but also energy, water and pollution may be relevant. Stakeholders should make the legislators aware of regulation being a barrier of industrial symbiosis.

10.4 Capacity building

How to build up capacities depends on the current status of capacities on IS. In general, the capacities in the Nordic countries are higher than in Poland and the Russian Federation. The process model below

shows some of the steps that is needed to establish industrial symbioses. The model is built on the basis of the stakeholders' practical knowledge.

Experience shows that agencies within the area of business development have better potential to support companies in the activities in support of IS than environmental ministries. National government can play a role to ensure that regional and local actors focus on this topic and further possess capacity to support business in circular economy and industrial symbiosis.

Firstly, it is important to identify which municipalities, regions or business hubs/agencies are best placed to support IS and already have several business-related activities and a great knowledge of what affects and drives businesses. These should be encouraged to support industrial symbiosis in a practical manner through business development.

Secondly, in order for regional and local actors to support IS in business, they need to possess the capacity and knowledge of resource efficiency and IS. National governments can support practical initiatives by funding and issuing initiatives such as it was the case with the Danish "*Green Industrial Symbiosis*" project, with a task force and supported regional activities. Symbiosis Center Denmark has also built up capacities in a number of municipalities, but they found it challenging to motivate these to invest. Therefore, the municipalities/regions/business hubs need to be given clear incentives to support IS.

Recommendation 7: Increase regional or local levels capacities to support industrial symbiosis and inform on the possibilities of IS when in dialogue with business.

Depending on who has the mandate to support business development, they should be given incentives for building capacities to support IS. Business know-how, and technical and legislative knowledge is required to successfully initiate IS, and often the regions, municipalities and business hubs are the direct interfaces for companies. If strong capacities and insights into the possibilities and good practises are found here, it is much more likely that the concept will be promoted.

Experts at regional and municipal level should be promoting the concept of IS when in dialogue with companies and if possible with the assistance of academia. This can be useful in contexts where there is little awareness of IS and if there is lack of local/regional platforms for capacity- and relation building. Raising awareness on the possibilities of recycling materials can be an eyeopener to companies who might not know of the economic benefits. Such examples of raising awareness should not stand alone, but can be incorporated into other activities such as energy screenings etc.

Certain universities possess a high level of expertise on IS. That is the case for the University of Linköping in Sweden and NTNU in Norway, wherefrom students have been involved in advising specific industrial symbiosis. In both cases, the students were an asset for the symbioses. To let students support IS in practice is recognized as a suitable tool to ensure knowledge sharing between universities and practice. In general, it is a critical long-term strategy that IS is implemented in the curriculum in universities in all the BIS-countries which is still not the case.

Target groups: National, regional and local governmental authorities

Awareness
Awareness of resource efficiency is a prerequisite for awareness of the potential of IS. Many businesses in the Nordics already possess good knowledge of their resource use. This has been achieved through decades with focus on resource efficiency in Sweden, for example, energy screenings in larger companies is a requirement. In Poland focus has only recently been placed on resource efficiency in companies. The same awareness on resource efficiency is not present in the Russian Federation, thus the first step here is to increase awareness of resource efficiency.

With the exception of Finland, awareness on IS needs to be raised in all the BIS countries, which is addressed in the first recommendation. The local and regional level can also do a lot to raise the awareness of IS. The municipality of Malmö is thus informing the companies on IS whenever they meet them in other circumstances.

Knowledge on IS
In the Nordic countries, the knowledge on IS is present, but often placed with a few specialists. Therefore, communication between specialists and policymakers, as well as between universities and practitioners is necessary to let knowledge and experiences lead the development of industrial symbioses. In some instances, students possess great assets on IS in practice.

Mapping resource flows
Experience shows that to identify potential exchanges of materials between companies and utilities, a screening of all companies' side-streams that feed into an overall mapping is a key tool to support IS.

Such a mapping can advantageously be built on digital platforms. Newer technologies such as blockchain and machine learning are expected to unlock new possibilities of resource use and waste stream mapping. By mapping resource flows, it is possible to identify potential IS. The Thams cluster in Norway was thus a result of a mapping carried out by students in collaboration with the local business hub, financed by the region of Trøndelag.

The national government of Finland is to issue a law requiring all SMEs, which use the waste management services from the municipalities, to report their side streams on the platform "*Materiaalitori*" at the turn of 2020. Likewise, both Finnish Industrial Symbiosis System (FISS) and Green Industrial Symbiosis (GIS) included digital platforms on resource flows.

Recommendation 8: Support companies in carrying out screening of resource side-streams

Assisting companies in screenings in an open and involving process to develop information- and relation building will clarify the potential of side streams while simultaneously creating opportunities for dialog where awareness can be raised and where potential matches can even be introduced. Relevant companies collecting wastes and consultants can also be incorporated in this agenda, since they will most likely be highly involved later when concrete industrial symbioses are established and operated.

Target groups: Local/regional actors

The regions and municipalities can support screenings and local or regional mappings to identify potential exchanges of side-streams. The national government should be responsible for a national digital platform, but the local and regional actors could support the companies in the actual screening. If no national system exists, a local or regional mapping could be an alternative.

Recommendation 9: Build up a national digital platform mapping resource side-streams of all companies

Exploit new technologies to build up a digital platform that maps side streams and resource needs of companies. To ensure data is registered, a law similar to the one being issued in Finland can be considered, or alternatively the establishment of a positive incentive structure for the companies to register their data can be considered. Through such platforms, markets for secondary products can be created, providing crucial information on availabilities and demand of certain side streams.

Target groups: Policymakers in national governments and stakeholders

Relation building

IS involves many different stakeholders. Therefore, it is important to build up relations between companies, utilities and experts through meetings, facilitation of networks and/or partnerships. In general, in the Nordic countries there exists a culture of cooperation and thus a potential to build up trust between partners, whereas in Poland and the Russian Federation there is often distrust between companies. In these countries networking arrangements can be held to increase the general trust among stakeholders and between companies, in particular. However, it might be important to focus more on awareness raising, good practices etc., before actually trying to match companies.

In the Nordic countries, two types of relation building are well spent. Firstly, a national network of all stakeholders engaged in IS to ensure exchange of knowledge. Such a network is established in Sweden; however, the network lacks funding to unlock its potential. Likewise, the regional network in FISS is a good example of how a network can ensure knowledge exchange among professionals involved in industrial symbiosis.

Recommendation 10: Establish a national network on industrial symbiosis

A national network of IS ensures knowledge sharing across main actors and can further contribute to new cooperation. A national network can enhance open dialogs and connect much of the needed platforms and activities while relating this to overall national strategies and targets.

Target groups: Stakeholders and policymakers in the Nordic countries in particular

Secondly, when a mapping has led to the identification of companies that potentially constitute an IS, matchmaking facilitation between these companies is a suitable policy tool.

Recommendation 11: When having identified companies that can potentially constitute an IS, facilitate match-making

Relation building activities can clarify the interests for cooperation, based on the mapping of side streams. Knowing the potential for IS companies have to make a decision whether they want to invest in IS. It makes sense to have a neutral facilitator in these processes, possibly a public entity. It also makes sense to involve the governmental agencies that are responsible of supervising the companies in the long run.

Supporting activities can bridge suppliers of secondary resources, potential buyers and providers of know-how and technology. Such activities could furthermore be linked material scans, matchmakings for SMVs, technical training and support in securing funding mechanisms.

Target groups: Local/regional governmental authorities or business hubs

Implementation

When a potential industrial symbiosis cooperation has been identified and the companies are engaged, the implementation phase can still be challenging. From the Danish GIS project, one experience was that it is important to keep the support through the entire process including the implementation. During the implementation, trust between the companies still need to be build. Public authorities can act as a "neutral" facilitator that can ease the implementation phase. The public authority can keep the role as a facilitator also after the IS has been established. In the municipality of Kalundborg, certain employees are functioning as a secretariat for the Kalundborg Symbiosis. It is an advantage namely because the local civil servants are neutral and can facilitate the communication and assist in meetings.

10.5 Coordination

The local and national initiatives should be coordinated to ensure an efficient effort in support of IS. Due to the mandate of the different policy levels in each country, the levels play different roles in supporting IS. The higher institutions of governance are important in ensuring supportive legislation, offer funding and initiate larger capacity building projects such as a digital platform of companies' side-streams.

The local or regional authorities play an important role in the more practical support of companies by initiatives of building capacities and relations. In particular, the actor with the mandate of business development can play an important role in supporting IS. As IS is often centred around the utilisation of wastewater and surplus heat, the local authorities who often provide the services of heat and water, are often key actors in the potential of IS. The local or regional authorities can also target specific industrial symbioses and thus design the initiative depending on what is needed in the concrete case. In Sweden, Finland and Norway, the regions can also ensure coordination across the municipalities within the region to exchange knowledge and experiences, as exemplified in Skåne.

The "*Green Symbiosis Project*" in Denmark showed how a coordinated effort can be in support of IS on a project basis. In this case, the government ensured funding and attention of IS, while the regions took care of screenings and resource efficiency capacities within the companies. In the longer run, however, systems to ensure coordination is needed. Such systems can include fixed meetings between the policy-makers involved in IS on national and regional/local levels. In Finland, a culture of cooperation between the different political levels is mentioned as a key success factor. Yet, the coordination needs to be systemised for such as culture to emerge.

Recommendation 12: Increase coordination between national and local levels of governance

The national and local/regional level should increase coordination in order to ensure a common and efficient effort in support of industrial symbiosis. Within such a coordination, responsibilities and resources need to be allocated to ensure the right policy structure in support of IS.

Target groups: Local/national governmental authorities

11 CONCLUSION

This report has mapped policies in support of Industrial Symbiosis in the Baltic Sea Region at local, regional and national level and further discussed commonalities in policy challenges and provided recommendations on how to address these. The policy mapping is not exhaustive, but should rather be seen as examples of policies that can support or inhibit IS. Many environmental policies affect industrial symbiosis, exactly which policies that an IS is subject to depends on the side streams being exchanged.

In general, industrial symbiosis has received relatively little focus from national governments. However, some policy instruments can be found that address IS directly or indirectly including funding, cluster and innovation support. National governments should include IS in their circular economy and/or green growth strategies, ensure long-term funding and offer economic incentives for companies to engage in industrial symbiosis. National governments can play a further key role by streamlining environmental

regulation, and waste regulation in particular, to ensure that it supports rather than inhibits a circular economy while not increasing risks of environmental pollution.

Local and regional government structures vary across the countries in the Baltic Sea Region, where few municipalities, regions and business hubs offer activities that are in support of IS. The actor with the mandate of business development should build up networks and capacities within and among companies. Capacity building can include awareness raising, information and screenings, while relation building can include networking and match-making facilitation.

The Nordic countries possess much of the business culture and organisational structures to carry out these activities, it is rather question of political priority. In Poland and the Russian Federation more initial steps need to be taken to develop the right systems and a culture of collaboration across companies to support industrial symbiosis.

12 REFERENCES

Borrás, S., & Edquist, C. (2013), The choice of innovation policy instruments. *Technological forecasting and social change, 80(8)*, 1513-1522.

Chertow, M. R. (2000). Industrial symbiosis: Literature and taxonomy. *Annual Review of Energy and the Environment* 25: 313–337.

Czerniak, A., (ed.) Wiejski, P., (ed.) Helak, M., Pawłuszko W., Szyszko J., van Horn, R., Wiatrowski M. (2019) No time to waste. Unlocking the circular potential of the Baltic Sea Region, *Polityka Insight.* Available on <https://strategyforum2019.eu/documents/810774/2291961/No+time+to+waste.+Unlocking+the+circular+potential+of+the+Baltic+region.pdf/bf58b8e2-1cad-486f-bd95-f3cd00185771>

EIPC (2018) *Country Report: Russian Federation*, EIPC. Available on http://www.uncrd.or.jp/content/documents/6601Country-G-5-Russia.pdf [28/08/2019]

Erhvervsministeriet (2019*) Aftale om rammerne for Erhvervshuse, 2019-2020 mellem Erhvervsministeriet (EM) Slotsholmsgade 10-12 1216 København K og Kommunernes Landsforening (KL) Weidekampsgade 10 2300 København S*, KL, Copenhagen S. Available on<https://www.kl.dk/media/18854/rammeaftale-om-erhvervshusene-2019-2020.pdf>

Erhvervsstyrelsen (2014) *Samarbejdsaftale vedrørende samarbejde mellem Erhvervsstyrelsen og regionerne om fremme af grønne industrisymbioser,* Erhvervsstyrelsen. Available on<https://www.rm.dk/api/NewESDHBlock/DownloadFile?agendaPath=%5C%5CRMAPPS0221.onerm.dk%5CCMS01EXT%5CESDH%20Data%5CRM_Internet%5CDagsordener%5CVaekstforum%202015%5C05-03-2014%5CAaben_dagsorden&appendixId=63725>

European Commission (2018) *Cooperation fostering industrial symbiosis: market potential, good practice and policy actions*, European Commission. Available on <https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en>

Finansministeriet (2019), *Finanslov for finansåret 2019*, Finansministeriet, Copenhagen K. Available on <https://www.fm.dk/publikationer/2019/finansloven-for-2019>

Fischer, C. & Krausing, J. (2018) *Grøn vækst og symbioser – Innovation med det offentlige som katalysator*, Gate21. Available on <https://www.gate21.dk/wp-content/uploads/2018/10/Grøn-vækst-og-symbioser.pdf>

Frelle-Petersen, C., Hansen, M.B. & Kristiansen, S.B. (2013) *Industrielle symbioser i hovedstadsområdet,* Copenhagen Economics. Available on <https://groenomstilling.erhvervsstyrelsen.dk/sites/default/files/industriellesymbioser.pdf>

Government of the Russian Federation (2018) *Order of the Government of the Russian Federation of January 25, 2018 N 84-P <On Approval of the Strategy for the Development of Industry for the Processing, Utilization and Neutralization of Production and Consumption Waste for the Period Until 2030> [translated]*, Government of the Russian Federation. Available on <https://rulaws.ru/government/Rasporyazhenie-Pravitelstva-RF-ot-25.01.2018-N-84-r/>

Hållbar Utveckling Skåne & IUC SYD (2018) *Cirkulära Skåne***,** Hållbar Utveckling Skåne. Available on<https://mplusext-hr.unikom.se/welcome-sv/namnder-styrelser/kommunstyrelsen/kommunstyrelsen-2018-08-14/agenda/kortinfo-cirkulara-skanepdf?downloadMode=open>

Interreg Europe (2017), *Policy Brief Industrial Symbiosis*. European Union, European Regional Development Fund. Available on<https://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/TO6_policybrief_Industrial_symbiosis_final_IK_CLEAN.pdf>

Kingdom of the Netherlands (2019) *Waste Management in Russia*, The Netherlands Embassy in the Russian Federation. Available on<https://www.nederlandwereldwijd.nl/binaries/nederlandwereldwijd/documenten/publicaties/2019/09/05/factsheet-on-waste-management-in-russia/Waste+management+20190726+FINAL.pdf>

Klima- og Miljødepartementet (2017) *Bedre vekst, lavere utslipp – regjeringens strategi for grønn konkurransekraft,* Klima- og miljødepartementet. Available on<https://www.regjeringen.no/contentassets/4a98ed15ec264d0e938863448ebf7ba8/t-1562b.pdf>

Lombardi, D. R., & Laybourn, P. (2012) Redefining industrial symbiosis: Crossing academic–practitioner boundaries. *Journal of Industrial Ecology*, 16(1): 28-37.

Lybæk et. al. (2019). Policy review for deploying 'Industrial Symbiosis – What are the obstacles, drivers and future way forward?'

Miljø- og Fødevareministeriet (2015) *Vandsymbioser i Kalu*ndborg, The Danish EPA, Copenhagen K. Available on <https://www2.mst.dk/Udgiv/publikationer/2015/07/978-87-93352-50-6.pdf, The Danish EPA, Copenhagen K. Available on <https://www2.mst.dk/Udgiv/publikationer/2015/07/978-87-93352-50-6.pdf>

Miljø- og Fødevareministeriet og Erhvervsministeriet (2018) *Strategi for cirkulær økonomi,* The Danish EPA, Copenhagen K. Available on <https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Cirkulaer_oekonomi/Strategi_for_cirkulaer_oekonomi.pdf>

Miljøstyrelsen (2015) *Vandsymbioser Kalundborg*, Miljøstyrelsen, Copenhagen K. Available on <https://www2.mst.dk/Udgiv/publikationer/2015/07/978-87-93352-50-6.pdf>

Ministry of Energy (2018) *EXTRACT FROM DRAFT – ENERGY POLICY OF POLAND UNTIL 2040 (EPP2040)*, Republic of Poland. Available on <https://www.gov.pl/attachment/376a6254-2b6d-4406-a3a5-a0435d18be0f>

Ministry of the Environment (2018) *From Recycling to a Circular Economy - National Waste Plan to 2023*, Ministry of the Environment, Helsinki. Available on <http://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/160889/SY_01en_18_WEB.pdf?sequence=1&isAllowed=y>

Mirata, M. (2018) *Examples of Ongoing Projects,* Lindköping University, Karlstad. Available on <http://industrialsymbiosis.se/wp-content/uploads/2018/12/5_Linköpings-universitet_Murat-Mirata.pdf>

NIRAS (2015) *Reguleringsmæssige barrierer for danske virksomheders ressourceeffektivitet*, NIRAS A/S, Allerød. Available on<https://groenomstilling.erhvervsstyrelsen.dk/sites/default/files/media/rapport_niras_endelig.pdf>

NISP (2009) *National Industrial Symbiosis Programme - The Pathway to A Low Carbon Sustainable Economy,* International Synergies Ltd, Birmingham. Available on <http://www.wrap.org.uk/sites/files/wrap/Pathway%20Report.pdf>

Nordland County Coucil (N.D.) *Introduction to Nordland*, Nordland County Coucil. Available on<https://www.nfk.no/_f/p34/i3e5f3b63-d682-471f-ac3c-e1fb0170cd27/introduction_to_nordland_0518_korr_1.pdf>

Nordland Fylkeskommune (N.D.) *Et nyskapende Nordland - Innovasjonsstrategi for Nordland 2014-2020*, Nordland Fylkeskommune. Available on <https://www.nfk.no/_f/p34/if7a0e349-8d24-464f-8c32-3b82d1bf11f4/vedtattft15oktris.pdf>

Norwegian Ministries (2016*) Familiar resources – undreamt of possibilities - The Government's Bioeconomy Strategy*, The Ministry of Trade, Industry and Fisheries. Available on <https://www.regjeringen.no/contentassets/5b2dc02e8dd047adba138d7aa8b4dcc1/nfd_biookonomi_strategi_engelsk_uu.pdf>

Olsson, A., Spjuth, H. (N.D.) *Research is Art,* Academy for Smart Specialisation. Available on<https://www.kau.se/files/2019-03/ENGPosterutst_Broschyr_A5_181207_LOW.pdf>

Persson, Tommy (2018*) Ett klimatneutralt och fossilbränslefritt Skåne. Klimat- och energistrategi för Skåne*, Länsstyrelsen i Skåne län, Skåne. Available on <https://www.lansstyrelsen.se/download/18.2e0f9f621636c84402734c0d/1528979328191/Klimat-%20och%20energistrategi%202018.pdf>

Region Värmland (2015) *Värmland's Research and Innovation Strategy for Smart Specialisation 2015–2020*, Region Värmland, Karlstad. Available on <https://www.regionvarmland.se/globalassets/global/utveckling-och-tillvaxt/naringsliv-forskning-innovation/vris3.pdf>

Regional Council of Lapland (N.D.) *Lapland's Arctic Specialisation Programme*, Regional Council of Lapland, Rovaniemi. Available on<http://www.lappi.fi/lapinliitto/c/document_library/get_file?folderId=1483089&name=DLFE-21423.pdf>

Republic of Poland (2019) *National Smart Specialisations*, Republic of Poland. Available on <https://www.gov.pl/attachment/ce982d48-f0c8-4532-90ef-a6094c2097b2>

SIVA (2013) *NY NASJONAL INKUBASJONSSATSING 2012-2022*, SIVA. Available on <http://v4dp610i86t3v9gxdj0cbh10-wpengine.netdna-ssl.com/wp-content/uploads/2015/03/programbeskrivelse-inkubator.pdf>

Swedish Environmental Protection Agency (2005) *A Strategy for Sustainable Waste Management: Sweden's Waste Plan,* Swedish Environmental Protection Agency, Stockholm. Available on <https://www.naturvardsverket.se/Documents/publikationer/620-1249-5.pdf>

Werner, S. (2017) District heating and cooling in Sweden. *Energy*, *126*, 419-429. Available on <https://www.sciencedirect.com/science/article/pii/S0360544217304140>

Tao, Y., Evans, S., Wen, Z., & Ma, M. (2019) The influence of policy on industrial symbiosis from the Firm's perspective: A framework. *Journal of Cleaner Production*, *213*, 1172-1187.

The Danish Government (2015) *Denmark Without Waste II - a Waste Prevention Strategy*. The Danish EPA, Copenhagen K. Available on <https://eng.mst.dk/media/164923/denmark-without-waste-ii_wasteprevention.pdf>

Thomsen, T. P, Thomsen, S.T., Lybæk, R. & Budde, T. (2019), *Maabjerg Bioenergy Center*. Unpublished draft report, RUC IMT, October 2019.

Trøndelag fylkeskommune (2017) *Et Verdiskapende Trøndelag – Strategi for innovasjon og verdiskapning i Trøndelag*, Trøndelag Fylkeskommune, Trondheim. Available on <https://www.trondelagfylke.no/globalassets/dokumenter/naring/vedtatte-versjon-14.12.2017-strategi-for-innovasjon-og-verdiskaping-for-trondelag-1.pdf>

Uddannelses- og Forskningsministeriet (2019) *Innovationsnetværk Danmark Programmet*, Uddannelses- og Forskningsministeriet, København K. Available on <https://ufm.dk/forskning-og-innovation/samspil-mellem-viden-og-innovation/viden-netvaerk-og-kommercialisering-til-virksomheder/klynger-og-innovationsnetvaerk/innovationsnetvaerk>

Vækstforum Sjælland (2015) *Den regionale vækst -og udviklingsstrategi 2015-2018*, Vækstforum Sjælland, Sorø. Available on <>

Verdung, E. (2010) Policy instruments: Typologies and theories. In: Bemelmans-Videc, Marie-Louise, Rist, Ray C, and Vedung, Evert (2010) *Carrots, Sticks & Sermons: Policy Instruments & Their Evaluation*. Fifth paperback printing, Transaction Publishers, New Brunswick, New Jersey.

Vitálišová, Katarína & Borsekova, Kamila & Blam, Inna. (2016) Industrial symbiosis in European policy: overview of recent progress. *Acta Universitatis Lodziensis. Folia Oeconomica: 2.*

13 APPENDIX

Interview Guide – BIS project partners

Introduction
PlanMiljø is carrying out a mapping of symbiosis policies in the countries represented in the BIS project. The aim of the interview is to gain insights into policies and measures promoting industrial symbiosis in your country.

Introductory questions

- Will you shortly describe how [your organisation] works with Industrial Symbiosis?

Framework conditions

- In your opinion: Does [country] in general have good framework conditions for the establishment and operation of industrial symbioses?
    - Why/why not?
- What are the main barriers?
    - Which of these should – in your opinion – be addressed by policy and how?

Symbiosis policies in [country]

- Does [country] have a national strategy for industrial symbiosis either stand-alone or as part of a wider strategy (e.g. green growth, circular economy, resource efficiency, other)?
    - What are the main objectives and actions of the IS part of the strategy?
- Are there also regional IS or IS-relevant strategies in [country]?
    - Which region(s)
    - What are the main objectives and actions of these?
- Which types of IS-relevant policy measures have been implemented at national or regional/local level? *See table below for inspiration*

POLICY TOOL CATEGORIES	EXAMPLES OF POLICY TOOLS
REGULATION	• Land-planning/zoning for industrial areas that promote IS • Environmental regulation such as emissions control • Removal of regulatory barriers • Streamlining and development of end-of-waste criteria and standardization of secondary materials • *Others?*
ECONOMIC INCENTIVES	• Taxes e.g. landfill tax, resource tax • Removal of raw resource subsidies • Subsidies for secondary resources • Funding (e.g. IS earmarked) • Removing market barriers • Green public procurement • *Others?*

RELATION BUILDING	• Establish or facilitate clusters, networks or public-private partnerships • Codes of conduct • *Others?*
CAPACITY BUILDING	• Knowledge sharing and gathering • Support research on IS • Build technical capacities • Create awareness through campaigns, talks, workshops etc. • *Others?*

- Briefly describe the policy measures which you feel have had **most** relevance. E.g. When established, who initiated them, geographical location, goal
- Have these policy measures been successful in your opinion?
    - Why/why not
      If successful:
    - What were the prerequisites for success?
    - Which supporting measures have been important for success?
    - Which stakeholders were key for the development of the successful policy measures?
    - Are the policy measures cost effective?
- Are any new policy measures under development? Which?
- Are policy measures at different governing levels (national, regional, local) coordinated?
- Which level of government has been most effective in driving industrial symbiosis in your country: National, regional or local?

Competencies

- Does [country] have the necessary competencies within the different governing levels to promote industrial symbiosis and prepare effective policies?
- Is academia (university etc.) working with industrial symbiosis?
- Do the industries have access to relevant and competent staff for the process of establishing and maintain industrial symbiosis?

Systems and structure

- Which physical systems - such as waste management system, transport infrastructure, energy distribution systems etc. - support industrial symbiosis in your [country]?
- What systems are missing/insufficient?
- Is it realistic that such systems will be developed to support industrial symbioses in the near future?

Communication/dissemination

- Are the positive effects of symbioses communicated in [country]? How, by whom?
- Is there knowledge sharing within the field? (Conferences, expert groups, articles, etc.)
- Do industrial organisations promote industrial symbiosis?

Further information

Please forward any national studies or insights on policy measures related to industrial symbiosis.

PlanMiljø
ELLEVEJ 5 ØSTRUP
3670 VEKSØ
WWW.PLANMILJOE.DK

BALTIC INDUSTRIAL SYMBIOSIS
Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND