SYMBI

Comparative analysis study of regional and national policies on industrial symbiosis and circular economy (1st version)

Project Activity: A1.1

August 2017

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1 Introduction

This paper was prepared by the Region of Malopolska within the context of the SYMBI project and, more precisely, activity A1.1. It outlines the results of a comparative policy analysis of the policies and measures that support the initiation and advancement of industrial symbiosis and circular economy in the partnership countries. The analysis was based on data collected by the SYMBI partners from the partnership countries, i.e. (Poland, Italy, Greece, Spain, Finland, Hungary, Slovenia). The Region of Malopolska further contributed to the analysis by gathering data from the rest of the European Union.

After briefly presenting some key information about the research process (research questions, data collection and data analysis principles), the paper proceeds in presenting the answers to the research questions. Throughout the data, open coding revealed that the European Union countries can be divided into three categories with respect to the level of integration of industrial symbiosis and circular economy in their development policies, i.e. those with low (Category 1 countries), medium (Category 2 countries) and high (Category 3 countries) levels of such integration. Each of these categories is characterised by distinct enablers and inhibitors of industrial symbiosis and circular economy development and, hence, different policy recommendations for the advancement of these two innovative development strategies.

And it is exactly towards developing policy recommendations that the paper proceeds in discussing after having answered the research questions. The paper first presents the key existing policies for the development and proliferation of industrial symbiosis and circular economy in the SYMBI partnership countries and then proceeds to the description of the key policy recommendations, based on the proposals of the SYMBI partners.

The paper concludes with a discussion on the dynamics of development of industrial symbiosis and a description of the potential for growth and jobs that exists if industrial symbiosis and circular economy are developed appropriately.

2 The activity

The exact object of activity A1.1 is the development of regional policies for the advancement of industrial symbiosis and circular economy through comparative analysis. What follows is an outline of the steps of the activity.

Step 1: Methodology development. In semester 1, Malopolska develops the methodology that will enable partners to monitor, document, and peer review policies at regional and national level on the following:

a) Industrial symbiosis
b) Secondary raw material regulation
c) Relevant circular economy initiatives.

Step 2: Data collection and analysis. In semester 2, after receiving the methodology, all partners will gather data and provide input on regional and national policies in their own countries, whereas Malopolska will investigate policies in European Union countries without a SYMBI partner. SYMBI partners will provide the conclusions of their research in the form of input papers that will be peer-reviewed among them.

Step 3: First policy overview and recommendations. In semester 2, Malopolska will use the input papers and peer-review forms to synthesise, analyse, and compare partners' input & data gathered to develop a policy overview and recommendations to:

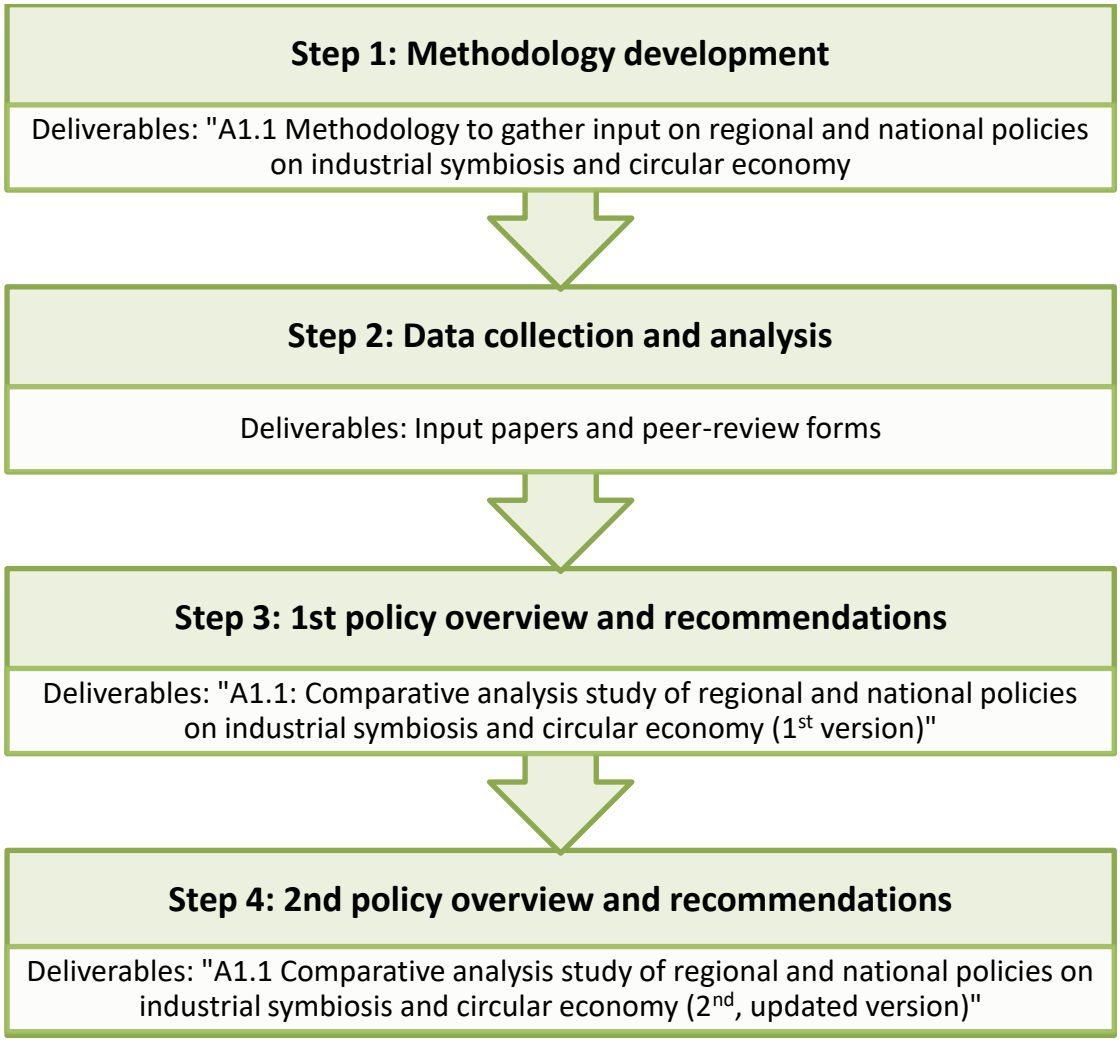
a) Understand the dynamics, potential for growth and jobs, inhibitors and policy obstacles related to industrial symbiosis

b) Integrate effective practices for the improvement of policy instruments.

All other partners will provide suggestions & feedback through peer-reviewing.

Step 4: Second policy overview and recommendations. In semester 5, Malopolska will update the study on regional and national policies, to include developments on the continuously maturing topic of circular economy and to provide up to date input for the development of the SYMBI action plans, based on the emerging developments in each

region/country of the SYMBI partnership that took place within the "EU action plan for the Circular Economy" framework).



3 Overview of the research

3.1 Research questions

SYMBI A1.1: Comparative policy analysis: Research questions	
1	What is the state of development of industrial symbiosis and circular economy in your region? Which are the most important enabling and constraining factors to this development?
2	Which are the most important policies used to further strengthen the impact of enabling factors and facilitate the development of industrial symbiosis and circular economy in a) European state members and b) your region?
3	Which are the most important policies used to reduce the impact of constraining factors and facilitate the development of industrial symbiosis and circular economy in a) European state members and b) your region?
4	Which policies designed to support industrial symbiosis and circular economy have been applied repeatedly in more than one region or country and have proven to be successful?

3.2 Data collection methods

Data collection followed a rigidly defined approach using specific data collection methods that provided sufficient data for answering these questions. The data collection was divided in the following three parts:

- **Part 1** (semester 1) consisted of data collection within the region and the country of each SYMBI partner. Each member of the SYMBI consortium gathered from his own region and country data capable of answering the research questions listed in the previous section.
- **Part 2** (semester 1) consisted of gathering suitable data from EU members that are not represented in the SYMBI consortium, and was conducted by Malopolska.
- **Part 3** (semester 5) consists of updating the data collected in parts 1 and 2, and using them to update and prepare the second version of the deliverable "A1.1 Comparative analysis study of regional and national policies on industrial symbiosis and circular economy". Part 3 will be conducted during semester 5.

The basic method SYMBI partners used to collect data was secondary desk research. The main reason why desk research was chosen as the basal part of the investigation had to do with the fact that it is an efficient and cost-effective way to capitalise on already existing knowledge which does not require specialised personnel. Thus it made easy the collection of all the relevant information about the supportive to industrial symbiosis policies. The fist source of data consisted of documents available online retrieved from external desk research. This source of data will be used throughout the three parts of data collection. The second source of data was the internal documents of the SYMBI partners. This source of data was utilised only in part 1 of this research.

3.3 Data analysis methods

Data analysis was based on the open coding method. Open coding is a type of data analysis that is not guided by researchers' theoretical assumptions, but by the data per se. Researchers do not chose to pick and code the patterns that fit their own theoretical assumptions, but on the contrary they have to identify, note and code all patterns that emerge from the data, even if they contradict the researchers' assumptions. To achieve this, they do the following:

a) Read through the data several times
b) Start creating tentative labels for chunks of data that summarize the phenomena described therein (not based on existing theory - just based on the meaning that emerges from the data)
c) Step (b) leads to the development of a simple system of codification for the patterns that they found.

After collecting data up to the point of saturation, i.e. up to point where more research does not provide data with significantly different additional information, researchers have to assemble all data in the same form, i.e. as a document. After assembling all data, researchers have to read through them several times and then start to match similar data and create categories for chunks of data that summarise various policies for the support of industrial symbiosis and circular economy (or the reasons for the absence of such policies). SYMBI partners had to find and provide examples that best represent the characteristics of various policies to support industrial symbiosis and circular economy.

4 Results

The main pattern that emerged from the data revealed that countries of the European Union can be divided in the following three categories in terms of the state of development of industrial symbiosis:

1. Countries with a relatively low level of development of industrial symbiosis, where the latter's integration in development planning is in its first steps. Among the countries of the SYMBI partnership, Italy, Greece, Hungary, Slovenia and Poland belong in this category.
2. Countries with a medium level of development of industrial symbiosis, where the latter has been integrated in development planning, without, however, having developed to its full potential. Among the countries of the SYMBI partnership, Spain belongs in this category.
3. Countries with a high level of development of industrial symbiosis. Industrial symbiosis is regularly included in development planning and it has realised its true potential at least in some economic sectors. Among the countries of the SYMBI partnership, Finland belongs in this category.

Nevertheless, this typology is not rigid: there is great diversity in terms of the qualitative characteristics of industrial symbiosis and circular economy development within each category. This diversity is explored below:

4.1 Research question 1

4.1.1 State of development of industrial symbiosis and circular economy in category 1 countries

A common characteristic among these countries is that they have included industrial symbiosis in their development planning under the guidance of the European Union, and, more specifically, the Circular Economy Action Plan[1]. However, this does not mean that there were no environmental concerns in the development planning of these regions before this action plan. There were environmental considerations in the development plans of these countries, especially in terms of waste management. As a result, it is possible to conclude that the absence of plans for the integration of industrial symbiosis and circular

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

economy does not imply that there were no environmental considerations within public authorities in these countries. On the contrary, what can be confirmed is the relative slow pace of innovation adoption in the public authorities of these countries. Fortunately, these countries' integration in the European Union institutions signifies an increase in the adoption of innovative development planning, at least in terms of incorporating industrial symbiosis and circular economy. The contemporary level of development of industrial symbiosis in each of these countries is summarised in the following paragraphs:

Italy and the Region of Molise

In Italy, circular economy and industrial symbiosis became priorities for the Italian Gorvernment only after a) the adoption on behalf of the National Senate Environment Commission of a resolution on Circular Economy on July 30 2015, and b) the adoption of the national Law n.221/2015, namely the "Environmental provisions to promote Green Economy measures and to contain the excessive use of natural resources". The former proposed a road map for the development of circular economy that outlines the following step in order to strengthen the efficient use of resources in Italy. The road map outlines the steps to achieve the following:

- to promote Industrial Symbiosis models and Eco-innovation
- to stimulate a market for byproducts and quality recycled materials through a wider use of green public procurement;
- to promote consumer awareness through clear and credible Eco-labels
- to implement a wide environmental tax reform;
- to preserve and to stimulate Italian SMEs international competitiveness;
- to review waste legislation, increasing attention on prevention;
- to promote recycled products quality and traceability.

The latter established several measures (Green Public Procurement, environmental footprint for products called Green Made in Italy, post-consumer materials and scraps recovery, waste management, composting and used packaging), with a clear vision: to strengthen the protection of the environment and to push the Green Economy, in the Circular Economy direction, where each waste is considered as a resource, in a circular and closed cycle.

These regulatory measures are significant, however at a national level there is still the absence of a formally adopted plan that aims exclusively at the Industrial Symbiosis and Circular Economy implementation.

At the regional level, the Region of Molise still has a long way to go towards the integration of industrial symbiosis in its development strategies. In general, the absence of a policy dedicated to the topic was recorded: no regional law was adopted to cover the topic of Industrial Symbiosis or Circular Economy. To initiate, support and advance industrial symbiosis projects, territorial public authorities can use other axes of the Molise ROP 2014-2020 that cover the issues of technological development and innovation, and productive system competitiveness.

Greece and the Region of Western Macedonia

The state of development of industrial symbiosis in Greece is quite similar to the one in Italy described above. Industrial symbiosis projects are rare and, in general, industrial symbiosis as a concept is not well known among regional authorities that do not include it in their development strategies. A good example is the Region of Western Macedonia that has not included industrial symbiosis in its Special Development Programme (SDP).

Similarly, usually Greek industries usually do not take advantage of opportunities to develop industrial symbiosis. There have been, however, important exceptions to this rule, such as the successful development of industrial symbiosis among cement and aluminium industries in the Thriasion field[2].

Nevertheless, recent changes in the National Waste Management Plan[3] and the National Prevention Plan for the Generation of Waste[4] have rendered, since 2014 and 2015 respectively, industrial symbiosis one of the sustainability targets of the Greek state. Developing industrial symbiosis will be a key target of the Greek state for the foreseeable future in order to sustainably prevent and manage industrial waste. This inclusion however, does not reduce the need for a holistic plan dedicated to industrial symbiosis and circular economy.

Slovenia

Industrial symbiosis (IS) and circular economy (CE) are relatively new concepts in Slovenia which are now being addressed and explored by different stakeholders (NGO, companies, public sector and others). Relatively few companies in Slovenia can claim that they are

[2] http://environ.chemeng.ntua.gr/gr/Default.aspx?t=189
[3] http://www.ypeka.gr/LinkClick.aspx?fileticket=xX4ZEfaIJVk%3d&tabid=238&language=el-GR
[4] http://www.ypeka.gr/LinkClick.aspx?fileticket=2Y2%2b%2bPSM4P0%3d&tabid=238&language=el-GR

involved in industrial symbiosis. This can be proved by one of SVRK's SYMBI survey, made in 2016, where 60% of companies and 85% of public sector are not familiar with the concepts. Both concepts have been promoted mainly by civil society organisations and—to a lesser extent—by the public sector through the organisation of seminars, conferences, trainings, producing brochures, leaflets, on-line campaigns etc. Hence, there is thus still much to be done on the level of raising awareness among relevant stakeholders, drafting appropriate policies and regulations for surpassing the remaining obstacles and to strengthen already existing leverages.

Slovenia does not have dedicated strategic documents on industrial symbiosis and/or circular economy. Both concepts are encompassed and addressed in other regulatory documents, but without an introduction or explanation about the concepts. SVRK has been working on addressing these two concepts on a national level and in cooperation with the Ministry of Environment and Spatial Planning (MESP) and the Ministry of Economic Development and Technology for over 5 years. It is worth mentioning that in 2014 the MESP published a study[5], where Industrial Symbiosis and Circular Economy are described as two potential driving forces for sustainable development, better industrial development and environmental solutions. Moreover, in 2016, the Government of Slovenia adopted the Programme for Waste Management and Programme for Waste prevention[6], where it is stated that the transition to a circular economy cannot be considered anymore only a vision, but a need. In addition, the programme exposes the industrial symbiosis as one of the concepts how to reach the circular economy. For the time being, circular economy, industrial symbiosis and secondary raw materials regulation are promoted by the following documents:

- Circular economy and industrial symbiosis are included in the targets of Slovenia's Smart Specialisation Strategy S4[7] and in the Slovenian Operational Programme for the Implementation of the EU Cohesion Policy 2014-2020[8].
- The Government of Slovenia[9] set four thematic priorities for Slovenia in its mandate 2014–2018, among which is the ***Transition to green economy***, which advocates the concept of circular economy.

[5] "Resource efficiency: Towards Slovenian Action Plan"
[6] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/medijsko_sredisce/2016/06_Junij/30_Program_odpadki/16_06_30_Program_odpadki_ravnanje_preprecevanje_cistopis.pdf
[7] http://www.svrk.gov.si/fileadmin/svrk.gov.si/pageuploads/SPS_predstavitve/S4_dokument_2015_october_eng_clean_lekt.pdf
[8] http://www.eu-skladi.si/sl/dokumenti/kljucni-dokumenti/op_ang_final_web.pdf

- The Governmental Programme for Waste Management and Programme for Waste prevention[10] initially exposes the need for developing new business models for a transition to circular economy.
- The Slovenian Operational Programme for the Implementation of the EU Cohesion Policy 2014-2020[11] is referring to industrial symbiosis only once, when urging the need for transition to a circular economy.
- The Programme for Waste Management and Programme for Waste prevention[12] suggests that companies use some new business models when dealing with the waste management, e. g. industrial symbiosis. For this purpose, in 2015 the MESP supported the project of setting up the platform for industrial symbiosis (*page 241*).
- The Government of the Republic of Slovenia adopted in 2013 the Slovenian Industrial Policy[13] document, whose aim was to set priorities of industrial development and economy for the financial perspective 2014-2020. Industrial symbiosis is pointed out only at one place, namely in section 3.3.1 Environment-energy challenges and smart use of natural resources.

Despite these advances, at the moment a systemic approach in these two areas has not yet developed. As a result, surveys have shown that 66% companies were not familiar with the concept of industrial symbiosis, but, when introduced to it, 67% of them expressed their willingness to implement and support it. This shows a great interest and readiness among companies to introduce such concept if they had more information. In fact, due to the absence of a strategic frame / regulation for industrial symbiosis on a national level, this concept is being explored mainly by companies and in recent years also by CSOs and agencies of the public sector (ministries, municipalities and regional development agencies).

Poland and the Malopolska Region

Circular economy and industrial symbiosis are relatively new concepts in Poland. As a result, despite the fact that Poland has already had a development strategy that took into account environmental considerations, especially in terms of waste management (the first Polish law

[9] http://www.vlada.si/teme_in_projekti/prehod_v_zeleno_gospodarstvo/ukrepi/trajnostno_upravljanje_z_viri/
[10] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/medijsko_sredisce/2016/06_Junij/30_Program_odpadki/16_06_30_Program_odpadki_ravnanje_preprecevanje_cistopis.pdf
[11] http://www.eu-skladi.si/sl/dokumenti/kljucni-dokumenti/op_ang_final_web.pdf
[12] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/medijsko_sredisce/2016/06_Junij/30_Program_odpadki/16_06_30_Program_odpadki_ravnanje_preprecevanje_cistopis.pdf
[13] http://www.mgrt.gov.si/fileadmin/mgrt.gov.si/pageuploads/DPK/SIP/SIP_-_vladni_dokument.pdf

concerning waste management was enacted in June 1997, and came into force on January 1 1998), there is still no specific plan for the development of industrial symbiosis and circular economy.

Nevertheless, in Polish industrial sectors there are many solutions fitting the idea of circular economy and industrial symbiosis. Most often these are private sector-led solutions in which economic profit was the reason to choose industrial symbiosis. Many Polish enterprises, since decades reuse their waste and improve resource efficiency such as ZGH “Bolesław”, a Małopolska metallurgy plant which developed an innovative technology allowing to recapture deposits of zinc and lead from a mining waste dump. There are also other facilities which reuse water, mainly for cooling purposes to minimise raw water intake and wastewater discharges.

However, these efforts of the private sector are hindered by the lack of awareness at the societal level about sustainable consumption. The conviction about the real impact of consumers on the environment in which they live and on the quality of life of present and future generations is also poor. Unfortunately, the price is still a decisive factor when taking consumer choices. Meanwhile, consumer choices are one of the most important instruments of our impact on the environment.

Hungary and West Transdanubia

Hungary does not yet have a specific plan for the promotion and support of industrial symbiosis and circular economy projects. Despite the fact that sustainable lifestyle and consumption was promoted in the 2007-2013 period, through the allocation of siginificant amounts of funding to local, regional and national campaigns and sample projects, sustainable development has been pursued systematically basically through the implementation of the EU 2020 Strategy aiming at intelligent, sustainable and inclusive growth in the form set out in the Partnership Agreement. The European Union Strategy aims to advance economic growth built on sustainable, high value added production and an extension of employment, and is based on the 2005 UN General Assembly resolution, confirming the 2000 Millennium Declaration, identified three closely interrelated and interdependent dimensions of sustainable development: economic, social and environmental.

Specifically in Hungary, the EU2020 Strategy is implemented through the interventions of Environment and Energy Efficiency Operational Programme (EEEOP) that primarily and directly aims to strengthen the environmental dimension of sustainability, yet, indirectly, to

contribute to advancing economic growth as well. EEEOP includes policies and priorities that are very close to the goal of advancing industrial symbiosis, secondary raw material regulations and circular economy, especially with regards to the improvement of waste management and resource and energy efficiency policies in Hungary.

Similarly to Poland, industrial symbiosis development in Hungary is hindered by the lack of awareness at the societal level. This is the reason why the awareness raising strategy of the EEEOP aims at large groups of society, and mostly the most receptive category, children, where the results can be actually measured in the behavioural change.

Other European Union countries

This category includes countries such as the Czech Republic and Croatia which have since 2004 and 2013 respectively adopted all European Union legislation, including the Circular Economy Action Plan. The main challenge now is the implementation of the legislation in order to reach their national targets. On July 13 2015, the Czech government approved an Action Plan to support the increase in the self-sufficiency of the Czech Republic in raw material resources by substituting secondary raw materials for primary resources. The main constraining factor for the implementation is to change habits and the most important enabler is the businesses' need to abide by the new legislation and the adoption of national recycling targets.

4.1.2 State of development of industrial symbiosis and circular economy in category 2 countries

This category includes Spain from the SYMBI partnership, and several other countries such as Ireland, Belgium, and France.

Spain, Andalusia and Extremadura

Industrial symbiosis and circular economy have been integrated to development planning in Spain to a larger extent compared to the countries in the previous category. In fact, there is a wide range of national and regional strategies or action plans for material resource efficiency advocating a transition towards circular economy and symbiosis-driven industries in Spain. Among its territories, Catalonia and Basque Country Autonomous Communities

seem to have given greater impetus in the process of moving towards industrial symbiosis. Andalusia has also integrated the circular economy in its strategic documents and developed successfully industrial symbiosis and circular economy projects, especially with regards to the following industries:

- Sustainable chemical industry (biomass, agricultural waste management, fertilisers)
- Agri-food
- Construction
- Forestry
- Power generation (biodiesel).
- Smart cities

The development of industrial symbiosis, secondary raw material regulations, and circular economy in Extremadura are in an early stage. Due to the fact that the traditional economy is based on the agriculture, there are regional examples of circular economy in the traditional activities of this sector. Extremadura has managed to preserve its environment and natural resources as a basis for its future development. That factor positions the region as one of the EU territories with a greater potential for circular economy development.

The achievements of both regions have contributed to the increase in Spain's eco-innovation potential. Spain is currently ranked number 9 in the EU Eco-innovation Scoreboard 2015. The country's strongest performance remains in eco-innovation activities. It stands slightly above EU average when it comes to eco-innovation outputs (patents, academic literature and media contributions). Spain ranks above average with regards to resource-efficiency outcomes, i.e.:

- Material productivity (GDP/Domestic Material Consumption)
- Water productivity (GDP/Water Footprint)
- Energy productivity (GDP/gross inland energy consumption)
- GHG emissions intensity (CO2e/GDP)

In addition, Spain's performance is higher than average in terms of socio-economic outcomes:

- Exports of products from eco-industries (% of total exports)
- Employment in eco-industries and circular economy (% of total employment across all companies)
- Revenue in eco-industries and circular economy (% of total revenue across all companies)

Despite these achievements; however, Spain still shows a relatively low level of R&D intensity.

Spain's success in the domain of eco-innovation is largely due to a mix of first and second-generation policies and measures of support, addressing technologies and resources for energy efficiency and pollution control. Eco-innovation is generally embedded in national and regional policies targeting resource efficiency, environmental innovations, clean technologies and sustainable development. The National Plan for Waste Management 2016 – 2022 sets up a new framework for replacing the traditional, linear "take, make & dispose" model and lead the transition towards a more circular economy in Spain, where products are designed for ease of recycling, reuse, disassembly and remanufacturing.

Furthermore, remanufacturing has generated sales of near 30 million € in the UE and 190 thousand jobs in 2015. 5% of this turnover comes from Spanish companies (6% of the total employment dedicated to the remanufacturing). In 2030 it is expected that remanufacturing in the EU will generate annually up to 98.9 million Euros and employ up to 587 thousand people, which is more than 200% growth. At Spanish level, this would mean more than 3.3 million Euros with a contribution to the economy of 4.8 million Euros.

The combination of regulation and technology innovation has led to more efficient resource use and lower emissions per good produced in Spain. According to a recent study conducted by the Club of Rome (*The Circular Economy and Benefits for Society*), Spain has moved towards a relative decoupling in its energy use. Together with a modest increase in the share of renewables in the energy mix, energy-related carbon emissions have eventually started to come down.

The above-mentioned study predictions for Spain state that up to 2030, expected results for decoupling resource consumption from GDP (enhancing energy efficiency, increasing the percentage of renewable energy in the energy mix and organising manufacturing along the lines of a materially-efficient) and the transition towards a circular economy are clear:

- Carbon emissions are likely to be cut by almost 70%
- The number of additional jobs would exceed 400 thousand in Spain and the unemployment rate is likely to be reduced from a bit above 20% to somewhere close to 15%
- The improvement in the trade balance would be around 1.5% of GDP, representing 20 billion euros

Finally, thanks to its successful mix of policies, in 2016 Spain averaged an impressive 47.2% renewable energy share in its generation mix: wind power (21.8%), hydroelectric (17.8%), solar PV (3.4%), solar thermal (2.4%), other (1.8%).

Other European Union countries

- **Ireland** is still making progress in the development of circular economy with special focus at food waste prevention and resources efficiency and exchange by creating synergies and industrial symbiosis. Ireland recycling level gives them 11th place in EU-28 with 36% recycling from municipalities. One of the biggest problems of Irish circular economy is the high level of landfilling (53%)[14]. While Ireland incinerates only 4% of municipal waste, it could create a proper circular economy model if the waste stream directed to landfills descreases.
- **France** has reported many ambitious targets in their circular economy related policy announced by the President of the French Republic in The Energy Transition for Green Growth Act (2015). Since Paris is hosting COP 21, France must be able to tell the other developed countries and the new emerging powers that they can follow France in many environmental and industrial cases. Words of the French President shows that the government is aware of its strengths and weaknesses with a extremely balanced ratio of recycling/incineration/landfill - 35%/34%/31%[15] .
- **Belgium** has got high potential to become a circular economy country. Due to the ban on municipal waste landfill, only 1 % or less waste is being disposed of by this method since 2010. The recycling level has reached 58% in 2013 (3th place in EU).

[14] http://eng.mst.dk/media/mst/Attachments/Ressourcestrategi_UK_web.pdf - page 21
[15] http://eng.mst.dk/media/mst/Attachments/Ressourcestrategi_UK_web.pdf - page 21

4.1.3 State of development of industrial symbiosis and circular economy in category 3 countries

This category includes Finland from the SYMBI partnership, and several other countries such as the Netherlands, Sweden and, of course, the pioneer of circular economy and industrial symbiosis.

Finland

Finland has already come a long way towards putting in place circular economy practices in many sectors of the country's economy. Examples include improved energy efficiency in the paper industry, bottle recycling, flea markets and efforts made by forestry sector in the development of new products. Simultaneously, Finnish actors are increasingly considering industrial symbiosis as a means to promote cross-sectoral collaboration and to support local and regional growth, create jobs and foster industrial clusters that share a mutual interest in resource efficiency. In Finland, industrial symbiosis is considered to advance and contribute to the wider goal of a circular economy as a whole.

According to a survey conducted in 2013 by Sitra – a key Finnish organization advocating green growth – circular economy represents an opportunity for Finland worth 1.5 to 2.5 billion EUR. Despite its small size, Finland is in a good position to thrive in the face of global competition. Advantages such as its high education levels, good technological expertise and strong reputation as a clean-tech operator are also fundamental to its success in the field of circular economy andindustrial symbiosis. However, there is still room for the further enhancement of circular economy activities and industrial symbiosis in the country before the desired extensive, systemic change will be achieved: only 54% of all waste in Finland is recycled or reused in any way, and, similarly, few innovative service concepts concerning the maintenance, reuse or remanufacturing of equipment have emerged.

The drive for the development of industrial symbiosis in Finland is based on both societal and commercial factors. Societal support arises from the need to establish new pillars for the national economy, to create versatile, internationally competitive industries and to use resources in a more efficient manner. Simultaneously, an enhanced system of industrial symbiosis holds potential for extended Finnish business opportunities and commercial gains on the global market. High education level among citizens increases the awareness of environmental issues and thus creates demand for new kinds of solutions. Systematical land

use planning enables the proximity of industries which is seen as prerequisite for creating newindustrial symbiosis.

However, the Finnish operative environment for circular economy development contains many challenges to overcome. The existing or prospective symbiosis and circular economy opportunities generally go unrecognized, and cross-sectoral co-operation is often too weak to generate the preconditions for symbiotic activities. Simultaneously, there is a lack of the demonstration activities and venues required to generate and disseminateindustrial symbiosis-related knowledge and good practices. Even though activities and businesses related to industrial symbiosis and circular economy are increasingly attracting attention and finance in Finland, there is still a lack of substantial private (risk) finance directed toindustrial symbiosis- and resource efficiency-focused activities. This consequently affects the growth and internationalization potential of domestic SMEs and their capacity to engage in symbiotic ventures. Thus, there is a need to produce innovative industrial business models between companies, to support the commercialization ofindustrial symbiosis- and efficiency-focused activities and to remove barriers currently paralysing the operational environment for industrial symbiosis enhancement. The Finnish market is small and therefore the opportunities are limited for enterprises to increase their reference list.

Moving on from Finland as a whole to the Häme region, it is safe to say that industrial symbiosis and circular economy have so far developed significantly. This is due to the strict requirements in waste management (high 'gate fees' in solid waste disposal sites, high targets in reusing materials, no bio waste allowed in disposal sites, etc.) and the presence of a couple of innovative companies (mainly Ekokem, Envor Group) in the region. Industrial symbiosis and circular economy in Häme are among the most developed in Finland. Nevertheless, most projects are still quite local, with the exception of large scale industrial symbiosis in the area of Forssa and the strong effort to develop something similar in the area of Riihimäki. All in all, there are huge possibilities to develop industrial symbiosis in Häme (e.g. there is a lot of available biomaterial in the centre of densely populated and industrialized South-Finland); however, these depend on the improving the awareness of the inhabitants of these areas about these projects.

Other European Union countries

Denmark is the pioneer of industrial symbiosis in Europe that started in Kalundborg.

Kalundborg Symbiosis is the world's first working industrial symbiosis. The symbiosis has been viewed an industrial ecosystem, where the by-product residual product of one enterprise is used as a resource by another enterprise, in a closed cycle. An industrial symbiosis is a local collaboration where public and private enterprises buy and sell residual products, resulting in mutual economic and environmental benefits. In the development of the Kalundborg Symbiosis, the most important element has been healthy communication and good cooperation between the participants. The symbiosis has been founded on human relationships, and fruitful collaboration between the employees that have made the development of the symbiosis-system possible[16].

Denmark has instituted the **Symbiosis Center Denmark**, that uses industrial symbiosis as a tool to create sustainable value growth in companies and in society through green conversion. Industrial symbiosis is considered a mindset and a set of methods that combine the logic of natural ecosystems with industrial production and partnerships.

Symbiosis Center Denmark paves the way for symbioses, and through partnerships and projects has created results in several areas. For example, we assisted in a resource check of more than 500 companies. This resulted in more than 170 symbiosis matches and formed the basis for establishing industrial symbioses. The Center was also involved in developing the model that ranks industrial parks and their opportunities for symbioses. The work at Symbiosis Center Denmark does not merely involve the promotion of symbioses in large, heavy industries. There is a great pent-up potential in small and medium-sized companies, where job creation occurs to a great degree[17].

Beyond the Symbiosis Center, the programme Green Industrial Symbiosis, which ran from 2013-2015, was aiming at promoting competiveness and resource efficiency through symbioses. There are great financial and environmental benefits for businesses that take part in symbiosis collaborations. Many Danish businesses have already established or are currently developing green industrial symbioses.

The Netherlands' policy aim is to combine raw materials policy with waste management policy, together leading to a policy on circular economy. The effort to turn waste into resource was further promoted by the circular economy programme From Waste to

[16] http://www.symbiosis.dk/en

[17] http://www.symbiosecenter.dk/en/the-process/

Resource, published in 2014, which formulated specific measures to enable the transition from a linear to a circular economy. Therein, the Dutch public authorities outline all the necessary steps for reducing the waste that is not used as a resource to an absolute minimum: sustainable sourcing, circular design and production, sustainable consumer behaviour, waste prevention and better recycling of what waste there is. More precisely, the programme has three objectives:

- keeping our natural capital vibrant;
- improving the security of supply;
- reinforcing the earning power of the Dutch economy.

These objectives can be neither considered nor achieved independently of each other. Economic growth, employment and competitiveness are tied to keeping the natural capital vibrant. This scope encompasses the sustainable extraction of raw materials, making circular services and design, production and consumption, and finally – because there will still be waste for some time to come – the programme also focuses on the waste stage. Furthermore, nine operational goals are defined in the programme:

a) identify, sustainably manage and utilise natural capital;

b) focus the design and development of products on circularity;

c) increase and disseminate knowledge about the circular economy and make it practicable;

d) encourage resource-free business operations;

e) turn chains into cycles;

f) develop financial and other market incentives;

g) make consumption and procurement circular;

h) gear waste policy to the circular economy, and improve waste collection and recycling;

i) develop indicators and metrics that quantify the transition to a circular economy.

Sweden has shown strong commitment to environmental protection initiatives and policies, particularly in the area of waste. Already by 1969, The Environment Protection Act imposed far-reaching environmental obligations on new waste treatment facilities. Several regulations came into force during the 1990s, including the increasing importance of producer responsibility and a concentrated effort on measures to reduce the landfilling of waste. The Environmental code of 1999, replacing the previous Environmental Protection Act, integrated 15 previously existing environmental laws and formed an umbrella legislation governing all environmental impacts within the framework of a sound sustainable development for Sweden. In 2005, Sweden's Waste Plan 'A Strategy for Sustainable Waste Management' laid down the future direction of waste management and set distinctive targets to be met by 2010, based on the Swedish Environmental Objectives which were enacted by the Swedish government in the same year (SEPA, 2005).

Germany could play a pioneering role internationally by showing how it is possible to increase recycling and resource efficiency in a highly developed industrialised country without sacrificing prosperity and thereby reduce resource consumption. Germany is already demonstrating this, reducing resource consumption while economic output is increasing: whereas economic growth rose sharply during the period 2000 to 2010, resource consumption fell by 11.1%. In 2010 Germany took second place after Austria in achieved recycling level (62%) and eliminating landfilling of municipal waste.

Austria occupies the first place from all EU countries in the level of recycled waste collected from municipalities (Recycling 70%; incineration 29%; landfill 1%)[18] which is also the best ratio between recycling level and other forms of waste processing. This fact shows that the development of industrial symbiosis, secondary raw material regulations and circular economy is very advanced.

4.1.4 Enabling and constraining factors of industrial symbiosis and circular economy development

The following table summarises the enabling and constraining factors of the countries and regions that participate in the SYMBI project. The factors listed below also apply to other European Union countries and regions with a comparative level of development of industrial symbiosis and circular economy.

[18] http://eng.mst.dk/media/mst/Attachments/Ressourcestrategi_UK_web.pdf - page 21

Enablers and inhibitors of industrial symbiosis and circular economy development	
Spain- Region of Andalusia and Extremadura	
Enablers observed at a national level:	**Inhibitors observed at a national level:**
• Use of voluntary agreements as a strategic tool to go beyond legal commitments • Development of non-legal standards to help producers with greener products to differentiate them • Measures supporting extended producer responsibility (EPR) for materials and/or products • Regulation compliance at all levels with EU and National plans • Existence of a complete set of strategies, policies and programmes designed at neutralising the environmental impact of the economy • Desire to increase competitiveness • Securing the supply of raw materials and energy • Reducing dependence on imports • Financial savings • Building resource efficiency related skills and capacity for innovation and support for entrepreneurial activities • Achieving lower pressures on the environment. • Importance given to the green economy, green jobs and the transition of the economic model to a resource-efficient and more	• Lack of other measures such as support for industrial symbiosis, providing targeted resource efficiency information and advice, improving financing, and other non-legislative support measures. • No specific strategy or action plan on resource efficiency in Spain. • Lack of time and capital and qualified human resources in companies • Lack of knowledge about the opportunities for symbiosis development • Lack of demonstration activities • Regulation and taxes • Weak cross-sectoral cooperation • Need to introduce innovative industrial business models (e.g., sharing economy models, and businesses using waste stream flows as process inputs) • Lack of information and platforms to support company interaction around a symbiosis • Lack of a strategy for circular economy or industrial symbiosis at a national and regional level • Consumers and businesses' reluctance to more efficient service-oriented business models;

environmentally friendly one.

- Structures providing long-term and consistent support frameworks, enabling public authorities collaboration with business and NGOs to integrate eco-innovation in products design
- Recognition of natural limits and systems boundaries (material, water, energy reduction)
- Application of methods and indicators for measuring and monitoring progress (social, economic and environmental)
- New consumption modes and lifestyles (underpinned by greater awareness)
- Raising the environmental awareness of the population and public realisation of the potential for economic growth in the green economy sectors.
- Spain is rich in resources such as renewable energy (hydro, wind, solar and biomass), agri-food and raw materials.

Enablers observed at a regional level (Andalusia):

- Capacity to create industrial enterprises
- Large number and wide range of companies
- Large dimension of the internal
- Availability of investment capital
- Capabilities for developing and disseminating knowledge

Inhibitors observed at a regional level (Andalusia):

- Low industrial density
- High failure rate of businesses
- Relatively small scale of most businesses
- Low openness to innovation and cooperation
- High concentration in regional market
- Lack of exporting companies
- Potential not fully exploited for investment

Inhibitors observed at a regional level (Extremadura):

- Low industrial density
- Economy based on one sector (agricultural)
- Lack of a strategy for circular economy or industrial symbiosis (document at regional level under development)

market • Intensifying presence in the most important markets outside Andalusia **Enablers observed at a regional level (Extremadura):** • Smart specialisations around green economy • Preserved environment and natural resources. • Examples of circular economy in the traditional activities in the agricultural sector	
Greece – Region of Western Macedonia	
Enablers observed at a national level: • Start of the introduction of industrial symbiosis in national development planning. **Enablers observed at a regional level (Western Macedonia):** • Western Macedonia is the energy production centre of Greece • Abundance of well-trained industry personnel • Improved and fast access to industrial areas due to the Egnatia highway • Existence of University and Research institutions in the area.	**Inhibitors observed at a national level:** • Lack of the necessary infrastructures for the realization of industrial symbiosis projects • Lack of assessment of the impact of waste management from Environmental Impact Studies which makes more difficult the identification of measures for its improvement in terms of sustainability. • Untrained public authorities' personnel. • Lack of planning for the utilisation of byproducts **Inhibitors observed at a regional level (Western Macedonia):** • Industrial symbiosis projects are rare • Industrial symbiosis as a concept is not well known among regional

	authorities. • Industrial symbiosis is not included in the development priorities of the Special Development Programme (SDP) of the Western Macedonia Region.
Italy – Region of Molise	
Enablers: • The increasing demand for green goods and services by consumers recorded in Italy. • Good ability of Italian SMEs to work in networks and in cooperation with other organizations. • The Italian recycling sector resilience to the last prolonged economic recession: it remained competitive despite the crisis and it recorded high growth margins. • Economic benefits arising from the by-products reuse: the disposal costs reduction and the consequent turning of this cost category into profit. • A good national regulatory framework fostering Green Public Procurement. • The Italian SMEs spontaneous orientation to Green Economy as response to the economic crisis, despite the lack of measures in support of that. • An already diffused attention to the Environment and to the efficient use	**Inhibitors:** • Critical issues related to waste legislation (waste vs byproduct) and application of various special definitions of byproduct: different according to the several local authorities (regions, provinces, municipalities) and regulatory agencies (health and inspection authorities, the police authority..). • Critical issues related to the implementation of waste legislation at local level. • Regional heterogeneity concerning tools use, such as program agreements that facilitate the management of by-products and industrial wastes. • Lack of a multi-annual strategy with long-term objectives, including concrete tools that can support business investment. • Scarce public investments in research. • Lack of confidence on byproducts quality. • Lack of a standardized methodology

of resources among citizens, SMEs and public authorities.	reproducible in different areas. • The excessive managerial short-term orientation concerning the feasibility assessment and the return on investment evaluation (managerial myopia). • Missing or erroneous communication between Research and Industry.
Finland – Region of Häme	
Enablers: • Companies can avoid extra costs (gate fees and similar) and get more revenue by using recycled components / raw materials • New business possibilities arising in logistics, in refining raw material from waste, in designing machines, etc. • General policies in EU and nationally supporting circular economy • Education and research institutes (HAMK, Luke) are situated in the region and working in many projects supporting industrial symbiosis and/or circular economy • Land use planning in municipalities is mostly done in the way that companies benefitting from each other can be located in same areas • Infrastructure (roads, railways, power grids, ICT grids) in relatively good condition • According to their strategies, public	**Inhibitors:** • Low level of awareness of possibilities among industry • Quite often we come across some resistance against changes • Lack of resources (money, man power) in innovation work • Some constrains in legislation also (how the second hand products are allowed in projects, what is the definition of waste versus side product) • Sometimes the price of virgin raw material is so low that reuse becomes economically not feasible. • If starting new business is requiring big investment (the pay back time is long) that is creating a remarkable constrain

organizations supporting business innovations financially (mainly TEKES) are having circular economy as one of the key criteria	
Slovenia	
Enablers: • Existing capabilities among firms for eco-design, eco-innovation and recycling and repair, refurbishment and remanufacture. • Economic incentives and finance. • Business models. • Public employees with skills and knowledge. • Existence of some good practices on natural resource management, knowledge and good practices of some green companies in one side, but the lack of system approaching on inter-sectoral level with the aim to stimulate material resource efficiency on the other side. • Desire to reduce Slovenia's dependence on the imports of materials. • Desire of Slovenian's companies to become more active in terms of improving the material resource efficiency. • Benefits from the creation of green jobs (sustainable local self-supply and wood chains). • Challenges on how to recognize and use the opportunities derived from	**Inhibitors:** • Absence of national regulatory frame in the field of industrial symbiosis and circular economy. • Lack of company interest, stakeholders' involvement and cooperation between the industries (related to adaptation of industrial processes). • Absence of awareness and information about the collective benefits among industry – what happens when industry enters the industrial symbiosis. • Dilemma whether there is sufficient flow of materials for Slovenian companies. • Initial investment costs before entering the industrial symbiosis and circular economy (adaptation of new business models, introducing new technologies, working processes etc.). • Lack of financial incentives for companies (closely related to absence of national regulatory frame). • Compartmentalisation of planning and implementation within

transition to green economy.

- Soft law and smarter regulation, involving the modernisation and simplification of regulations.
- Adoption of flexible standards, which provide some room for innovation and encourage the development of bottom-up initiatives, such as industrial symbiosis.
- Changes in taxation systems, with a shift from labour to material taxation.
- Fiscal measures can be implemented to incentivise repair and reuse and/or product design, e.g. incentive schemes or VAT reductions.
- Possibility for economic gains through, for instance, reduced energy and material use.
- The economic value added and business interests in reducing expenses and increasing profit.
- Strength the environmental profile of the companies and increases opportunities for innovation and access to new markets.
- Co-operation with science and technology institutions.
- Access to advanced technologies and knowledge transfer between firms and academia or researchers.
- Geographical factors and regional infrastructure as well as the local individual government agencies.
- Slovenia's highly decentralised governance system combined with only limited controls on local development.(page 3)

diversity of economic activities.

- Trust and shared norms between relevant stakeholders (policy-makers, business, research).
- Desire to create a clear, cross-departmental, consistent strategy for building a circular economy
- Aim to develop a coherent education and research plan for the circular economy
- Desire to make a comprehensive assessment of the pros and cons of existing rules and regulations regarding waste
- increase knowledge and awareness of raw materials in each value chain;
- ensure that frontrunners and others who stick their necks out receive a permanent and true advantage, for example through value chain management;
- review the effectiveness of a broad set of fiscal and financial incentives to promote circular behaviour;
- determine the impact of incineration plants on the viability of circular business cases and take appropriate action;
- develop the role of the government as an active and expert
- use the international arena to help the circular economy move forward.

Poland - Region of Malopolska

Enablers:	Inhibitors:
• Existence of waste management planning • Many Polish enterprises, since decades reuse their waste and improve resource efficiency • Existence of facilities that reuse water, mainly for cooling purposes to minimalize raw water intake and wastewater discharges. • It is mainly the result of using hard coal and lignite as a main energy source.	• Lack of integrated planning for industrial symbiosis and circular economy. • Low level of consumer awareness of Poles for industrial symbiosis and circular economy. • Poland has a relatively low waste production index per capita and also a low resource efficiency index

4.2 Research question 2

4.2.1 Category 1 countries

The main characteristic of Category 1 countries in terms of fostering the impact of enabling factors for industrial symbiosis and circular economy projects, is their efforts to speed up the development of these processes in order to bridge their gap with countries in categories 2 and 3. The measures they took to support the enabling factors are the following:

- All countries have tried to reorient their waste management plans, so as to provide more support for industrial symbiosis and circular economy. For example, Slovenia has included industrial symbiosis support in its Programme for Waste Management and Programme for Waste prevention[19].
- Poland provides support to this issue through the following:
  - Act on keeping cleanliness and order in municipalities (1996): this act obligates municipalities to create points of selective collection of municipal waste. This project was realized to protect the natural environment, improve the city aesthetics and provide an efficient way to collect reusable waste.

[19] http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/medijsko_sredisce/2016/06_Junij/30_Program_odpadki/16_06_30_Program_odpadki_ravnanje_preprecevanje_cistopis.pdf

- Waste Act (2012): The Waste act provided a definition of a by-product in the Polish law which is crucial in the case of industrial symbiosis and circular economy showing the difference between waste and by-products. The Waste Act also specified all measures to protect the environment, human life and health to prevent and to reduce the negative impact on the environment and human health resulting from waste management and limiting the overall impact of resources use and improving the efficiency of such use.
- Packaging and Packaging Waste Act (2013): This act provides policies on packaging and packaging waste which obligate all manufactures that introduce packed products into the market to achieve recovery and recycling at certain level of waste of the same type as packaging waste generated by their products. All manufactures need to submit a report on the achieved level of recovery/recycling of packaging waste to the regional authorities. In case of failure in achieving the required level of recovery/recycling, the manufacturer needs to pay a product fee including interest tax. In 2013 the maximum product fee for packaging was 4.5 PLN = approx. 1 euro per 1 kilogram.
- National Programme for Waste Prevention (2014): The programme presents all actions for waste prevention at national level and at regional levels. National regulations in Poland consider waste prevention as a priority.
- Some aspects related to waste prevention are also included in sixteen regional waste management plans. Every regional plan defines strategic targets in waste prevention.

- Italy attempts to speed up industrial symbiosis development through the use of Green public procurement, i.e. the application of “Minimum Environmental Criteria" in public procurement for the award of works, services and supplies. Furthermore, there are efforts to achieve a signalling effect in the private sector through the institutionalisation of a "GREEN MADE IN ITALY" certification scheme, a voluntary scheme for the evaluation and the communication of the products environmental footprint. This certification scheme is a statement of products environmental performances based on the quantification of the

environmental impacts, using the methodologies to assess the life cycle of the product (LCA - Life Cycle Assessment), with independent control of third parties.

- Greece and Croatia have attempted to establish an automated process for rapid waste and by-product exchanges using online tools. More precisely, in its newly adopted National Waste Management Plan for period 2017 – 2022, the Croatian Government will finance a Digital IT Waste Platform to establish exchange of resources, increase recycling and reused materials, decrease landfill, make new jobs and decreasing demand of primary row materials. Similarly, in Greece, the The Ministry of Environment and Energy has initiated efforts to prepare an online database of waste producers, which will facilitate the creation of joint waste management networks. This online database will form the basis for the creation of an "Online Waste Market", designed so as to encourage and incentivise by-products and waste exchanges as well as facilitate the creation of networks of industrial symbiosis. Additionally, Greece, and in particular, the local public authorities of Viotia, is directing EU funds from the programme LIFE+ towards a project called *e-symbiosis*, aiming to improve cooperation, networking and information exchange between industrial stakeholders in this area. The foreseen network of stakeholders will allow for the exploitation of various opportunities for exchanges of services, resources, waste and by-products. The project is the first step towards the formation of a Greece-wide network of industrial symbiosis[20]. E-symbiosis attempts to develop industrial symbiosis as an automated process using online tools and platforms where industrial stakeholders can list the resources, waste and by-products they can exchange within the framework of industrial symbiosis[21].
- Hungary has attempted to promote the responsible use of natural resources and the enforcement of sustainability, by including the following priorities in the Environment and Energy Efficiency Operational Programme (EEEOP):
    - Priority Axis 3: Waste management and environmental remediation related developments
    - Priority Axis 5: Promoting Energy Efficiency and the Use of Renewable Energy Sources

[20] https://thinkgreenhellas.blogspot.gr/2012/03/blog-post_21.html
[21] http://epubs.surrey.ac.uk/804145/1/MyPaper(8).pdf

Therefore, its primary aim is to support developments that are linked to the establishment of local, decentralised small- and medium-sized generation units therevy adapting to the local resources and demands in a better way and generating energy with higher efficiency. Furthermore, Hungary has rendered compulsory the compliance with the sustainability criteria of the 2009/28/EC Directive in the biomass sector. For the purpose of enhancing sustainability and energy efficiency it is preferred to support the renewables-based, combined generation of heat and electricity.

4.2.2 Category 2 countries

Category 2 countries have proceeded in supporting the enablers for industrial symbiosis through their entire development strategies beyond their waste management plans. For example, the Wallonia region in Belgium has included industrial symbiosis in the priorities of it's a) funding and incentivisation mechanisms applied in fields such as the energy field, covering insulation, photovoltaic systems, green certificates, and b) special taxation systems in fields such as water abstraction and local taxation for material extraction related to mining activities). Furthermore, the Walloon government is giving SMEs all of needed technical support through a specialized Reference Center on Circular Economy and supports voluntary agreements and voluntary initiatives with the private sector through competitiveness clusters, employment-environment alliances, and branch agreements.

Spain, national level

Spain has upscaled its efforts to support the enablers for industrial symbiosis, which is evidenced by the following documents:

- National Action Plan on Energy Efficiency (2014–2020), which focuses on biomass and fossil fuels.
- National and Integral Tourism Plan /Plan Nacional e Integral de Turismo-PNIT (2012–2015) with the aim to link sustainability issues with economic opportunities and offer innovation support to this important economic activity and social responsibility, while indirectly looking for quality growth and an efficient use of material resources, water and energy.
- National Plan on Waste-PEMAR (2015–2020), which aims at securing a sustainable raw secondary material supply, raising resource efficiency in production when

closing cycles in a circular economy, making consumption more resource-efficient and enhancing resource-efficient closed-cycle management. PEMAR attaches particular importance to improving awareness and information, education and training, and innovation, and to strengthening voluntary agreements between industry, citizens and public administration. Progress towards the circular economy is considered in all the waste streams following waste management hierarchy. It sets a 50% target for waste to be recycled or prepared for re-use. Within that, 2% of furniture, textiles, electricals, and other suitable goods, must be redirected from recycling or landfill and sent for repair and resale instead. Therefore, Spain is the first European country to introduce a separate national binding target for re-use.

- Spanish Plan for Smart Cities, a "pioneer governance framework" according to ITU/UNESCO. This Plan includes standards for intelligent solutions and projects encouraging cooperation between companies and local authorities in order to favour the development of innovative solutions. Key measures are: aid programmes, interoperability between intelligent solutions promotion, R&D support around smart cities and industry promotion, and projects to encourage cooperation between companies and local authorities and the development of new business models based on efficiency and technology use, among others.

- The Spanish Bio-economy Strategy – Horizon 2030. It focuses on promoting the sustainable use of some biological resources through bio-innovation and its application in various industrial sectors, thus contributing to improved material and energy efficiency, climate protection and the use of materials and energy from renewable sources in order to accelerate the transition towards a circular economy.

- Additionally, the Royal Decree on Waste Electrical and Electronic Equipment (WEEE) is a good example of recently approved legislation which also aims to improve the contribution of waste management to environmental and climate protection as well as to increased resource efficiency in waste management through strengthening waste prevention and recycling.

Spain, Andalusia

Andalusia has attempted to promote industrial symbiosis and circular economy enablers through the following plans:

- S3-Andalusia which identifies synergies with bio-economy strategy since biomass and agricultural by-products represent opportunities for economic growth and job creation in sectors such as the pharmaceutical, health and wellness and tourism. It also reinforces the processes for obtaining biofuels in biorefineries and biofuel production.
- Energy Strategy for Andalusia 2020 committed to a self-sufficient, low carbon, smart and high-quality energy model and biomass use.
- Rural Development Program for Andalusia 2014-2020
- The Industrial Strategy for Andalusia 2020 with a focus on the industry as a driving force a new production model through increasing competitiveness, innovation, international presence and human resources skills
- The Non-hazardous Waste Management Master Plan 2010-2019 which includes as key measures the reduction in the amount of waste produced, improving the selective collection and awareness campaigns. Waste types covered: municipal waste, packaging waste, biodegradable waste, batteries /accumulators, WEEE, C&D waste, industrial waste.

- The Hazardous Waste Prevention and Management Plan 2012-2020 which represents an important step forward in promoting prevention, recycling, incineration with energy recovery and final disposal of waste and also in terms of improving the network of infrastructures. It includes tax deductions for environmental investments to reduce landfill and an appropriate counselling office for businesses.

- The Bioeconomy Strategy for Andalusia (writing in progress) focussing on full use of waste and by-products of agri-food, fishing and forestry sectors.

- The Green Jobs Strategy for Andalusia 2020 (writing in progress) focusing in particular on issues such as eco-innovation, and green jobs generation through structural changes in production models according to bio-economy principles.

- The Sustainable Development Strategy for Andalusia 2020 (writing in progress) committed to a "green economy" to promote rural development and the environment as a source of sustainable employment.

- Guidelines from the Regional Ministry of Agriculture, Fishing and Rural Development, and the Regional Ministry of Environment and Spatial Planning on plant remains' management from horticulture in Andalusia (2016). The overall aim of actions to be taken is to improve the management of this waste in a circular economy perspective.

- The Agri-food Industry Strategic Plan 2016-2020. It is also an important mechanism since its objectives include guaranteeing the environmental sustainability of companies in this sector.

- The Andalucía Smart Strategy and the Andalucía Smart Action Plan to promote smart development in Andalusian cities and municipalities

- Incentive Schemes to promote sustainable energy development 2017-2020 with three main axes (Sustainable Construction, Sustainable SME and Smart Networks) and a 227 million euro envelope.

- Law 2/2007 of March 27 2007, on promoting renewable energy and energy saving and efficiency in Andalusia. It establishes the regional regulatory framework for the promotion of renewables highlighting the primacy of renewable energy over traditional energy sources.

Andalusia's high level of commitment towards circular economy and low carbon economy have resulted in being selected by the European Commission **as a model region** for the sustainable development of the chemicals' industry together with five other EU regions. The aim of being a model region is research into and promotion of low-carbon circular economy systems and industrial symbiosis for improved and more sustainable use of resources. The project has been designed as a road map for sustainable chemical production for Andalusia that will generate and attract investment to create jobs and wealth. The proposal integrates and supplements various regional plans already mentioned.

The various agents and departments involved are coordinated by the Andalusian Regional Government, who will set up and enforce the legislative framework necessary for the development of these sustainable models and undertake to share the experience and knowledge acquired with the other European regions to boost cooperation between the chemicals sector and other sectors, like agriculture, forestry, energy intensive industries, waste management and recycling.

Spain, Extremadura

Extremadura possesses the following policies to promote industrial symbiosis and circular economy:

- Smart Specialisation Strategy of Extremadura (RIS 3 Extremadura). The strategy is based on five pillars identifying the main sectors to be promoted in Extremadura in medium and long-terms: agro-industry, energy, tourism, health and ICT in order to boost competitiveness and create new opportunities for entrepreneurship and businesses. The main detected challenges are:

  - To consolidate a society based on the knowledge and talent;
  - To develop an internationalised and competitive industry, capable of generating wealth in a sustainable manner;
  - To build a society of change, continuous improvement, creativity, knowledge, entrepreneurship and internationalisation;
  - To develop infrastructure adapted to the needs of the region, allowing development, and strategically connected with other regions and abroad.

- Regional Framework to Boost Green Economy and Circular Economy in Extremadura 2030 (currently under development and foreseen to be completed by the end of 2017). The framework initiative comes directly from the regional Presidency of Extremadura, with the cooperation of diferent public policies and government areas, such as education, culture, employment, health, economy, industry, agriculture. Its purpose is to indentify if there is a firm commitment in the region to develop a regional strategy on Circular Economy.
- Regional Integrated Waste Management Plan 2016-2022 (Plan Integrado de Residuos Extremadura 2016-2022), published on December 2016. The plan is completely aligned with the National Framework Waste Management Plan 2016-2022. When the SYMBI project started, the Regional Integrated Waste Management Plan was in public information stage. FUNDECYT PCTEX suggested to explicitly mention the Circular Economy concept that was only implicit in the context. As a result, the conept is included in the Plan in accordance with the Circular Economy Package.

- Regional Plan for Research Development and Innovation (under development) which will prioritize projects related to green economy and circular economy

4.2.3 Category 3 countries

Category 3 countries will support the drivers and enablers for industrial symbiosis through their planning strategies in various domains such as for example the promotion of sustainability in the demand for energy sector, recycling and bioeconomy. However, there are some measures directly related to industrial symbiosis and circular economy development. Countries such as Denmark and the Netherlands will build upon their support for the enablers for industrial symbiosis and circular economy through specific taxation regimes for unutilised waste[22] and specific subsidy and incentivisation regimes for circular economy related technology development in domains such as circular economy and recycling of waste, hazardous chemicals, the industry's environmental performance, and ecological and sustainable construction. Such subsidy schemes support[23]:

• The development, testing and / or demonstration of environmental technologies

•Conducting technical feasibility studies prior to the development, testing or demonstration.

Among the partners of SYMBI, Finland aims to further support the enablers for industrial symbiosis and circular economy development by the Finnish road map to a circular economy 2016-2035, which has established Sitra, an independent Finnish fund that reports directly to the Finnish Parliament, as the key national co-ordinator for circular economy and industrial symbiosis. Sitra's operations are guided by a vision of Finland as a leader in sustainable well-being. Sitra contributes to circular economy and industrial symbiosis by developing a road map in collaboration with other key players including national and international experts. The road map:

- describes the concrete actions that can accelerate the transfer to a competitive circular economy in Finland, highlights best practices and pilots.
- aims to make Finland a global leader in the circular economy by 2025 and turn the circular economy into a driver of growth, investment and export for Finland, according to cautious estimates the circular economy is expected to provide

[22] http://eng.ecoinnovation.dk/media/mst/8051407/Affald_Baggrundsartikel_affald_web_15.01.13.pdf

[23] http://eng.ecoinnovation.dk/the-danish-eco-innovation-program/ecoinnovation-subsidy-scheme/

Finland's national economy with 2 to 3 billion euros in added value potential by 2030 especially in the following sectors: machinery and equipment and forest industries, food waste reduction, altering the use of real estate, private consumption and second hand trade, nutrient recycling.

- encourages to change and take risks through: fast trials, concrete pilots and long-term change policy.
- emphasizes the state's role in facilitating a progressive growth platform that is favorable for the domestic market and companies and on the other hand, a strong company, export and technology orientation combined with the search for comprehensive solutions and co-operation covering the entire value chain.
- includes five focus areas:
    - Sustainable food system,
    - Forest-based loops,
    - Technical loops,
    - Transport and logistics,
    - Joint actions.

Furthermore, Finland will strengthen the positive impact of those enablers through the following programmes:

- Material Efficiency Programme released by the Ministry of Employment and the Economy in 2014[24]: The programme's objective is to create preconditions for ecologically sustainable growth and employment, to promote competitiveness and balanced operational preconditions for business, to utilize non-renewable natural resources in sustainable manner, and to promote the production of high value added products based on strong knowledge and skills. The goal of the programme is "sustainable growth through material efficiency", aiming simultaneously at economic growth, the sensible use of natural resources, and disengagement from harmful environmental effects. The programme's proposed measures include joint research programmes for the promotion of material efficiency, developing tools for promoting material efficiency in the private sector businesses, developing innovative legislation and seamless administration on the topic of clarifying the procedure for environmental permits, and finding international and European funding.

[24] https://tem.fi/documents/1410877/3437254/Sustainable+growth+through+material+efficiency+27022014.pdf

- Bioeconomy Strategy released by the Ministry of Environment in 2014[25]: The objective of the Finnish Bioeconomy Strategy is to generate new economic growth and new jobs from an increase in the bioeconomy business and from high added value products and services while securing the operating conditions for the nature's ecosystems. The leading idea of the strategy is that competitive and sustainable bioeconomy solutions for global problems will be created in Finland, and that new business will be generated both in the Finnish and international market, thus boosting the welfare of the whole of Finland.

Moving from the national to the regional level, Häme has included supporting the enablers of industrial symbiosis in a strategic development programme[26] which will shape the future of the region. It includes a regional strategic plan and a regional development programme. The aim of the programme is to show the direction into which the region will be developed and to gather resources so that various themes and ideas can be implemented.

The region will be developed so that: "People can and want to work and live in Häme". Sustainable success of the region is achieved through intelligent and specialized choices.

Through joint discussions, the following were chosen as key components of the Häme programme:

- Growth corridors and accessibility,
- Housing and well-being,
- Bioeconomy and a sustainable use of natural resources,
- Possibilities within the manufacturing industry
- International linkages and attractiveness.

The aim of these components is to create development entities that are large enough and have enough impact. In order to be able to implement these, municipalities, regions, regional networks, state, the European Union as well as enterprises need to contribute with resources.

A summary of economic intstruments and regulatory measures that support circular economy in Finland can be seen in the following table:

[25] http://biotalous.fi/wp-content/uploads/2014/08/The_Finnish_Bioeconomy_Strategy_110620141.pdf
[26] http://www.hameenliitto.fi/sites/default/files/hame-ohjelma_lopullinen_28.11.2013_1.pdf

Key economic instruments and regulatory measures that support circular economy in Finland		
Instrument	**Main characteristics**	**Type of measure**
Premium tariff	The generators of electricity from wind, biogas and biomass receive a variable premium feed-in tariff on top of the wholesale electricity price for a period of 12 years; the generators thus get a fixed (target) price for their electricity	Direct subsidy
Energy support	A state grant for investments in renewable energy production facilities and related research projects; energy support may be granted to companies, municipalities and other communities	Direct subsidy
"Heat bonus" for combined heat and power (CHP) plants	Co-generation of heat and electricity is promoted by giving CHP plants working on biogas and wood fuel the right to an increased fixed "heat bonus"	Direct subsidy
Investment support for farmers	Funds to support farmers' investments in the construction of heating facilities using renewable energy sources	Direct subsidy
Biofuel quota	The Act on the Promotion of Biuofuel in Transport obliges vendors of petrol and diesel to fulfill a defined quota of biofuels; the amount of biofuels has to be increased year by year to make up 20% of total sales by the year 2020.	Quota obligation
Environmental and energy taxes	Various tax measures in favour of energy transition, e.g. reduced taxation for biofuels.	Fiscal
Joint strategy for a circular economy and green growth by Tekes and Sitra	Promotion and funding of new business models in the field of circular economy and green growth	Funding; strategy
Landfill gate fees	Encouraging recycling and other waste	Economic incentive

Key economic instruments and regulatory measures that support circular economy in Finland		
Instrument	**Main characteristics**	**Type of measure**
	disposal methods by setting lower fees per tonne of waste so disposed than the equivalent landfill gate fees	
Voluntary energy efficiency systems	Supporting energy audits and analyses of buildings and production processes	Economic incentive

4.3 Research question 3

4.3.1 Category 1 countries

Croatia, Slovenia and Poland use existing development plans, such as waste management plans to limit the constraining factors for industrial symbiosis and circular economy development. More precisely, Poland and the Region of Malopolska focus on utilising the following plans:

The White Paper on the protection of strategic deposits (2015)

As regards the geological resources, there is a system of mining concessions. The "White Paper on the protection of the strategic deposits" (2015), calling for actions to guarantee exploitation possibilities in the future, presents a list of strategic deposit locations with the highest valorization score. These include: 43 deposits of hard coal, 15 deposits of lignite coal, 11 deposits of natural gas, 4 deposits of crude oil, 19 deposits of metal ores (Cu, Zn-Pb, Mo-W-Cu, Ni), 3 deposits of potassium-magnesium salts. The list, as the whole document, is under consultation and can be extended in the near future.

Poland recognizes the importance of preparing a list of industrial raw materials identified as key to Poland's industries, and as a result the "Action Plan for Poland's security regarding non-energy raw materials" is in preparation – an important part of the Action Plan will be a list of critical raw materials. The Action Plan considers them important for the growth of the Polish industry and simultaneously problematic due to possible supply risks.

Therefore, the identification of critical raw materials is going to be correlated primarily with the development prospects of Polish industry (for example, based on an analysis of growth dynamics in the recent years, as well as on a study of various strategy documents which define the most promising branches of industry in Poland, and which have stimulated development of concrete measures to support them (for example, National Intelligent Specializations).

The Act on keeping cleanliness and order in municipalities (1996)

The guidelines concerning required levels for the management of municipal waste in the act on keeping cleanliness and order in municipalities, also intended to encourage municipalities to use circular economy solutions.

The resulting regulations obligate municipalities to achieve appropriate levels of recycling and preparation for reuse of paper, metals, plastics, glass (- 50%, until December 31 2020) and non-hazardous construction and demolition waste (- 70% until December 31 2020).

The Ordinance of the Minister of Environment on specific selective collection system of chosen waste fractions

One of the basic constraining factor of circular economy development is the presently used collection system. In the present system, secondary materials like metal, paper, plastics are collected in one container by some municipalities. This solution leads to low quality of secondary materials and slows down circular economy. According to a new ordinance of the Minister of Environment, there should be a change in collected waste fractions with separation into four containers:

a) Paper
b) Glass
c) Metal and plastics
d) Bio-waste and other biodegradable waste.

The new ordinance will enter into force as of July 1 2017.

In Greece on the other hand, the negative effects of the constraining factors of industrial symbiosis and circular economy development will be reduced after the preparation of a

national plan for industrial symbiosis that will coordinate such efforts. The need to reduce the negative impacts of the constraining factors through coordinated efforts is also reflected in Italy's initiative to develop ENEA, i.e. the Italian National Agency for New Technologies, Energy and Sustainable Economic Development and the Law n.221/2015.

The ENEA agency proposed a plan, characterized by four points, to facilitate the transition to the Circular Economy:

1. The establishment of a National Agency for the efficient use of resources, with the task to coordinate initiatives and the implementation of policies aimed at the sustainable management of resources. ENEA has offered to fill this role impartially.
2. The development of new and simplified regulations with a specific focus on waste reduction by acting upstream of the supply chain and increasing the recycling rate.
3. To encourage cooperation and synergies between all the actors of Circular Economy: public administration, business, science and technology research institutes.
4. Transfer of technologies for the national production system innovation.

Moreover, the Law n.221/2015 introduced incentives for companies that produce goods resulting from post-consumer materials and waste recovery, fostering the development of by-products market.

Finally, in Hungary, the most important policies used to reduce the impact of constraining factors and to facilitate the development of industrial symbiosis, secondary raw material regulations and circular economy are the following:

- EEEOP 3. Priority AXIS - 1. Measure: The development of separate collection and transport systems.

The main target of the measure is primarily to develop the existing separate waste collection system, increase the efficiency and reach the number of non-isolated areas. More specifically, it aims to facilitate the utilisation of municipal waste (paper, glass, plastic, biodegradable organic hazardous waste), to increase the separation of housing waste, and the establishment of appropriate collection points and recycling

- EEEOP 3. Priority Axis - 2. Measure: The development of sub-systems in pre-treatment, recycling and disposal in terms of municipal waste.

The main target of the measure is to extract useful substances from municipal waste. The measure supports the continued management of separately collected waste, the development of the necessary selection plants, as well as the establishment of complex waste management centres realising the combination of selection and biological and mechanical treatment.

Furthermore, other measures in Hungary include the following:

- Recycling centres
- Development of Home/Community composting
- Raising public awareness
- Development of transport capacity for the separate and mixed collection of waste
- Distribution of collection boxes, vehicles, and points
- Establishment of waste yards
- Increasing the preparation prior to recycling
- Improving the sorting of collected waste
- Utilisation of bio-waste.

4.3.2 Category 2 countries

The following practices have been used in category 2 countries to reduce the negative effects of the constraining factors to the development of industrial symbiosis and circular economy:

- Environmental information / awareness raising: Spain made impressive efforts in recent years to improve the collection and dissemination of environmental information at both national and AC level with topic-focused databases, registries and inventories. The main challenge now is to make environmental information more consistent across regions.
- Extremadura indicates lack of specific tools or instruments to promote and help companies to adopt industrial symbiosis models.
- Capacity building: By 2015, 90 thousand workers in existing jobs had been trained through the Green Jobs Programme (Empleaverde).
- Incentivisation schemes: In Flandres region there is a landfill and incineration ban on recyclable waste. To stimulate consumers, producers and waste managers to look

for alternatives to landfill and incineration of materials the government introduced also taxes on landfill and incineration of waste. On the other hand Belgium has developed "pay-as-you-throw" schemes and extended producer responsibility schemes.

4.3.3 Category 3 countries

Beyond reorientating existing policy instruments, Denmark has tried to reduce the negatiove effects of the constraining to the development of industrial symbiosis and circular economy factors by developing a Task force on resource efficiency: The Danish Taskforce for Resource Efficiency was set up with aim of increasing the competitiveness of the Danish economy. Increasing and volatile materials prices have a major impact on the Danish manufacturing sector where resources make up 45% of production costs. The taskforce was established by a broad political agreement in 2014 and is a joint initiative of the Ministry of Business and Growth and the Ministry of Environment and Food. It is run by the Danish Business Authority. Its aim is to monitor and review existing regulations (both Danish and EU) affecting resource productivity and circular economy practices, identify barriers and find solutions. During 2015 the taskforce is identifying barriers preventing potential increases in resource efficiency. Sectors covered include manufacturing (including machinery, furniture and food), waste management, construction, and retail/wholesale. Resource streams covered include raw materials, semi-produced goods, water and chemicals. In 2016–2017 the taskforce will establish solution teams for each selected barrier to find the most effective way to overcome it.

Finland, on the other hand, reduced the negative effects of the constraining factors through a mixture of taxation and incentivisation measures which are outlined in the following table:

Key economic instruments and regulatory measures that support circular economy in Finland		
Instrument	**Main characteristics**	**Type of measure**
Premium tariff	The generators of electricity from wind, biogas and biomass receive a variable premium feed-in tariff on top of the wholesale electricity price for a period of 12 years; the generators thus get a fixed (target) price for their electricity	Direct subsidy

Key economic instruments and regulatory measures that support circular economy in Finland		
Instrument	**Main characteristics**	**Type of measure**
Energy support	A state grant for investments in renewable energy production facilities and related research projects; energy support may be granted to companies, municipalities and other communities	Direct subsidy
"Heat bonus" for combined heat and power (CHP) plants	Co-generation of heat and electricity is promoted by giving CHP plants working on biogas and wood fuel the right to an increased fixed "heat bonus"	Direct subsidy
Investment support for farmers	Funds to support farmers' investments in the construction of heating facilities using renewable energy sources	Direct subsidy
Biofuel quota	The Act on the Promotion of Biuofuel in Transport obliges vendors of petrol and diesel to fulfill a defined quota of biofuels; the amount of biofuels has to be increased year by year to make up 20% of total sales by the year 2020.	Quota obligation
Environmental and energy taxes	Various tax measures in favour of energy transition, e.g. reduced taxation for biofuels.	Fiscal
Joint strategy for a circular economy and green growth by Tekes and Sitra	Promotion and funding of new business models in the field of circular economy and green growth	Funding; strategy
Landfill gate fees	Encouraging recycling and other waste disposal methods by setting lower fees per tonne of waste so disposed than the equivalent landfill gate fees	Economic incentive
Voluntary energy efficiency systems	Supporting energy audits and analyses of buildings and production processes	Economic incentive

4.4 Research question 4

4.4.1 Category 1 countries

The relative absence of development planning in which industrial symbiosis and circular economy are the epicentre, has led to a relative scarcity of successful and tested policies in category 1 countries. As a result, data revealed a general list of measures that supported industrial symbiosis and circular economy along with a small number of specific examples that will be described subsequently. The general list includes the following policies[27]:

- Incentivisation and funding of waste management processes with an "extended" logic, i.e. with a rationale that faces waste as a resource.
- Incentivisation and funding of industrial ecology production and implementation.
- Providing specialised engineering education.
- Regulation directed towards webs of products and networks of processes not individual products and processes.
- Industrial symbiosis inspired specifications for public sector projects.
- Awareness raising to eliminate the perception that adopting industrial symbiosis is costly.
- Centralised planning of industrial symbiosis development.

Moving now to the more concrete examples the data revealed the following efforts:

- Slovenia aims to include such policies in the Slovenian Development Strategy which is currently being drafted and is expected to be finalized in the 2nd half of 2017. It is expected that the transition into the circular economy will be embedded into the final document of this policy instrument.

- In Italy, a pilot project realized by ENEA in one of the Italian regions (Sicily Region) has recorded good results and there is a possibility that it will be replicated in other regions or at a national level in the future. The project, named "Eco-Innovazione Sicilia", led to the creation of the first Industrial Symbiosis Platform in Italy that, through a complex information structure, aims to bring together supply and demand for resources according to principles of the Industrial Symbiosis. Through the dedicated website, in fact, each company can communicate what are its by-

[27] https://www.researchgate.net/profile/Emmanuel_Adamides/publication/223717617_Industrial_ecosystems_as_technological_niches/links/5575c93708aeacff1ffe5912.pdf

products; namely waste, energy or scraps and which raw materials it needs. More precisely, the Industrial Symbiosis Platform consists of:

- A Platform Manager;
- an information system, designed to contain the information, also geo-referenced, about the flows of resources (material, energy, water, skills, services, etc) that can be shared and then exchanged;
- a network of interlocutors that through the registration to the Platform become users, while providing functional information for the enrichment of the database;
- an informative web portal that provides information and services to users.

- In Poland, there is a mechanism for subsidizing investments in the field of environmental protection and water management. The funds coming from fees and fines for using the environment go to one national and sixteen regional funds for environmental protection and water management which subsidize investments preventing environmental pollution, e.g. changing heat source or thermo-modernization of public or private buildings. One of the instruments which applies the polluter-pays principle is a landfill fee. First elements of a landfill fee system were introduced in the 1970s– for waste from the mining industry. The system was expanded over years and in 2002 the last group of waste, i.e. municipal waste, was included into the system. Landfill fee is submitted to national (14%) and regional (26%) funds of environmental protection and water management and poviat (county) (10%) and municipal (50%) budgets. Revenues are used exclusively for investments in the field of environmental protection and water management. By those means, manufacturers are encouraged to close their productions loops with the aim of maximizing material life cycle and minimalizing waste production.

- The policies successfully designed to support industrial symbiosis in Hungary belong to the EEEOP Priority axis 3: Waste management and environmental remediation related developments topics. Their direct and indirect specific objectives are developing selective waste collection and a systemic network of waste management facilities. Waste management related development projects have achieved the objectives formulated in the 2008/98/EC Waste Framework Directive and other EU directives supplementing the Framework Directive and in Act CLXXXV of 2012 on

Waste (among others, achievement of increasing utilisation rates, ensuring high-level public services and compliance with other requirements). Furthermore, Hungary approved a new Waste Act that fundamentally changed the entire system of waste management. By introducing the landfill tax, the act managed to reduce the quantity of waste deposited in landfills and to recycle a greater volume of waste. Nevertheless, there are still inadequacies resulting from the areas missed out in former development projects and cancelled facility development activities as well as the implementation of further development needs, identified in relation to legislation, will be indispensable for the effective operation of the waste management systems. The infrastructure built in the previous support period provides appropriate bases for a system fitting into the waste hierarchy.

- Croatia has applied a "returnable fee system" which is a good example how circular economy can work in practice within the Croatian market. Namely, almost all PET, Al and glass packaging for beverages is collected, recycled and transformed into new products to be placed on the market. Examples of good practices also include the Waste Tires Ordinance and the Ordinance on the management of end-of-life vehicles which allow for the collection of waste tires and waste metal from ELVs and give the possibility for recycling of waste materials and transformation in new products intended for placing on the market.

4.4.2 Category 2 countries

The greater level of development of industrial symbiosis and circular economy policies compared to Category 1 countries has allowed for the identification a wider spectrum of successful measures that have been replicated in various regions. The following list presents the most important such policies found in Spain and Ireland:

- Policies aiming at supporting voluntary agreements and initiatives as a strategic tool to go beyond legal commitments to implement circular economy principles, to promote business competitiveness and to encourage resource efficiency. Businesses may become more motivated and committed to take steps towards greater resource efficiency. Measures include: codes of conduct/covenants (between businesses, or between businesses and government), voluntary product labelling, voluntary corporate disclosure or voluntary collaboration between actors along a supply chain, or hosting meetings/discussions between businesses.

- Development of non-legal standards to help producers with greener products to differentiate them from less environmentally-friendly alternatives, as well as allowing consumers to make more informed purchasing choices. Spain's Green Public Procurement Plan has been in force since early 2008. Significant progress has been made in the implementation of green procurement practices across the country at national and regional ministries level, including Andalusia.

- Measures supporting extended producer responsibility (EPR) for materials and/or products to support more circular supply chains between the production and end-of-life phases of a product. The Waste Electrical and Electronic Equipment (WEEE) scheme is a good example aiming at promoting EPR for products and clarifying its role and function on the management of waste more effectively. Spain was the first EU country to mandate re-use of electrical goods. WEEE Spanish legislation intends to integrate a single control instrument on regional and national WEEE data to identify compliance with the objectives in this field and ensure the traceability and appropriate management of waste. It promotes re-use and preparation for re-use and will encourage the creation of re-use centres and jobs in this sector. It provides reliability and systematise reporting obligations of EEE producers and WEEE managers on the collection and recovery of WEEE throughout the country, ensuring uniformity of WEEE management criteria and market unity.

- Building resource efficiency related skills and capacity within a company/business with the aim to reduce the environmental impacts of their activities. Spain promotes the development of green skills through the Green Jobs Programme (Empleaverde). As part of the programme, trainings for employees are offered with the aim to reduce the environmental impacts of activities in their respective sectors. The programme is operated nationwide by the Fundación Biodiversidad (a foundation within the Spanish Ministry of Environment). By 2015, 90 thousand workers in existing jobs had been trained through the Green Jobs Programme

Beyond the national measures successful regional instruments have been instroduced in some Spanish regions.

Catalonia:

- **Ecodesign Award in Catalonia:** The Catalonia Eco-Design Award is a part of the Catalan Eco-Design Strategy (Ecodiscat) 2012-2015. Its goal is to encourage the incorporation of eco-design in the production process, to foster a cross-cutting approach and knowledge transfer, and to boost the consumption of sustainable products and services in Catalonia.

- **Eco-Vouchers Catalonia:** this Eco-Vouchers Programme is aimed at fostering eco-innovative projects and solutions that would help SMEs to turn their processes, products and services to a more green and circular innovative way. Four main eco-innovation services can be funded through the voucher:
  - analysis of production processes and identification of environmental improvements,
  - eco-design for products and services,
  - product recovery and prevention of waste generation studies,
  - studies to promote new business models related to green and circular economy.

  Companies pay an accredited supplier (engineering and environmental consultancies) with the voucher. Each voucher can pay up to 4.000 €. The company co-finances at least 80 % of the service cost.

  Results of 2015 Catalan Eco-Vouchers Programme: In the first year of the Catalan Eco-Vouchers Programme (2015), the total investment reached almost 80.000 € of which the Eco-Vouchers funded around 35.500 €. This amount concerned 13 eco-innovation projects that included a broad range of the productive economic sectors. Eight of the projects were aimed at the eco-design of products and services and five more were focused on the analysis of production processes and identification of environmental improvements.

- **MANRESA en Simbiosis:** Manresa is the first industrial symbiosis project in Catalonia to maximize efficiency in the use of available resources, creating the bases to favour synergies between companies / entities.

- **By products exchange platform in Catalonia:** On-line platform based on marketplace concept addressed at all compies aimed at promoting economic and

business activity and boosting waste recycling. After more than twenty years of existence, the Byproduct Exchange Platform has been renewed and it is in full relevance for its commitment to a conception of waste as a resource and source of secondary raw materials, key elements in the transition to a circular economy model.

Basque Country has a wide range of instruments to boost the circular economy. On the one hand, some instruments enable circular economy demand:

- **Green Public Procurement** includes different tools to support the development of green procurement technical purchasing criteria for products and services. Nowadays, major efforts are focused on the field of construction and public works.

- **Green Supply Chain Management**, as an example of Green Private procurement and it is especially important in large companies that must differentiate themselves with *greener* goods and products.

- **Development of technical and environmental standards** as a basis for building trust between the supply and demand of secondary raw materials and sustainable products.

- **Basque Ecodesign Center** - Private-public partnership promoted by 9 large companies and 2 public societies, with the aim to foster the design and execution of innovative ecodesign projects.

- **Plan of Inspection and Environmental Control 2011-2018**: promotion of the circular economy in the framework of the Environmental Authorizations and Inspections of industrial and waste management. Basque industries are required to demonstrate that there is no alternative to recycle their waste in order to accept them in landfill.

- **Tax of waste to the landfill**. It is one of the most relevant measures of the "Prevention and Management Plan for Waste 2020 of the Basque Country" to promote the circular economy and is currently in the phase of economic impact assessment.

On the other hand, some instruments boost Circular Economy offer side:

- **Grants for R&D projects**: There are several programmes used by the Basque companies as the *Hazitek* grant of the Department of Economic Development and Competitiveness of the Basque Government, and one of the fundamental instruments of the Of Science, Technology and Innovation 2020 of the Basque Government. Additionally, there are small periodic grants from a public corporation Ihobe to "Excellent project design Of R&D&I in Eco innovation "that facilitate the access of Basque companies to financing (CDTI) and European (Horizon 2020 and Life Program).

- **Grants for Demonstration Projects in Circular Economy** as well as the grant for ecodesign projects, which also drive design projects for durability, maintenance, repair, dismantling, remanufacturing and recyclability.

- **Grants for business differentiation** for new business models through the Lehiabide program managed by the public partnership SPRI of the Basque Government. These grants aimed at generating more value in the company can support new circular models.

- **Non-refundable subsidies** to co-finance investment in equipment and facilities which contribute to environmental improvement, mainly through the annual Order of

  Subsidies for Environment Enterprises from the Department of Environment and Territorial Policy. There are also grants from the Department of Economic Development and Competitiveness of the Basque Government which can co-finance business investments in circular businesses.

- The **environmental tax deductions** of the Provincial Councils of the Basque Country on The Corporate Tax rate, 15% for business projects, in particular related to the field of waste and circular economy. Additionally, deductions of 30% of agile and simplified application for the investment in equipment recognized in the Basque List of Clean Technologies.

Republic of Ireland also introduced tools designed to support industrial symbiosis and circular economy:

- SMILE Resource Exchange – an Irish free service for businesses that encourages the exchanging of resources between its members in order to save money, reduce waste going to landfill and to develop new business opportunities. Potential synergies are identified through an online platform www.smileexchange.ie or through facilitated technical assistance. Businesses can request or offer resuable materials, by-products or surplus stock that could potentially be a raw material in another business. All resources offered are either free of charge or below market value. The service is available to businesses in the Republic of Ireland. SMILE members have identified the following benefits:
    - Cut costs
    - Reduce waste
    - Source materials
    - Network with business
    - Identify new business opportunities
    - Improve competitiveness

4.4.3 Category 3 countries

The high level of development of industrial symbiosis and circular economy in Category 3 countries means that there are replicable successful policy measures in a wide spectrum of development plans covering issues such as bioeconomy and material efficiency. However, the most important successful policy measure in these countries is the autonomous planning for industrial symbiosis and circular economy. Examples of such plans include the following:

- Leading the cycle – Finnish road map to a circular economy 2016-2035.
- The Danish programme Green Industrial Symbiosis, which ran from 2013-2015.

5 Key Existing Policies

The following table presents the key existing policy instruments for the support of industrial symbiosis and circular economy in the partnership countries.

Key policy instruments for the development of industrial symbiosis and circular economy	
Partner	**Policy instruments**
Andalusia and Extremadura Spain	**At national level:** 1. National Programme on Waste Prevention (2014–2020) 2. Spanish Strategy on Food Waste (*More Food, Less Waste Strategy*) 3. National Action Plan on Energy Efficiency (2014–2020) 4. National Plan on Waste-PEMAR (2015–2020) 5. Spanish Plan for Smart Cities 6. Spanish Bio-economy Strategy – Horizon 2030 7. Royal Decree on Waste Electrical and Electronic Equipment (WEEE) **At regional level (Andalusia):** 1. S3-Andalusia 2. Energy Strategy for Andalusia 2020 3. Rural Development Program for Andalusia 2014-2020 4. The Industrial Strategy for Andalusia 2020 5. The Non-hazardous Waste Management Master Plan 2010-2019 6. The Hazardous Waste Prevention and Management Plan 2012-2020 7. The Bioeconomy Strategy for Andalusia (writing in progress) 8. The Green Jobs Strategy for Andalusia 2020 (writing in progress) 9. The Sustainable Development Strategy for Andalusia 2020 (writing in progress) 10. The Agri-food Industry Strategic Plan 2016-2020 11. The Andalucía Smart Strategy and the Andalucía Smart Action Plan 12. Incentive Schemes to promote sustainable energy development 2017-2020 **At regional level (Extremadura):** 1. S3-Extremadura 2. Regional Framework to Boost Green Economy and Circular Economy in Extremadura 2030 (writing in progress)

Key policy instruments for the development of industrial symbiosis and circular economy	
Partner	**Policy instruments**
	3. Regional Integrated Waste Management Plan 2016-2022 4. Regional Plan for Research Development and Innovation (writing in progress)
Häme Finland	1. Häme programme 2. Leading the cycle – Finnish road map to a circular economy 2016-2035 3. Sustainable growth and jobs 2014 - 2020 - Finland's structural funds programme 4. Finnish Government Programme 2015 & Action plan for the implementation of the key project and reforms defined in the Strategic Government Programme 5. Bioeconomy Strategy released by the Ministry of Environment in 2014 6. Material Efficiency Programme released by the Ministry of Employment and the Economy in 2014
Kozani Greece	**At national level:** 1. National Waste Management Plan 2. National Prevention Plan for the Generation of Waste **At regional level:** 1. Special Development Programme (SDP) of the Western Macedonia Region
Malopolska Poland	**At national level:** 1. National Waste Management Plan 2022 2. National Programme for Waste Prevention **At regional level:** 1. Regional Waste Management Plan of Malopolska Region
Molise Italy	**At national level:** 1. the Law n.221/2015 "Environmental provisions to promote Green Economy measures and to contain the excessive use of natural resources" 2. the action plan drawn up by ENEA for an 'Italian model' of Circular Economy. **At regional level:**

Key policy instruments for the development of industrial symbiosis and circular economy	
Partner	**Policy instruments**
	1. the ERDF Molise Region Operational Programme for the period 2014-2020
SVRK Slovenia	1. Framework Programme for Transition to Green Economy 2. The Operational Programme for the Implementation of the EU Cohesion Policy 2014 – 2020 3. Smart Specialisation Strategy S4 4. Programme for Waste Management and Programme for Waste prevention
West Transdanubia Hungary	1. Environment and Energy Efficiency Operational Programme (EEEOP)

6 Key policy recommendations

The regions of the SYMBI project differ significantly in terms of overall size and population and in terms of the characteristics of their economy and society. This diversity exists also in the development characteristics of their industrial symbiosis and circular economy. Hence, each region has different needs and different enablers and inhibitors or industrial symbiosis and circular economy are present therein. As a result, different policies are necessary to foster the effects of the enablers and reduce the negative impact of the inhibitors.

Despite the above fact, there are a number of key transnational recommendations that can be derived from the data. The key policy recommendations derived from the research that can foster the development and expansion of industrial symbiosis and circular economy projects are the following:

1. The use of financial incentives can foster the initialisation of industrial symbiosis and circular economy projects.
2. Awareness raising about the benefits of industrial symbiosis and circular economy can help overcome the negative stereotypes about the costs of such processes among stakeholders and the public.
3. Specialised planning for industrial symbiosis can have a significant positive impact to industrial symbiosis and circular economy projects. If such planning is not possible, then industrial symbiosis and circular economy can be fostered through improvements in waste management plans and recycling processes.
4. Efficient information flows can be the key of the successful initialisation of industrial symbiosis initiatives.
5. Beyond the first stages of industrial symbiosis and circular economy development, the maturation of these industries depend largely on instituting efficient networking among the public sector, private businesses and other stakeholders. Countries with relatively more developed industrial symbioses have specialised institutions carrying out and/or facilitating this process (e.g. Sitra in Finland).

Beyond the transnational policy recommendations, the recommendations that are specific to a region are presented in the following sections.

6.1 Region of Molise - Italy

The main remark concerns the necessity of designing not only environmental policies, but also industrial ones. It is important to properly support companies and SMEs in the establishment of Industrial Symbiosis paths, applying the Circular Economy model. Secondly it is urgent to define clear regulations exclusively dedicated to these topics with simple and efficient dispositions, in order to not only reduce waste or increase the recycling rate, but especially aimed at the encouragement and creation of Industrial Symbiosis parks or networks, fostering the second raw materials market. Below is a list of the main points recommended to be included in the key policies:

1) Financial subsidies and long-term incentives to facilitate forms of cooperation between enterprises;
2) Financial subsidies to support investments related to replacement and renewal of machineries;
3) Well-structured information/formation processes to increase key players awareness on the subject and on potential benefits;
4) Application of support measures for the competitive development of by-products market, especially in the competition with the virgin raw materials market;
5) Tax exemption for investments in the field of Industrial Symbiosis;
6) Reduction in taxes affecting recycled products and by-products;
7) An integrated policy approach;
8) Ministerial or regional subsidy programs and concessions;
9) Prevision of specific tools related to the topic in the ROP of each region;
10) Financial support to the technological innovation spreading;
11) Clear and explicit regulation for by-products discipline;
12) Actions or programme agreements for the realization of informative platform or catalogues, including companies scraps or wastes that can be provided as by-products to other organizations.

6.2 Region of Malopolska – Poland

Proposals regarding the development of modern waste management system:

The EU waste hierarchy and circular economy package requires a change of the current point of view focused on linear economy and to start looking at waste as a potential

resources. Improving the waste management system as a basic element of circular economy is going to bring a positive economic effect (waste reuse, energy recovery) but also will improve the quality of life by eliminating any inconvenience associated with waste landfill. Currently, the main challenges in the area of circular economy and waste management are the following:

1) The development of selective municipal waste collection which will provide high quality input materials for recycling processes.
2) The development of bio-waste treatment plants to change the collection system.

Proposals regarding the preparation of the Strategy of Responsible Development:

In 2016 the Polish Ministry of Development in cooperation with other ministries submitted a draft "Strategy of Responsible Development" (SOR) under public consultations. This document presents challenges faced by the Polish economy, called "development traps". It highlights some exemplary economical and financial instruments focused around 5 development pillars. SOR presents a new view on the economic policy and the key initiatives for completing tasks connected to circular economy vision.

In the area of reindustrialization, SOR aims at external factors impacting the industry:

1) Transition from linear economy to circular economy, developing and implementing of modern business models, as well as technological solutions allowing for the modernization of production processes or the products themselves using innovative solutions.
2) Transforming the present Polish economy into a "low-carbon" economy with necessity to invest in low-carbon solutions and to move business in the value chain.
3) Access to resources - resources security is a condition of permanent development of the Polish industry– supply of a sufficient amount of resources in competitive prices for which an industry demand exists and will exists.
4) Higher exploitation of digital models of products and digitalizing the supply chains (called "the 4th industrial revolution") – production in smart, cooperative factories with high flexibility, reliability and efficiency and where pieces of logistic information are automatically exchanged between main manufacturers and between suppliers and sales networks.
5) Regarding the resources policy it is necessary to prepare an action set to secure industry access to non-energetic mineral resources (with specific consideration of

circular economy and the resources policy) which will represent an important input in the national policy.

Proposals regarding the development of ecological education:

It is necessary to provide consumers with the knowledge needed to make smart purchasing decisions and to encourage them to select products with improved environmental characteristics. Hence, the main aims of ecological education in the area of circular economy are the following:

1) Provide consumers with education in order to improve theit behaviour by raising awareness of goods and services
2) Strengthen their rights for having access to information on the products and their manufacturers in order to ensure product safety.

Proposals regarding the development of an interdepartmental circular economy team:

The following departments have been invited to form a circular economy team: environment, national education, energy, infrastructure and constructions, science and higher education, family, employment and social policy, agriculture and rural development and public health. This group is expected to be extended by representatives from the industry, universities and other stakeholders that are or could be involved in circular economy or industrial symbiosis. It is recommended that this team should perform the following:

1) Identify opportunities and threats, strengths and weaknesses in the context of the transition towards circular economy.
2) Develop the position with regard to the European Union initiatives related to the transformation towards circular economy.
3) Develop a road map for the implementation of the circular economy in Poland, specifying in particular the objectives and priorities together with their time horizon and institutions responsible for their implementation.

6.3 Region of Western Macedonia

The Special Development Programme (SDP) of the Region of Western Macedonia should be updated in order to include the priorities of the National Waste Management Plan (NWMP) and the National Prevention Plan for the Generation of Waste (NPPGW). More precisely,

industrial symbiosis measures should be included in the following axes of the Special Development Programme:

Axis 2: Support of the productive environment: Two types of industrial symbiosis relevant measures could be included in this axis:

1) Firstly, funding specific types of infrastructure development (e.g. online database of waste producers) to support industrial symbiosis.
2) Secondly, funding and incentivising the introduction of innovative waste management technologies that allow for the initialisation and advancement of industrial symbiosis projects.

Axis 3: Enhancing and utilising human resources:

1) Increasing awareness among public authorities' personnel about industrial symbiosis
2) Training public authorities' personnel to promote and support industrial symbiosis projects.
3) Increasing the amount of research dedicated to industrial symbiosis in the research institutions of the area.

Axis 4: Improvement of the (natural and anthropogenic) environment, quality of life and social cohesion:

1) Adding industrial symbiosis in the principles of rational management of water resources in the area.

Axis 7: Maturation of development planning:

1) Integration of industrial symbiosis in the development planning for the area.

6.4 Slovenia

Key policy proposals for Slovenia can be split in to three main categories:

1. Policy level

- Define, at the national level concepts industrial symbiosis, circular economy and secondary raw material market.
- Set up regulatory framework and strategy that will enable adoption of industrial symbiosis, transition to circular economy and development of secondary raw material market.

- Strengthen the implementation and enforcement of green public procurement in public sector (as well as in state owned companies).
- Support the research and innovation for these areas.

2. Economy level

- Introduce financial mechanisms and / or incentives, also via using ESI Funds (the incentives should address the development of new business models, development of new production processes, new products and services, etc.)
- Tax incentives for shifting towards circular economy and industrial symbiosis.
- Support the establishment of business cluster, based on principles of industrial symbiosis and circular economy.

3. Social level

- Trust-building process between companies, public sector and CSOs.
- Introduce and capitalize educational programmes.
- Building value system and environmental culture.

6.5 Region of Andalusia and Extremadura

Measures at a national level:

To move the economy in the direction of a circular economy and deliver considerable social benefits, would require deliberate policy measures and cooperation among policymakers at all levels in Spain.

Some of these measures are already being implemented in Spain although they are in need of being strengthened in areas such as:

1) support systems for renewable energy
2) emissions trading
3) review of eco-design legislation
4) improving energy efficiency standards
5) targets for recycling of materials, etc.

In addition a number of new policy measures should be considered like:

1) a more proactive use of public procurement

2) earmarking investments in favour of resource efficiency within EU's different funding schemes
3) rethinking taxation, lowering taxes on work and increasing taxes on the consumption of non-renewable resources in the form of materials and fossil fuels
4) carefully analysing the VAT system, so that goods produced by secondary materials (where VAT has already been paid once) are exempted from VAT and the use of secondary materials is promoted (i.e. reuse and recycling) which will help correct a situation where it is often less expensive to use virgin materials than recycled ones
5) adoption of resource efficiency targets for materials where scarcity is looming or the overall environmental impact of resource extraction and use is significant
6) promotion of new business models geared at functional sales
7) increasing investments in the following sectors:
    i) agriculture, forestry, timber, pulp and paper to promote biofuels and to develop new bio-based products
    ii) installation services and construction/renovation to promote energy-efficiency and renewable energy sources
    iii) sustainable infrastructure concerning especially energy and transport, for instance mass-transit transport systems and electric vehicles and ways to charge them
    iv) maintenance and repair, recycling and development to promote material-efficiency
    v) engineering services and as well in education to be able to meet the increased demand for new competencies in areas like product design, recycling and remanufacturing as well as new business models.

Measures at a regional level (Andalusia):

Waste management plans play a key role in achieving sustainable waste management and are of high importance in the transition towards a circular economy and industrial symbiosis.

The Non-Hazardous Waste Management Master Plan 2010-2019 is the policy instrument to be tackled by Andalusia within the SYMBI project. The Plan includes among its key measures the following:

1) Reduction in the amount of produced waste
2) Improvements in the selective collection of waste

3) Awareness campaigns about recycling needs and improved waste management.

Most of the above-mentioned policies have contributed and will contribute to improving the plan and therefore to balance economic activities and sustainable development with an efficient use of resources.

Measures at a regional level (Extremadura):

The development of circular economy policy is a multistakeholder challenge that requires a close collaboration between public and private sectors in Extremadura. Consequently, it must be tackled from an integrative point of view, coordinating different sections of public administrations: environment and legal services, economic services, research and innovation services as well as transversal tool services related to training and communication.

Taking into account the potential of the region, Extremadura proposes:

- Awareness raising campaign aimed at different stakeholders.
- Waste disposal tax.
- Tax benefits for companies applying green criteria (recycling, use of by-products, etc.).
- Legal conditions to encourage introducing waste back to the market as by-products.
- Promotion of by-product markets at regional level.
- Creation of standards that guarantee the quality of by-products as raw materials
- Creation of standards that ensure the quality of recycled products.
- Promotion of industrial eco-parks.
- Promotion of eco-design through awards and labels.
- Boosting the role of research centres and the University in the development of demonstrative projects related to industrial symbiosis and circular economy.
- Public calls for funding R&D&I projects related to industrial symbiosis
- Innovative Public Procurement (public administration demand research and innovation of new goods and products).

6.6 Region of Häme

The following policy suggestions will enhance even more the proliferation of industrial symbiosis and circular economy in the Region of Häme:

1) In order to utilize the full dynamic and regional potential of industrial symbiosis, there is a need for a long-term public support framework for circular economy and industrial symbiosis, including comprehensive and coherent strategies and binding objectives.
2) Development companies, regional clusters or similar organizations can play an important role in facilitating and promoting industrial symbiosis in Finland. They can support industrial symbiosis activities by helping companies identify relevant partners for collaborations and new synergy opportunities, as well as developing business plans.
3) Local and regional authorities can and should support and facilitate the development of industrial symbiosis, for instance by promoting the development of networks/clusters based on local and regional strengths and helping to identify industrial symbiosis exchanges for which there is a good business case.
4) Industrial symbiosis development should be based on private sector needs and actual demand for relevant inputs (i.e. the resources nominated for exchange) in the industries involved. Business opportunities should be the driving force behind the development of industrial symbiosis, meaning that it is essential that companies can achieve economic gains from industrial symbiosis activities. From this base, there will likely emerge new businesses and innovations.
5) The European Structural and Investment Funds provide good opportunities to apply for industrial symbiosis projects focused on resource efficiency and innovation, and could be more widely used to support industrial symbiosis activities in Finnish regions.
6) The leading cases of industrial symbiosis show that both individual companies and regional clusters can play an important role in facilitating industrial symbiosis development.
7) The industrial symbiosis concept and designation are insufficiently familiar, although examples of industrial symbiosis-like phenomena can clearly be found (albeit often under other names). There is a need for further clarification and for raising awareness of the industrial symbiosis concept in Finland. In this regard, it is crucial to overcome information-related barriers. Thus, dissemination of knowledge about the opportunities related to industrial symbiosis development is extremely important. Although an attempt has been made to highlight some successful industrial symbiosis initiatives, there is still a long way to go when it comes to

mapping the current industrial symbiosis activities. Key challenges are thus to obtain an overview of what is really going on in other countries and different regions within them, as well as to further assess the types of support that the private sector needs and to transfer knowledge from successful industrial symbiosis cases, in order to expand the number of industrial symbiosis activities.

8) Sitra and other public actors working for the promotion of industrial symbiosis could support the formation of target market-specific solutions through industrial symbiosis.
9) As a way to promote actual demonstrations of industrial symbiosis (deemed critical for enabling industrial symbiosis solutions and the opening up of markets), Sitra should bring together industrial symbiosis solution providers with potential pilot environments and clients, both in Finland and abroad.
10) The efforts of promising SMEs to create industrial symbiosis ideas with good potential for internationalization in response to the global demand for industrial symbiosis should be supported through the use of business development tools, by making capital investments in companies and through sharing ideas on business development and internationalization.

6.7 Region of West Transdanubia

The following policy suggestions will support and promote industrial symbiosis and circular economy in Hungary and the Region of West Transdanubia:

1) Initialisation of efforts to prepare a national/regional plan for the development of industrial symbiosis, which will integrate European best practices with regards industrial symbiosis development in the reality of Hungary.
2) Inclusion of industrial symbiosis in the development planning of the region.
3) Realisation of an awareness raising and educational campaign to abandon sterotypes about green products and processes.

6.8 Netherlands

In 2016 a governmentProgramme on Circular Economy will be developed in close cooperation between at least four ministries – Infrastructure and the Environment; Economic Affairs; Foreign Affairs; and Interior and Kingdom Relations – under the leadership of the Ministry of Infrastructure and the Environment. It will combine and integrate the

circular economy policies of the different departments and will include the programme From Waste to Resource. In addition, the Dutch Cabinet wants to see 75% of domestic waste being separated by 2020, with no more than 100 kilograms of such waste per head of the population being produced annually. The 75% target is also a Cabinet ambition for comparable non-domestic waste. In combination with measures earlier in the value chain, there should be a 50% reduction in material losses, from 10 million to 5 million tonnes, over the next decade. Several measures on closing the value chains have been formulated, outlined below.

1) Removal of legal obstacles: taking stock of obstacles that entrepreneurs encounter when investing in innovation and ensuring that the solution to a particular problem is made available to the entrepreneur concerned. Dealing with complex obstacles can require international pilot projects.
2) Promote the use of end-of-waste and by-product criteria.
3) National criteria for assigning end-of-waste classification.
4) Regulatory criteria for by-products under the WFD: on April 1 2015, the

a) Ministerial Decree specifying the criteria for by-products under the WFD came into force. This Decree utilises the freedom offered by the WFD to classify production residues as a by-product instead of as waste. As a result, companies can more easily use production residues as a resource. For the time being, the Decree applies only to crude glycerin.

5) Optimum use of the EU Waste Shipment Regulation.
6) Promote innovation in the field of recycling: further promotion of innovation takes place within the context of the Netherlands' Agreement (covenant) for More and Better Recycling (Meer en Betere Recycling). This includes tree steps: produce a list of innovative recycling technologies that are suited to a circular economy; identify the barriers to the introduction of such innovations; and identify methods or instruments that can provide more encouragement for adopting such innovations.
7) Tailor norms or certification to the circular economy.
8) Promote high-value recycling: in collaboration with processing companies and the recycling industry, 20 collaborative projects are now ongoing thanks to the Agreement for More and Better Recycling, aimed at higher-volume recycling on the one hand and high-value recycling on the other. A project for defining and producing high-value recycling has been started within the context of the Agreement. Tenders

will be requested for the development of methodologies on which to base policy for high-value recycling of waste.

9) Encourage better waste separation at sorting facilities.
10) Sustainable use of bottom ash produced by waste-to-energy plants while making the reprocessing of bottom ash acceptable to society.
11) Collect more separated domestic waste: in collaboration with municipalities, a public framework for sustainable waste management has been defined, and an action programme for reducing the amount of residual waste has been set up.
12) Motivate private citizens to separate waste: campaigning and fitting actions to themes.
13) Separation of non-domestic waste: the aim of the VANG Buitenshuis programme is to achieve non-domestic waste separation, and hence bring about a widespread change in behaviour.

6.9 Summary matrix

The following matrix summarises the policy recommendations from the previous sections of this chapter and presents them according to their category in terms of the level of development of industrial symbiosis. The recommendations have been divided into the following four categories:

1. Economic recommendations refer to provision of financial/economic incentives for the advancement of industrial symbiosis.
2. Policy recommendations refer to changes in policy, regulation, and policy making procedures to achieve the advancement of industrial symbiosis.
3. Social recommendations refer to interventions designed to achieve social/stakeholder learning and change that will utlimately promote industrial symbiosis.
4. Environmental-technical recommendations refer to potential transformation of the production process that will facilitate the diffusion and expansion of industrial symbiosis and have environmental impacts.

Type of recommendation	Category 1 countries
Economic	1) Use financial subsidies and long-term incentives to: a. facilitate forms of cooperation between enterprises b. support investments related to replacement and renewal of machineries c. support regional industrial symbiosis development 2) Application of support measures for: a. the competitive development of by-products market, especially in the competition with the virgin raw materials market b. ensure resource security and supply in competitive prices 3) Reduction in taxes for: a. investments in the field of industrial symbiosis b. use of recycled products and by-products c. shifting towards circular economy and industrial symbiosis 4) Financial support to: a. the spreading of technological innovations (e.g. innovative waste management technologies) b. specific types of infrastructure development (e.g. online database of waste producers) to support industrial symbiosis. 5) Introduce financial mechanisms and / or incentives, also via using ESI Funds (the incentives should address the development of new business models, development of new production processes, new products and services, etc.)

Policy	1) Develop an integrated policy approach to industrial symbiosis, consisting of: a. Defining, at the national level, the concepts of industrial symbiosis, circular economy and secondary raw material market. b. Setting up the regulatory framework and strategy that will enable adoption of industrial symbiosis, transition to circular economy and development of secondary raw material market. 2) Provide specific tools related to industrial symbiosis in the ROP of each region 3) Design clear and explicit regulation for ensuring the appropriate use of by-products 4) Prepare an action set to secure industry access to non-energetic mineral resources (with specific consideration of circular economy and the resources policy) 5) Integrate the perspective of European Union initiatives related to the transition towards circular economy. 6) Develop roadmaps articulating step by step the process for the implementation of circular economy, specifying in particular the objectives and priorities together with their time horizon and institutions responsible for their implementation. 7) Develop an educational programme to increasing the awareness of public authorities' personnel about industrial symbiosis 8) Strengthen the implementation and enforcement of green public procurement in public sector (as well as in state owned companies).

Social	1) Provide well-structured information and training/formation processes to increase key players and stakeholders' awareness on industrial symbiosis and on potential benefits 2) Design and develop actions or programme agreements for the realization of information platforms or catalogues, listing companies scraps or wastes that can be provided as by-products to other organizations 3) Development of selective municipal waste collection which will provide high quality input materials for recycling processes. 4) Strengthen consumers' rights for having access to information on the products and their manufacturers in order to ensure product safety. 5) Increase the amount of research dedicated to industrial symbiosis in the research institutions of the area. 6) Realise an awareness raising and educational campaign to abandon sterotypes about green products and processes. 7) Trust-building process between companies, public sector and CSOs. 8) Introduce and capitalize on educational programmes. 9) Building value system and environmental culture friendly to industrial symbiosis 10) Support the establishment of business clusters, based on the principles of industrial symbiosis and circular economy.
Environmental-technical	1) Develop bio-waste treatment plants to change the collection system. 2) Develop and implement modern business models, as well as technological solutions allowing for the modernization of production processes or the products themselves using innovative solutions. 3) Utilise to a larger extent the digital models of products and digitalizing the supply chains (called "the 4th industrial revolution") 4) Produce in smart, cooperative factories with high flexibility, reliability and efficiency and where pieces of logistic information are automatically exchanged between main manufacturers and between suppliers and sales' networks. 5) Add industrial symbiosis in the principles of rational management of water resources in the area.
Type of	**Category 2 countries**

recommendation	
Economic	1) Design financial support systems for renewable energy 2) Develop an emissions' trading system 3) Earmark investments in favour of resource efficiency within EU's different funding schemes 4) Rethink the taxation system, i.e.: i) Lower taxes on labour in industrial symbiosis systems ii) Increase taxes on the consumption of non-renewable resources in the form of materials and fossil fuels 5) Carefully analysing and reform the VAT system, so that goods produced by secondary materials (where VAT has already been paid once) are exempted from VAT and the use of secondary materials is promoted (i.e. reuse and recycling) which will help correct a situation where it is often less expensive to use virgin materials than recycled ones 6) Increase investments in agriculture, forestry, timber, pulp and paper to promote biofuels and to develop new bio-based products
Policy	1) Design policy support systems for renewable energy 2) Adopt resource efficiency targets for materials where scarcity is looming or the overall environmental impact of resource extraction and use is significant 3) Review eco-design legislation 4) Improve energy efficiency standards 5) Develop targets for recycling of materials 6) Make more proactive use of public procurement 7) Improve the selective collection of waste

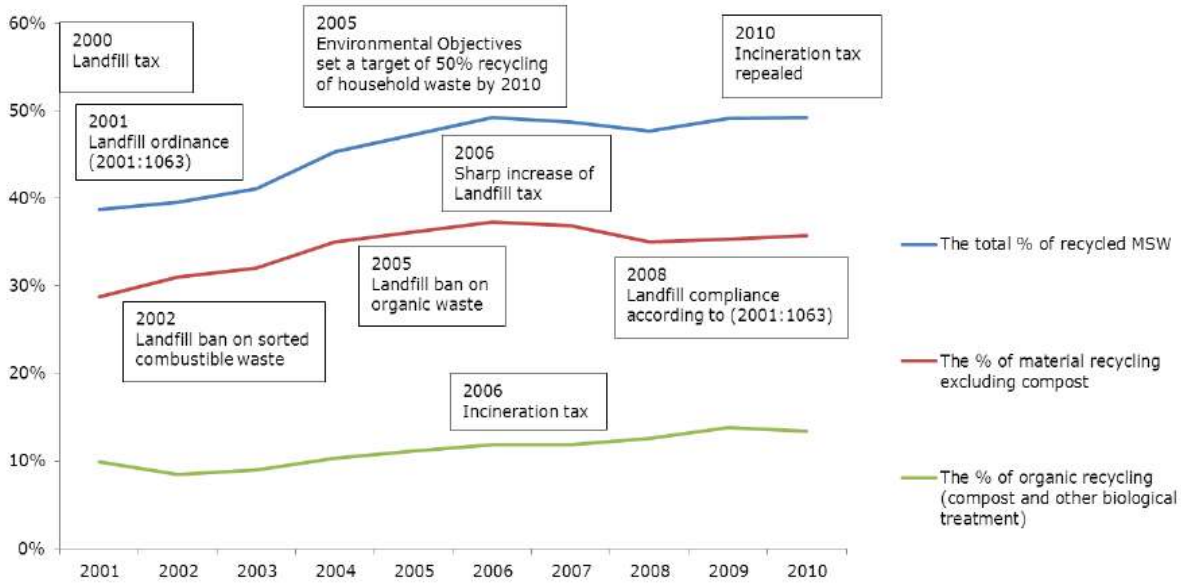
Social	1) Promote new business models geared at functional sales 2) Conduct awareness raising campaigns about recycling needs and improved waste management
Environmental-technical	1) Deliver installation services and construction/renovation works to promote energy-efficiency and renewable energy sources 2) Construct sustainable infrastructure concerning especially energy and transport, for instance mass-transit transport systems and electric vehicles and provide ways to charge them 3) Promote material-efficiency through maintenance and repair services and recycling 4) Promote engineering services to be able to meet the increased demand for new competencies in areas like product design, recycling and remanufacturing as well as new business models. 5) Reduce the amount of produced waste
Type of recommendation	**Category 3 countries**
Economic	1) Base industrial symbiosis development on private sector needs and actual demand for relevant inputs (i.e. the resources nominated for exchange) in the industries involved. Business opportunities should be the driving force behind the development of industrial symbiosis, meaning that it is essential that companies can achieve economic gains from industrial symbiosis activities. From this base, there will likely emerge new businesses and innovations. 2) Utilise the European Structural and Investment Funds that provide good opportunities to apply for industrial symbiosis projects focused on resource efficiency and innovation, and could be more widely used to support industrial symbiosis activities in Finnish regions.

Policy	1) To utilise the full dynamic and regional potential of industrial symbiosis, develop a long-term public support framework for circular economy and industrial symbiosis, including comprehensive and coherent strategies and binding objectives. 2) Ensure that local and regional authorities can and should support and facilitate the development of industrial symbiosis, for instance by promoting the development of networks/clusters based on local and regional strengths and helping to identify industrial symbiosis exchanges for which there is a good business case. 3) Ensure that Sitra and other public actors that work for the promotion of industrial symbiosis, could support the formation of target market-specific solutions through industrial symbiosis. 4) Obtain an overview of what is really going on in other countries and different regions within them 5) Disseminate knowledge about the opportunities related to industrial symbiosis.
Social	1) Facilitate the development of specialised companies and regional clusters that can play an important role in advancing and promoting industrial symbiosis in Finland. 2) Assess the types of support that the private sector needs and transfer knowledge from successful industrial symbiosis cases, in order to expand the number of industrial symbiosis activities. 3) Support the efforts of promising SMEs to create industrial symbiosis ideas with good potential for internationalization in response to the global demand for industrial symbiosis, through the use of business development tools, by making capital investments in companies and through sharing ideas on business development and internationalization.
Environmental-technical	1) Ensure that, as a way to promote actual demonstrations of industrial symbiosis (deemed critical for enabling industrial symbiosis solutions and the opening up of markets), Sitra should bring together industrial symbiosis solution providers with potential pilot environments and clients, both in Finland and abroad.

7 Discussion of the dynamics and the potential for growth and jobs of industrial symbiosis and circular economy

The development of industrial symbiosis in Europe started in Kalundborg, Denmark without the guidance of public authorities. Soon, however, the Danish public authorities saw the opportunity in terms of sustainability and economic efficiency, and started integrating industrial symbiosis in their development planning. After the endorsement of the EU Circular Economy Action Plan on behalf of the European Commission, industrial symbiosis will become a priority for the entirety of the European Union.

The Danish road towards developing industrial symbiosis can be considered an original archetype of such development. Industrial symbiosis starts without supervision in an industrial area and then, public authorities begin its integration in more and more national and/or regional development plans. That way, industrial symbiosis and, in general, the reutilisation of waste and by-products can help to achieve specific environmental targets such as for example a steady increase in recycling, as can be seen in the following image, which depicts the situation in Sweden:



However, this archetypical development of industrial symbiosis is not the most common practice nowadays. The endorsement of the Circular Economy Action Plan and the integration of industrial symbiosis and circular economy in national and regional development plans, signify that the speed of the development of these practices depends on

the quality supervision and incentivisation of relevant projects on behalf of public authorities. Hence, industrial symbiosis and circular economy depend on the existence of an efficient institutional interventionist system that takes into account and does not obstruct the priorities of the free market.

This conclusion is supported by the observation in the data that countries with the most efficient integration of industrial symbiosis and circular economy in their development plans have achieved a greater proliferation of industrial symbiosis and circular economy projects. Category 3 countries (e.g. Denmark, Finland, Sweden), that are the most developed in terms of industrial symbiosis and circular economy, have not limited themselves in developing plans for the integration of industrial symbiosis in their development strategies, but are now on the verge of developing managing authorities taylor-made to the management needs of these practices.

On the other hand, Category 1 countries that have not yet entirely integrated industrial symbiosis and circular economy in their development strategies, are the least developed in terms of these practices. Even though there are succesfull examples of development of industrial symbiosis (e.g. the Thriasion field in Greece), these are isolated examples. Category 2 countries lie between these two edges of the spectrum. Hence, it is safe to suggest that industrial symbiosis and circular economy do depend on the institutionalisation of a set of interventionist measures from public authorites taylor-made to the needs of the specific country and region and the characteristics of the markets for industrial products therein.

Furthermore, the data revealed that countries that achieve a fast pace of development of industrial symbiosis and circular economy are rewarded by an enhanced sustainable and economically efficient growth. More precisely, the benefits from the development of industrial symbiosis are the following:

1. Re-utilising waste and by-products can lead to significant reductions in costs of production. Reducing the costs can be a significant enabler of the creation of more jobs.
2. Reducing waste increases the sustainability of the development in a reggion.
3. Public employees familiar with the concepts of circular economy and industrial symbiosis are up to date with the latest innovations in public management. Hence, the whole public sector’s function could improve.

8 Research validation

SYMBI partners managed to collect data that meet their obligations according to the key performance indicators that can be seen in the following table and that were outlined in the Methodology to gather input on regional and national policies on industrial symbiosis and circular economy:

• Quantitative KPIs	• Qualitative KPIs
• Number of referenced data sources from academic journals or books: 3	• Data are relevant to the research questions of the enquiry
	• Data are provided in a form that can be compared
• Number of referenced data sources from other websites: 5	• Data are provided in a form that can be synthesised for the final deliverable of the enquiry
	• Conclusions derived from the data form a rigorous and coherent narrative to avoid significant contradictions

The following table describes the performances of SYMBI partners compared to the quantitative KPIs. All the partners responsible for data collection managed to gather sufficient data, with the exception of SVRK that gathered one less source from websites than the KPI:

Data collection performance				
Partner	**Performance**		**KPI**	
	Sources from academic journals or	*Sources from other websites:*	*Sources from academic journals or*	*Sources from other websites:*

	books:		*books:*	
Andalusia - Spain	7	6	3	5
Häme - Finland	3	9	3	5
Kozani - Greece	4	6	3	5
Malopolska - Poland	5	14	3	5
Molise - Italy	6	20	3	5
PANNON NOVUM - Hungary	1	1	3	5
SVRK - Slovenia	10	4	3	5

It is evident that partners outperformed expectations about the data collection. SVRK's lack of one data source from websites is more than covered by the fact that it managed to gather thrice the number of prerequired data sources from academic journals or books.

Moving on now to the qualitative KPIs, the detailed analysis and policy recommendations of the previous pages demonstrate that the data gathered were relevant, comparable, synthesisable and concise, and hence, they abide by the requirements of the qualitative KPIs of the research.