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RECYCLING BUSINESS MODELS

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State of Circular Economy Among SME's in Science and Technology Parks and Suggestions for Circular Economy Loops

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Johanneberg Science Park

PACT PARQUE DO ALENTEJO DE CIÊNCIA E TECNOLOGIA

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1 Introduction

An eco-industrial park is an area where companies work together to optimize the use of resources. This synergy between industries promotes economic benefits and contributes to sustainable development.

The main objective of the Project Recycling Business Models (RBM) is to investigate and analyse the possibility of transforming traditional science and technology parks into more sustainable areas, to establish the basis for eco-science models and technology parks, including the creation of circular maps of companies within science and technology parks.

Our goal is to create a specific methodology and strategy to drive the creation of new business opportunities for SMEs and the creation of new companies, based on the revaluation of waste, equipment, and its reincorporation in the life cycle of companies located in science and technology parks.

This report is based on the work carried out in Activity 2 of the RBM Project, including a survey aimed at small and medium-sized enterprises (SME's) residing in Science and Technology Parks (STP's) to learn about the state of practice in circular economy as well as the barriers and drivers and the opportunities that this model can bring to the development and competitiveness of companies.

The survey addressed firms residing in STP's in each participating region (partners and associates) and addressed topics such as quantities and types of waste produced, waste management/recycling practices and attitudes and ambitions concerning Circular Economy. In total, 53 companies responded to the survey. The collected data was analysed and compiled in the present document.

2 Results of company Survey

2.1 Typology of respondents

2.1.1 Geography

Out of the 53 received responses to the questionnaire, more than half were originated in Portugal, 16 in Spain and 9 in Sweden (Figure 1).

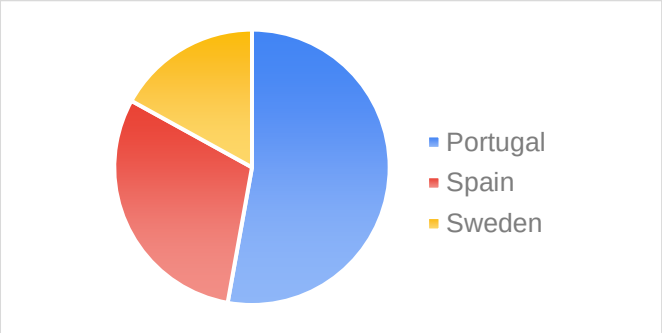

Figure 1. Geographical distribution of respondents

2.1.2 Size

Most companies responding were micro companies (10 or fewer employees), followed by mid-sized (50-249 employees) and finally large enterprises (250 or more employees), see Figure 2.

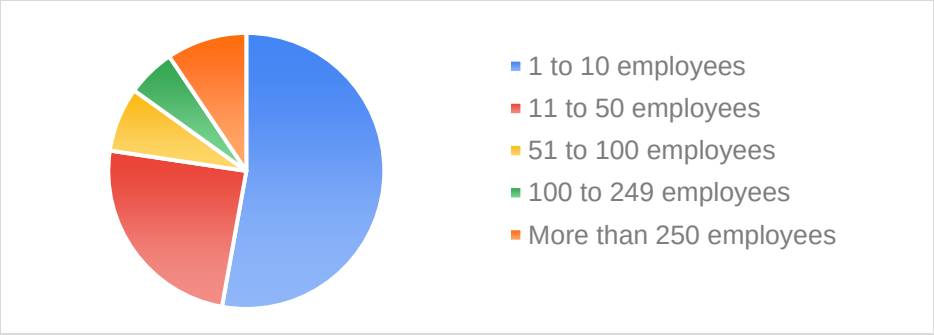

Figure 2. Size distribution of respondents

2.1.3 Sector

Respondents came from a wide range of sectors with some preference to Information and Communications Technology, Research and Development and Software, Computer and Electronics (Figure 3).

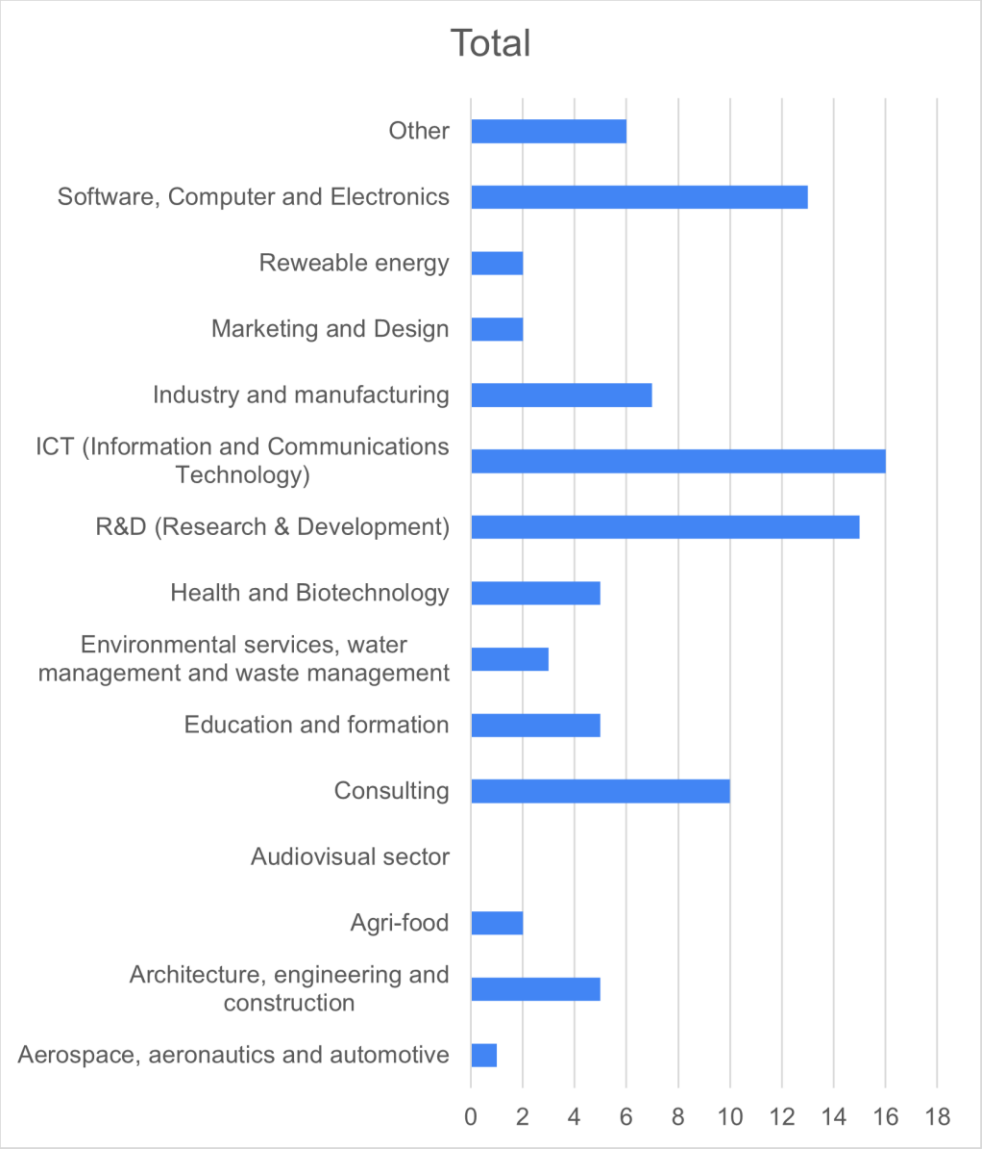

Figure 3, Sectorial distribution of respondents

2.1.4 Resource Usage and Waste Streams

One objective of the survey was to investigate typical waste streams produced by companies in Science and Technology Parks (SPT's). It should be noted that this is very much dependent on the nature of the STP. Some STP's offer exclusively or predominantly office premises, which will limit the scope of activities carried out and thus the kind of resources used and waste produced, whereas more industrially oriented parks will deal with a wider range of materials and waste streams.

The three main resources which represent more than 50% of the total amount of resources are firstly electronic material, then electricity, paper, and cardboard, followed very closely by batteries and heating. Typical waste categories also include organic waste, plastic, and glass.

2.1.5 How frequently is waste generated?

The frequency with which waste is generated differs significantly between different categories of waste. Paper and cardboard, organic waste and plastic are the categories most frequently generated, whereas batteries and metal waste are very infrequently generated (Figure 4).

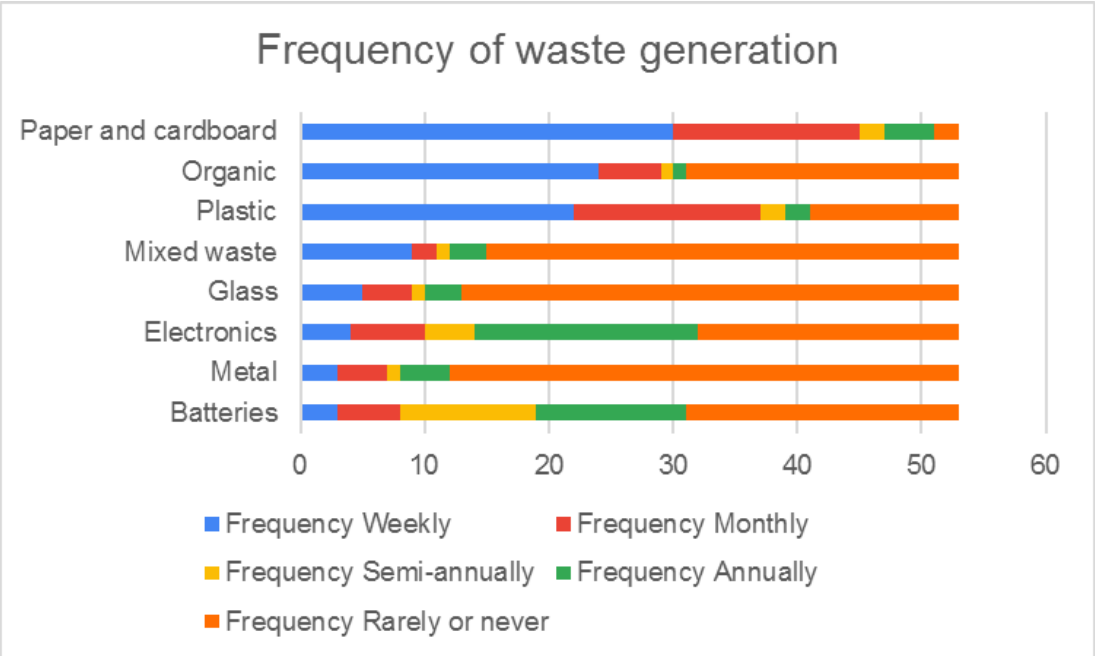

Figure 4. Frequency of generation of different waste categories

2.1.6 Quantities of waste

Respondents were asked about the amount (volume) generated each time according to the frequency stated in Figure 4. This data was used to calculate an estimated average annual waste amount for the different categories (Figure 5).

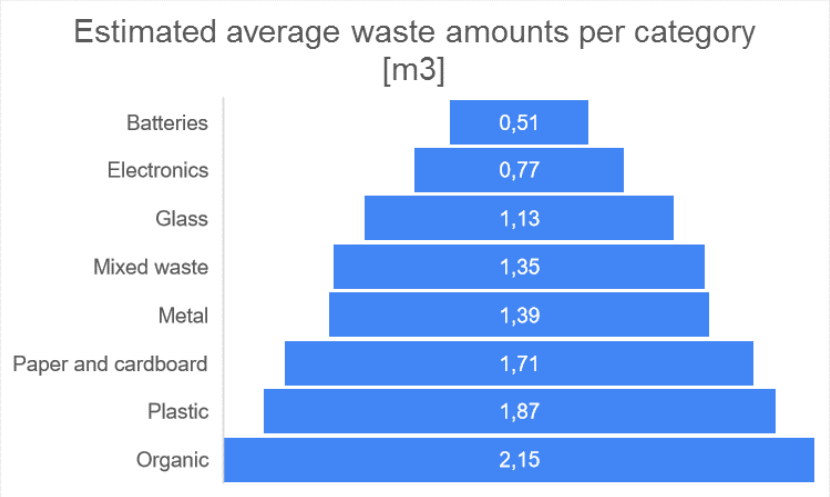

Figure 5. Estimated average annual waste volumes per category

2.1.7 Waste collection procedures

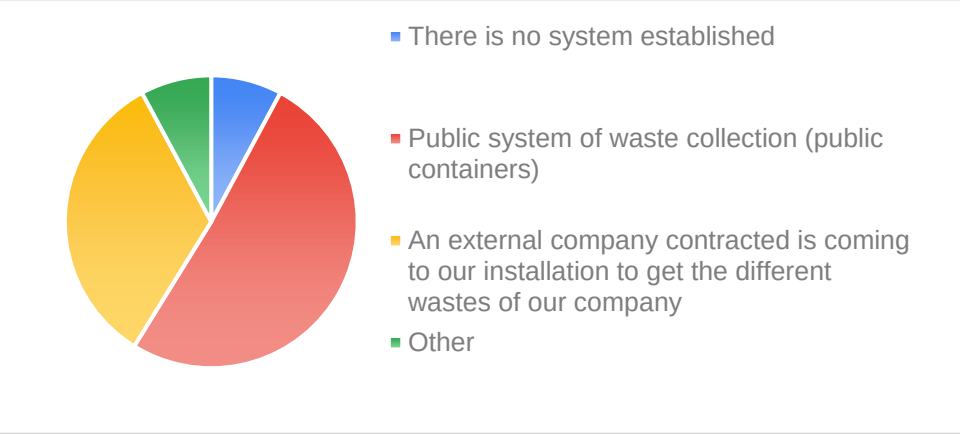

Figure 6. Waste collection procedures among respondents

As can be seen in Figure 6, about half of the respondents have their waste collected by public services, about a third employ an external contractor, and the remainder use other services or do not use any service at all.

2.1.8 Companies' waste management systems

Waste management systems in the responding companies mainly consist of sorting in bins, on the company premises or adjacent, according to type of waste (Figure 7). It is noteworthy that 17 % of the respondents' state that they do not have any system for waste sorting or management.

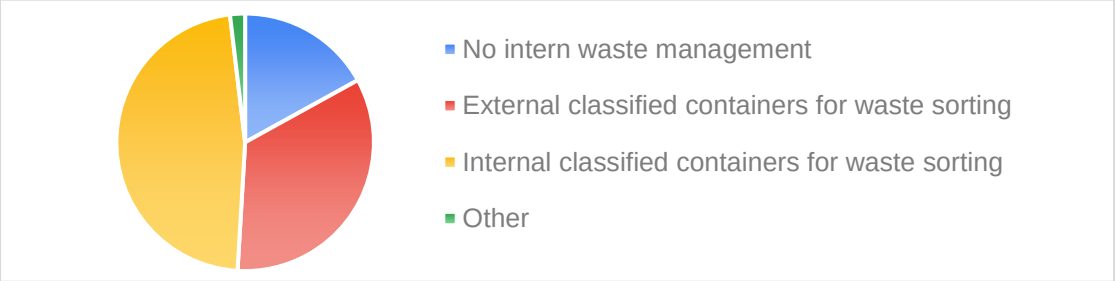

Figure 7. Waste management systems used by respondents

This is perhaps reflected in the ambitions to improve waste management, where 40 % of the respondents' state that they have such plans, where reducing total waste amounts and improve the internal system for waste handling share the first place.

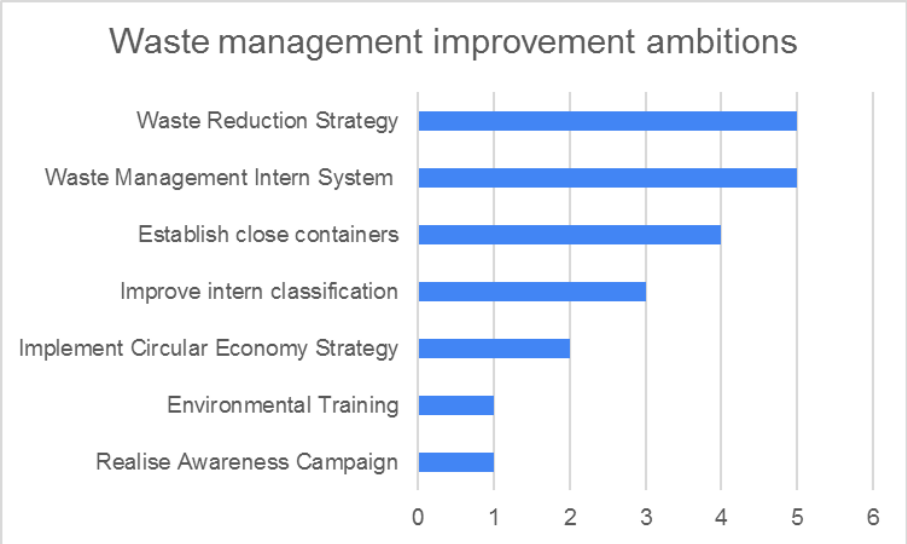

Figure 8. Improvement ambitions for waste handling in respondents (21/53 companies)

3 Barriers and Drivers for Circular Economy

3.1 Barriers

The respondents state several barriers to implementing circular economy (CE) in their practices (Figure 9), the most frequent being financial barriers, which are caused by the inability to forecast the possible financial benefits and costs from implementing CE practices. Other frequent barriers are the negative attitudes towards and lack of knowledge about sustainability issues as well as risk aversion strategies. Lack of information about the structure of value/waste chains and issues about not having control over one's processes also play a large role. Other barriers include technological, as in having to re-design products and processes, or legislative (lack of regulatory support).

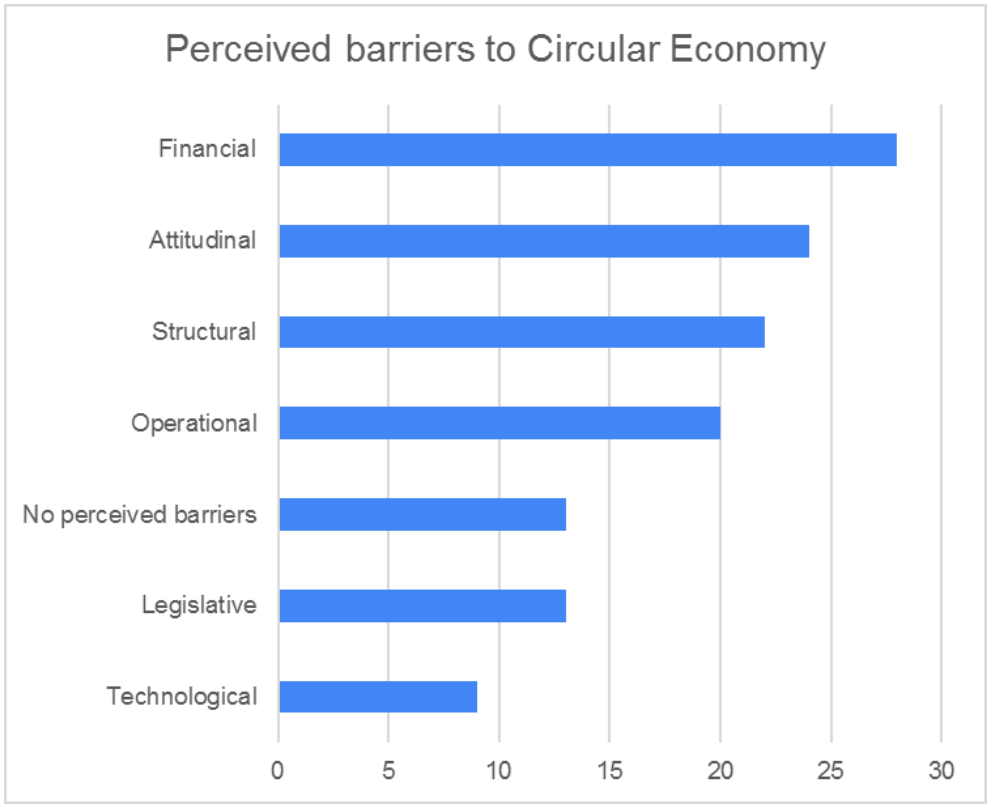

Figure 9. Perceived barriers to practising CE

3.2 Opportunities for the CE and the overcoming of barriers

Besides the barriers, many opportunities relate to increasing CE activities (Figure 10), the most frequently cited being to reduce environmental impact. The firm's image and reputation as a progressive and sustainable business also plays an important role. It is interesting to note, however, that opportunities relating to profit and growth (cost savings, competitiveness, economic growth, and job creation) together make up 60 % of the total designations.

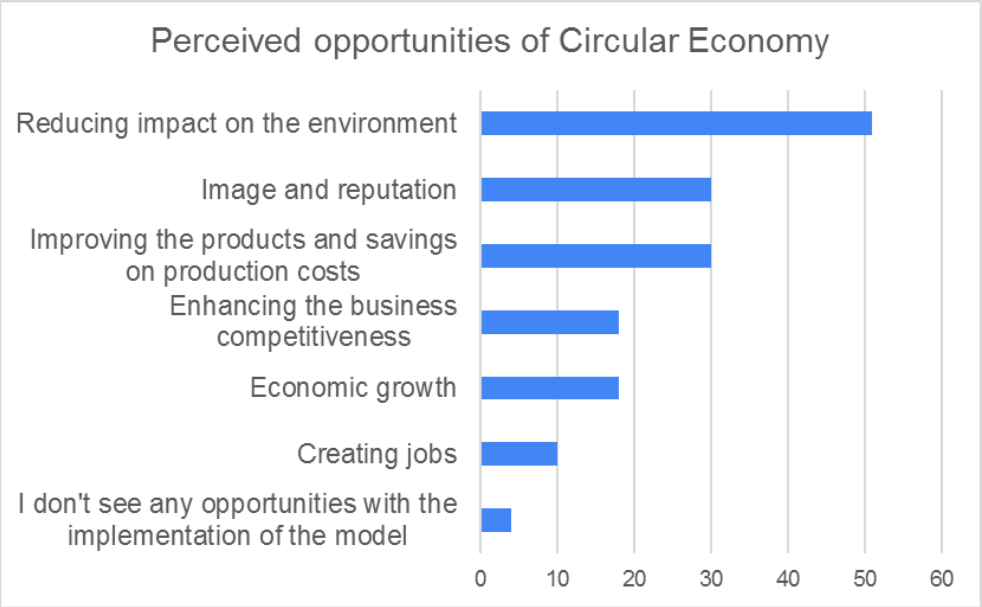

Figure 10. Perceived opportunities of practising Circular Economy

3.2.1 Financial benefits of Circular Economy

The Circular Economy has benefits that are operational as well as strategic and brings together a huge potential for value creation within the economical, business, environmental and societal spheres

Circular Economy can bring savings to businesses and consumers through improved resource efficiency. In 2015, the Ellen MacArthur Foundation report estimate that by 2030, a shift towards a Circular Economy could reduce net resource spending in the EU by €600 billion annually, bringing total benefits estimated at €1.8 trillion per year once multiplier effects are

accounted for. Additionally, research suggests that stricter environmental legislation can provide a competitive advantage to businesses.

However, the barriers associated with the adoption of a circular economy, namely financial barriers, are not undeniable.

In response to this, the "Handbook about Circular Economy Opportunities for SMEs and companies", created within the scope of the RBM Project, identifies funding opportunities for companies and institutions that aim to "take off" and accelerate the transition to a more circular economy. The handbook also refers to the National & European Frameworks, and "Green" Action Plans.

Other documents, as the 'Money makes the world go round' report, and the Financing the circular economy - Capturing the opportunity, provide directions for overcoming financial barriers that circular businesses encounter and bring new analysis that highlights the rapid growth in circular economy financing and investment across asset classes and sectors, and show that there has been a tenfold increase in the number of private market funds, including venture capital, private equity and private debt, investing in circular economy activities. Also, the financial sector is starting to capture the circular economy opportunity.

It is pointed out that barriers can be overcome or mitigated through the:

- Creation of legislation and regulations on waste matters.
- Creation of markets for secondary raw materials.
- Support for innovation, research and investment in sectors defined as critical to the Circular Economy.
- Investments in more efficient infrastructure and products.
- Adequate regulation for each sector of activity.
- Fiscal and financial incentives that promote activities related to the Circular Economy.
- Collaboration between economic agents and decision-makers.
- Increase in the dynamic tax burden on the extractive industry.
- Reduction of the tax burden on certain products (such as VAT).
- Changing mentalities and increasing environmental awareness.
- Fostering synergies along the production chain.

3.3 How important is it to be sustainable?

For companies to embark on CE-related activities we have seen that becoming more sustainable is a dominating driver. But how do the companies rank sustainability in relation to their future growth strategy? Again, there are some national differences as can be seen in Figure 11. In all three countries, about the same proportion of respondents, around 45 % rate

this as a “strong influence”, whereas in Sweden, more companies state “minimal” or no influence compared to Spain and Portugal. Effectively, however, one could expect the companies in the “strong” category to be the most likely candidates for transitioning to more circular practices.

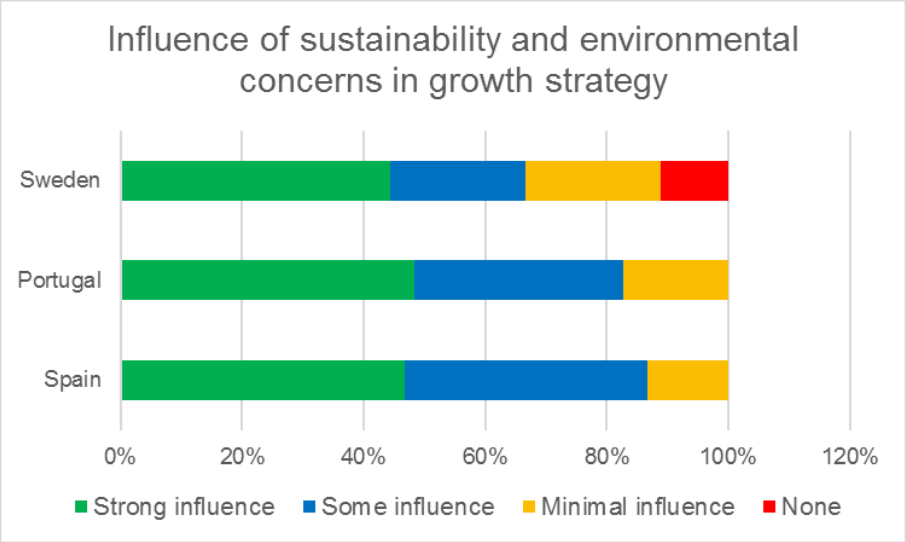

Figure 11. Influence of sustainability and environmental concerns in growth strategy among respondents

3.4 Circular Economy and the Covid-19 recovery

Perhaps paradoxically, many hope that the recovery from the Covid-19 pandemic can be used as a vehicle to speed up the transformation to a green society, powered by the enormous financial resources that have been made available to support the economy.

The Swedish government, for instance, has proposed several major industrial initiatives in its 2021 budget, including green credit guarantees and the “Green Industry Leap”, which will “allow more investments in facilities that reduce industrial emissions and contribute to the transition to a fossil-free and circular society”.

In spring 2020 the spread of the COVID-19 virus and the resulting economic crisis have had a severe impact on the Swedish society as in the rest of the planet. The world after the pandemic will not be what it was before the crisis. This enables the governments to contribute more intensively to a transition to a circular economy through a green recovery. As one of the world’s most innovative countries, Sweden has good prospects of addressing this transition. Important steps can be taken to strengthen Sweden’s competitiveness through technological development and innovation for circular solutions.

Many Swedish companies already see the potential in transitioning their businesses to a more resource-efficient, non-toxic, circular, and bio-based economy. All of this also provides

advantages in the global market, where Swedish companies can export the products and services in demand as the world transitions. This will create more companies and new jobs and enhance welfare, while reducing environmental impacts.

In this context, the Portuguese Government proposes in its state budget for 2021, a set of initiatives that will have the main focus of mitigating, adapting and accelerating the performance in energy transition, sustainable mobility, circular economy and the valorisation of natural capital, of the territory and forests, promoting sustainable investment and promoting initiatives that facilitate this transition, such as sustainable financing, green taxation and environmental education. There will be strong complementarity with the new Multiannual Financial Framework according to the type of investment. Companies will also be considered in terms of decarbonisation and the circular economy.

Through Financing mechanisms such as *Banco Português de Fomento*, the government aims to provide solutions and advice that reinforce the supply of financing instruments to the economy, always pursuing the aims of digitalization, decarbonization and the circular economy, thus increasing productivity and resilience of the Portuguese business fabric.

In 2021, the Environmental Fund (FA) (with a stipulated budget of 2 million euros), will integrate the Fund for Energy Efficiency, the Permanent Forest Fund, the Fund for Systemic Sustainability of the Energy Sector, and the Fund to Support Innovation. Other financing mechanisms such as the Fund for Innovation, Technology and Circular Economy (3 138 888 €) and IAPMEI - Agency for Competitiveness and Innovation (69 235 646 646), will also support the creation of greener companies as well as the transition existing ones for a more circular economy. In addition to these mechanisms, there are other supports already available for Portuguese SMEs in the recovery of Covid-9, such as the Covid-19 Helplines.

In the Handbook "Handbook about Circular Economy Opportunities for SMEs and companies", other support mechanisms are also mentioned.

As published in the ***European Circular Economy Stakeholder Platform***, at the beginning of June 2020 the Spanish Government published España Circular 2030, the new Strategy for Circular Economy in Spain until 2030. It contains circular economy objectives and a series of strategic orientations for the period 2020-2030 (Fig. 23).

The strategy includes the following concerns:

- sets up a series of objectives for 2020-2030 which will, inter alia, allow a 30% reduction in the national consumption of resources and a 15% reduction in waste generation (as compared to 2010).
- contributes to Spain's efforts to transition to a sustainable, decarbonized, resource-efficient and competitive economy.
- takes the form of successive three-year action plans providing for concrete measures to deliver on circular economy.

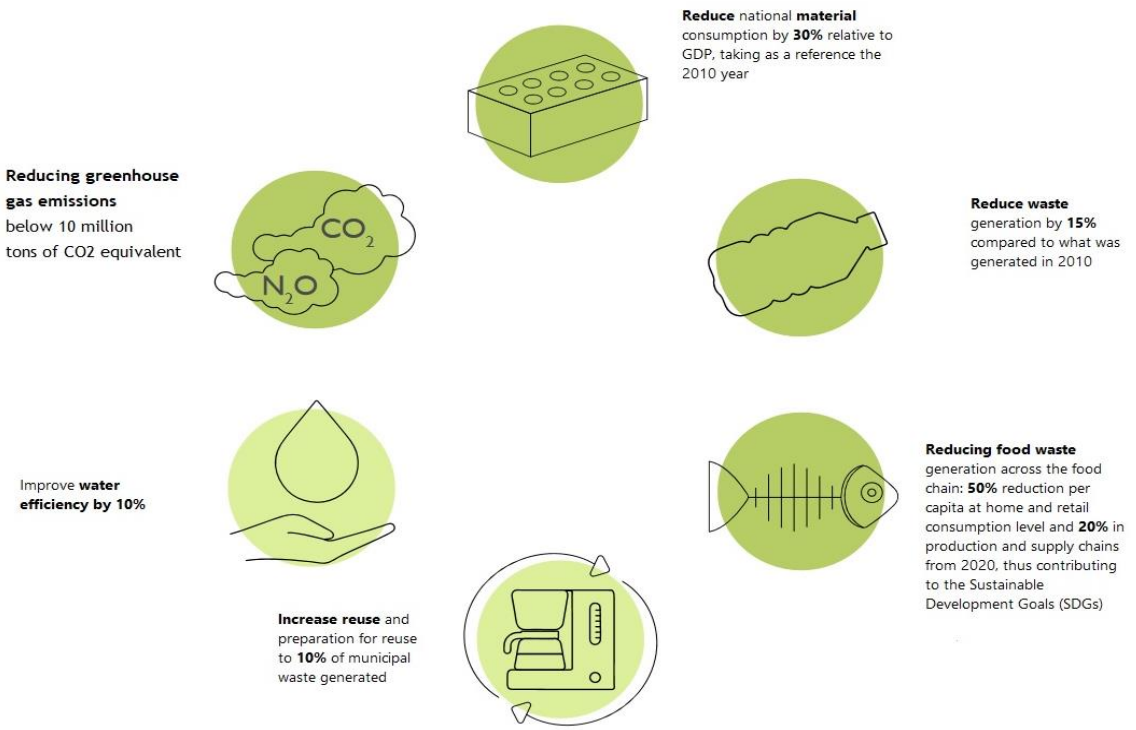

Figure 13, Circular Economy Strategy

The Ellen MacArthur Foundation in its paper titled "The circular economy: a transformative Covid-19 recovery strategy: How policymakers can pave the way to a low carbon, prosperous future" (Ellen MacArthur Foundation, October 2020), proposes a number of policies that will set a common direction of travel, foster collaboration, shape incentives and unlock circular investment opportunities for a circular, low-carbon economy. The paper identifies investment opportunities in the following areas:

- The built environment
    - Renovation and upgrade of buildings
    - Building material reuse and recycling opportunities
- Mobility
    - Multimodal mobility infrastructure
    - Automotive refurbishment, remanufacturing, and repair infrastructure
- Plastic packaging
    - Innovative reuse business models for plastic packaging
    - Plastic collection, sorting, and recycling infrastructure

- Fashion
    - Rental and resale business models for clothing
    - Clothing collection, sorting, and recycling infrastructure
- Food
    - Tools enabling farmers to shift to regenerative agricultural production
    - Food surplus and by-product collection, redistribution, and valorisation infrastructure

In the next section we will examine some opportunities to design circular value streams in some of the above areas.

4 Opportunities for New Value Streams

In this section, ideas and examples are offered concerning some of the important waste categories treated in the preceding section. These value streams offer the possibility of closing the loop and achieving a more circular system

4.1 A plastics closed-loop economy

The fact that plastics do not break down but accumulate in our ecosystems is a major environmental problem. According to one estimate only about 20 % of plastics are being recycled globally today, whereas the major part is being put in landfills or simply abandoned, in all likelihood ending up in the oceans (Figure 12). Other estimates state even lower proportions of recycling. Recycling of plastics can be done in several ways, the most common today involving mechanical treatment (milling) and re-melting. This process has drawbacks, for instance in that that it requires the plastic to be recycled to be cleaned and sorted according to polymer type. Moreover, it will generally yield a product which is lower in quality than the virgin material (Figure 13).

Chemical recycling of plastics is a new and possibly promising technology, where the plastics are turned into a gas mixture (Fig.17), which can then be recycled at a molecular level, rendering materials with the same quality as the virgin material. This method could be applied in a cost-effective way in large-scale petrochemical plants. However, chemical recycling has yet to see wide-spread commercial applications and there are concerns for instance about toxic substances being released in the process, as well as the overall carbon efficiency.

Figure 13 shows the material flows for each of the recycling technologies.

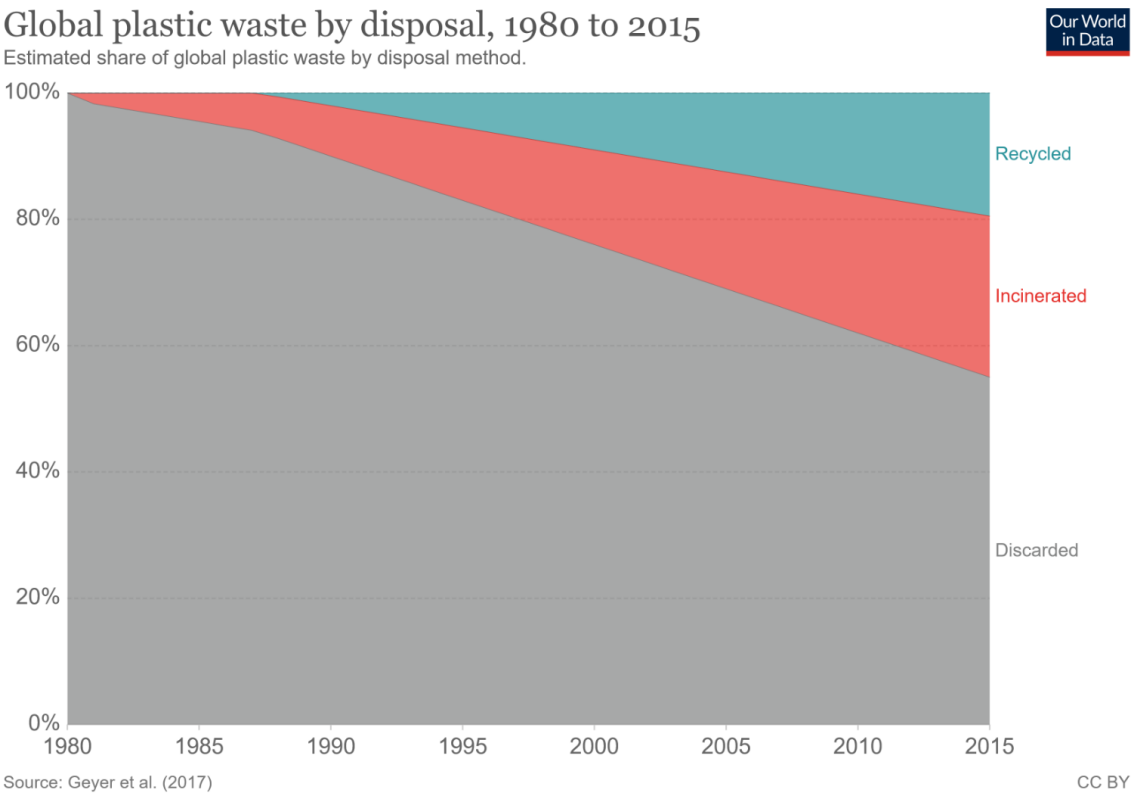

Figure 12. Global fate of plastics (from Geyer et al 2017)

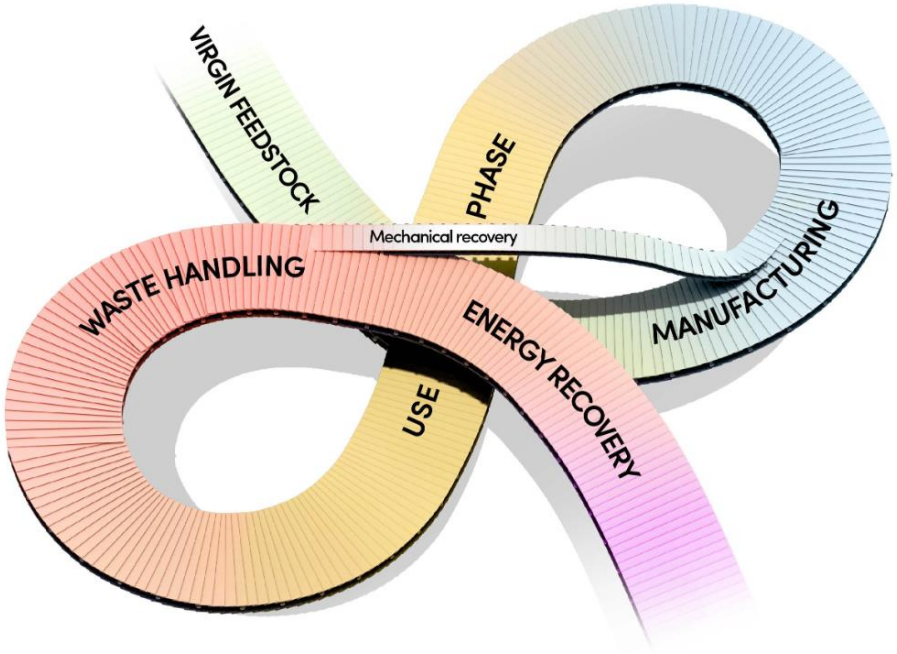

Figure 13. Mechanical recycling of plastics (Chalmers)

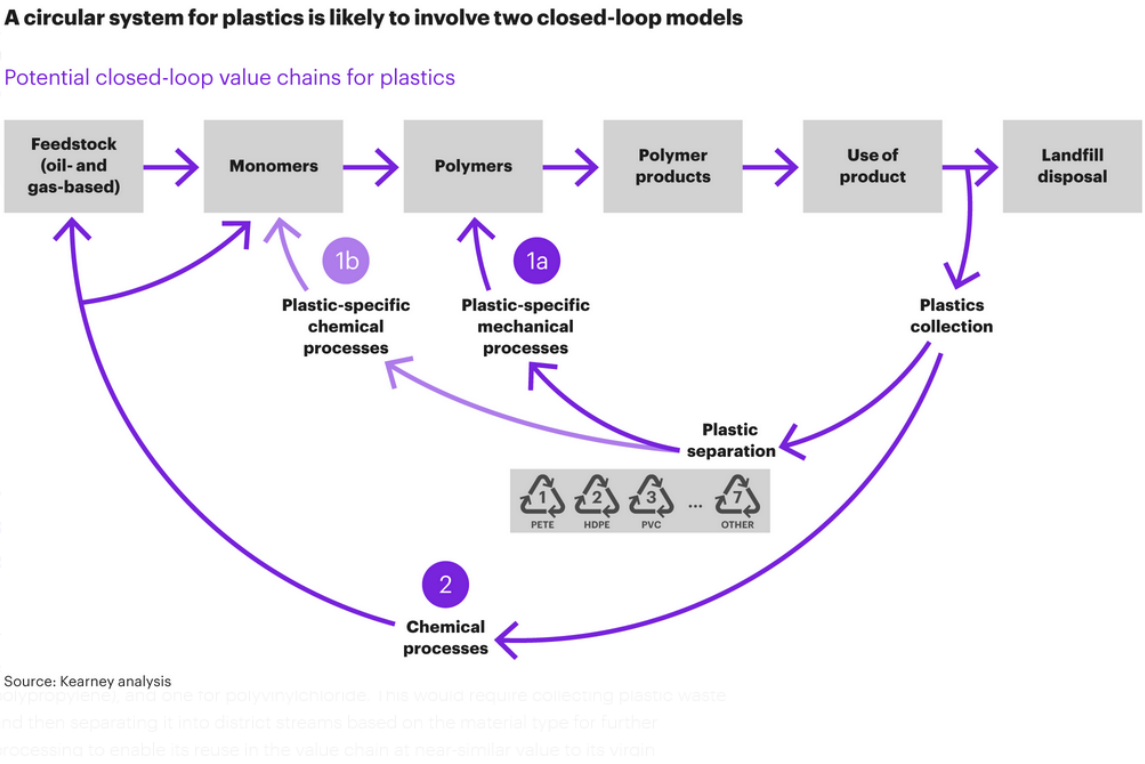

Figure 17. Schematic of a closed-loop plastics system (from Kearney)

4.2 Organic material and food waste

Recycling of food waste can be done in many ways (Figure 14), the most preferably being not to waste the food in the first place. Animal feed, anaerobic digestion (fermentation) and incineration are other typical endpoints of food waste.

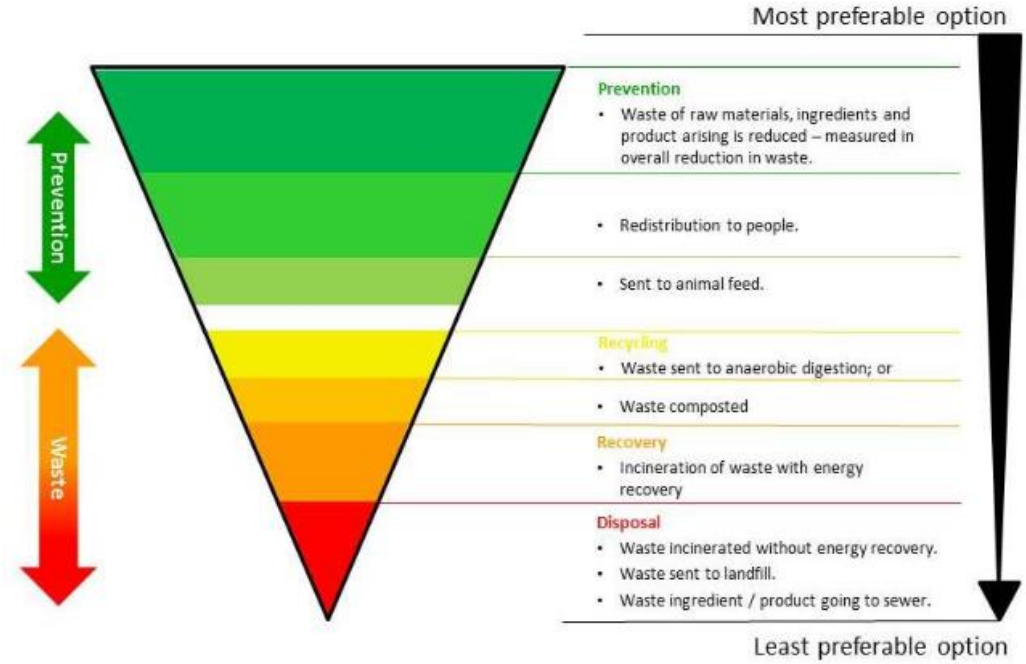

Figure 14. Recycling options for food waste (WRAP 2016)

4.2.1 Preventing food waste

Recent years have seen an upsurge of "food-saving" apps. Many of these aim at reducing food waste in restaurants by finding outlet for excess food that would otherwise be thrown away. Apps such as ResQ, Too Good to Go and Karma (Figure 15) connect restaurants with buyers and make it easy and convenient to purchase left-over food at a reduced price. Others, like FoodCloud and Re-food, connect retailers with charities to donate unsold food.

Other apps focus on the food management in households, matching recipes to the products currently in stock, or on connecting farmers and consumers to cut potentially wasteful steps out of the value chain.

Figure 15. Swedish food-waste app Karma

4.2.2 Regulatory issues

In many countries, regulations concerning food safety have not been written with the concept of "food rescue" in mind, and therefore may limit the possibilities of selling or distributing food outside of the normal channels.

Food waste is a significant environmental, social, and economic problem. To prevent food waste, both the EU and UN have encouraged grocery stores to donate rather than waste edible foodstuffs that are unable to be sold.

However, the foodstuff legislation causes problems. Especially the ambiguous regulations, liability legislation and tax legislation discourage companies from donating foodstuffs. The current legislation is ambiguous, and many stakeholders cannot determine the relevant legislation that applies to them and find it hard to interpret its terms. This may lead to potential donors choosing not to take part in food redistribution. Another consequence of the legislative ambiguities is that foodstuffs are being thrown away needlessly because of the legislation regarding date marking. To address these problems, the EU has published several documents in an attempt to clarify the legislation.

The current EU tax legislation leads to food waste as donors have to pay VAT when donating foodstuffs. In other words, donors have to pay for their unwanted foodstuffs to be donated, making throwing away the food cheaper. The EU Commission has encouraged the EU member states to interpret the tax legislation in a way that the VAT is lowered, but Sweden, for instance, has not acquiesced. Similarly, the liability regulation deters potential donors from

donating foodstuffs, because of potential fines in the case of a final consumer suffering injury, as well as the resulting damage to company reputation.

The EU has therefore suggested introducing a legal principle that excludes the possibility of keeping donors liable for injuries in cases where the donors have donated foodstuffs in good faith. The principle would also exclude liability from recipients (food banks) who are a part of the redistribution of the foodstuffs. It is possible that the proposed principle would increase the amount of food donations, but the principle might also lead to exposed persons who get foodstuffs redistributed to them becoming even more exposed as they would not have anyone to hold liable for potential injuries. It is a consequential political question that must be weighed carefully.

4.3 Biogas as automotive fuel

In Sweden, there are over 200 filling stations offering CNG (Compressed Natural Gas) as fuel. The CNG on sale in Sweden consists of 95 % biogas, made from fermentation of organic waste, such as household food waste, sewage sludge and waste from food industries and slaughterhouses (Figure 16). Many municipalities in Sweden have introduced waste sorting systems where organic waste from households is being turned into biogas. Biogas has a 97 % methane content and as a fuel will reduce CO_2 emissions by 80-90 % compared to regular petrol. Also, sulphurous, nitrous oxides and particle emissions are greatly reduced.

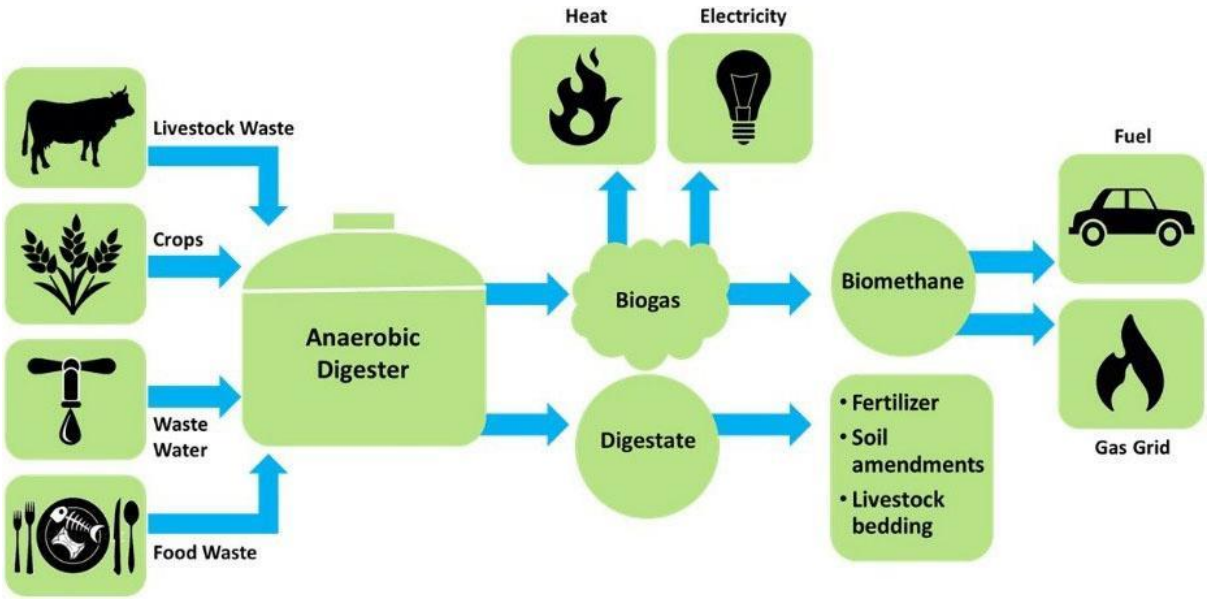

Figure 16. Biogas digestion process (from EESI)

4.4 Examples of Circular Business Models

Name of the company / initiative: Circula - Decoramos Reciclando

Link: www.circula.eu

Place: Málaga, Spain

Short Description: The company makes thermal-insulating and sound-diffusing decorative panels, outdoor & interior furniture, as well as urban orchards structure from recycled wood.

Art in Wood

Circula manufactures decorative panels that act as thermal insulators and sound diffusers with recycled wood

Light and Wood

With recycled wood the company creates panels, lighting, and backlit decoration, with Led technology and the best qualities

Carpentry

Circula produces pots, signs for routes and events, bird houses, outdoor and interior furniture...

Urban Orchards

They build urban and school gardens

Figure 24 Recycled wood products

The company, dedicated to carpentry with 100% recycled wood, is in an early stage. The raw material is coming both from industrial origin and driftwood (beach collection). Circula has made garden furniture and crops tables for urban orchards, and now they are focusing on the production of thermal-insulating and sound-diffusing decorative panels.

Name of the company / initiative: Caterpillar - Cat Reman

Link: https://www.cat.com/en_US/products/new/parts/reman.html

Place: Wordwide with a demonstration and learning centre in Málaga, Spain

Short Description: Remanufacturing takes advantage of the second life built into Cat® diesel engine parts and other components, returning used parts to like-new condition—sometimes even better. At Caterpillar, remanufacturing is not rebuilding, recycling, refurbishing, reconditioning, repairing, overhauling, or down-cycling. It is better. All Cat Reman engines and components are:

- Disassembled to their smallest parts, losing their original identity
- Cleaned to remove even microscopic debris
- Inspected for imperfections and cracks
- State-of-the-art technology is used to salvage otherwise scrap parts
- Assembled into like-new components with all engineering updates
- Tested to the same standards as new Cat parts
- Backed by a same-as-new parts warranty

CAT Reman

Name of the company / initiative: Reciclados Roster

Link: http://www.recicladosroster.com/

Place: Málaga, Spain

Short Description: Reciclados Roster is a company specialized in the collection of materials and sale of recycled aggregates. Its main activity is based on offering waste collection services and other waste management services.

Construction Surplus

They collect surplus works from excavations, demolition remains, etc.

Asphalt

Reciclados Roste extracts old asphalt from roads to recycle and reuse it in the construction of new asphalt pavements.

Soil

They transport soil from constructions, renovations or demolitions of public works or buildings.

Sand

The company collects sands from constructions, demolitions, and renovations to recycle it in their facilities.

The city of Malaga is one of the pioneering cities where there are precise usage specifications for recycled aggregates. In addition, this plan is being used in cities such as Madrid, Bilbao, Mallorca, and Barcelona in Spain. Malaga is indeed one of the leading areas of southern Europe in the standardization of the use of recycled aggregates and their integration into green purchasing processes. In addition, the city promotes the increase in the production and marketing of these aggregates to prevent the extraction of natural raw materials, always ensuring their quality.

According to the European Commission, Construction, and demolition waste (CDW) is one of the heaviest and most voluminous waste streams generated in the EU. It accounts for approximately 25% - 30% of all waste generated in the EU and consists of numerous materials, including concrete, bricks, gypsum, wood, glass, metals, plastic, solvents, asbestos and excavated soil, many of which can be recycled. CDW has been identified as a priority waste stream by the European Union. There is a high potential for recycling and re-use of CDW since some of its components have a high resource value. Such as the example of the company Reciclados Roster, there is a re-use market for aggregates derived from CDW waste in roads, drainage, and other construction projects. Technology for the separation and recovery of construction and demolition waste is well established, readily accessible and in general inexpensive.

Name of the company / initiative: SPAWNFOAM

Link: https://www.spawnfoam.pt/en/

Place: Regia Douro Park - Science and Technology Park of Vila Real, Portugal

Short Description: The company produces **Biomaterials** that combine natural elements: organic waste, agroforestry, and an organic adhesive; Eco-friendly biomaterials; biomaterials cost effective; biomaterials with good design; biomaterials that extend the useful life of natural resources. After use, or at the end of the life cycle, these products can be dumped into the soil, as they serve as fertilizers. The biocomposites can be used for everything. The multifaceted nature of Spawnfoam biocomposites makes it possible to transform them into a multitude of products (fig. 19). The company is however currently focusing on specific segments as a way of entering the international market. These include:

- Transplantation pots.
- Insulation for construction.
- Packaging.
- Decoration.

Figure 29 Spawnfoam products: pots and containers (left), Construction panels (center) and ornamental pots (right).

The “Spawnfoam” idea emerged in 2013 with the objective of changing the paradigm of production and consumption of composites and materials derived from petroleum, such as plastics, presenting a competitive alternative of organic and biodegradable origin. The biotechnology company has its headquarters in the Regia Douro Park - Science and Technology Park of Vila Real, in the north of Portugal, and aims to increase the planet's sustainability, efficiency in the use of resources and, consequently, for the transition to an Circular Economy. The products the company produces are forest vases and containers, construction panels and ornamental pots.

Spawnfoam's activity contributes to sustainability in two ways: by valuing end-of-life materials, such as forest and agricultural by-products, Spawnfoam avoids increasing the consumption of finite and polluting raw materials, while simultaneously reducing the need for use of plastic products.

Of the 5.281 million tonnes (t) of Urban Waste produced in Portugal in 2019, it is estimated that about 40% are bio-waste, comprising food waste and green waste. Much of this bio-waste is sent to landfills.

This diversion of biodegradable urban waste (RUB) to landfills is an urgent objective since organic waste is the one with the greatest emission potential, constituting a fraction with an increased environmental impact.

The prevention and enhancement of bio-waste plays an important role in closing nutrient cycles, in preserving biodiversity, in reducing anthropogenic emissions of greenhouse gases (GHG) and in the materialization of a sustainable bioeconomy. As such, these aspects are particularly important in important European and National strategies.

In addition to the most common recovery methods (eg production of agricultural fertilizers), Spawnfoam, through eco-innovation and eco-design, makes it possible to return these residues to the beginning of the production cycle, creating a new 100% biodegradable biocomposite material which effectively acts as an environmentally friendly plastic substitute.

The products contribute to greater environmental sustainability, decarbonization and reduced ecological footprint.

Spawnfoam relies on a network of partners to obtain raw material, technology validation, product design and marketing. As research and development partners, they have the University of Trás-os-Montes and Alto Douro, while the Regia Douro Park – science and technology park of Vila Real is the company's business validation and location entity. They also have MUSKI Design Studio, in product design, and Esporão, as a pilot user of biodegradable packaging. In acoustic solutions, they count on Artnovion.

Spawnfoam has the ambition to create a European cluster, which will characterize and develop the technology to use chitin as a structural adhesive. For this, they are in the market to develop contacts with potential partners throughout Europe. In parallel, notes that is also essential to invest in technology licensing. Spawnfoam's research and development capability has given rise to the creation of different technologies, processes, and products, which is important to validation and value.

5 Examples of Circular Science and Technology Parks

Below we have gathered some inspirational examples of how circular economy ideas are being put in practice in STP's and companies. These examples have been indicated by the survey respondents as successful business cases of circular economy.

5.1 Sweden: Sotenäs Symbiosis Centre – From Innovation to Commercialisation

5.1.1 Introduction

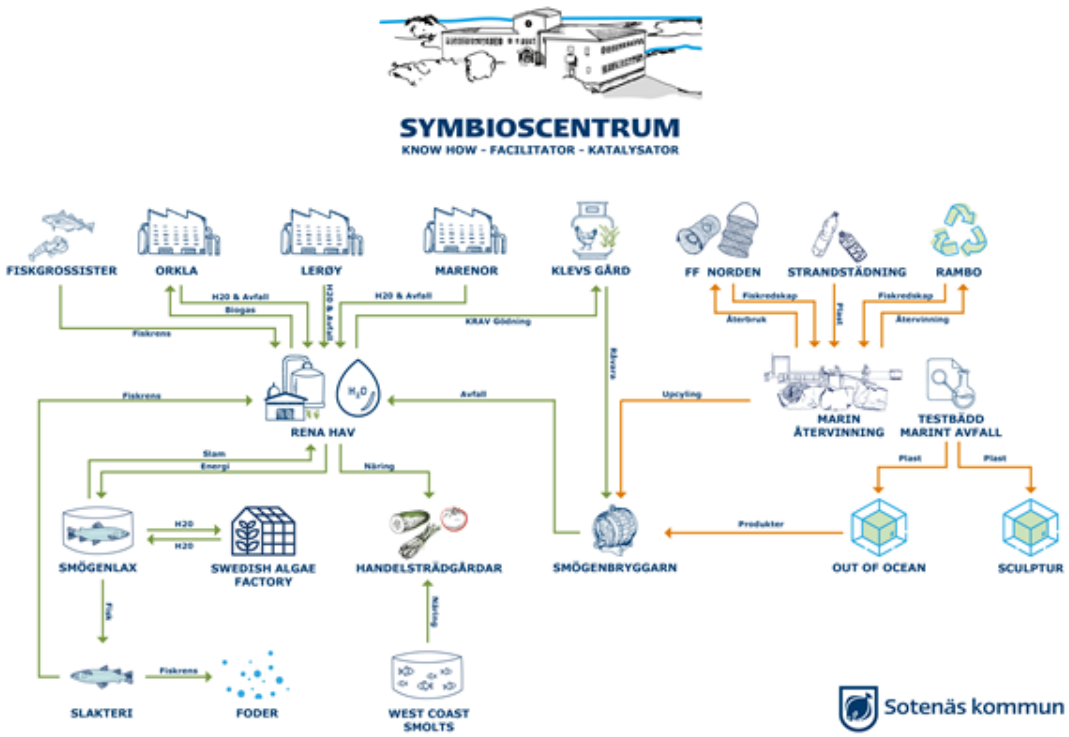

Figure 25 Sotenäs symbiosis map

The Sotenäs municipality set up an industrial symbiosis centre in 2015 with the aim to promote and develop industrial symbiosis networks in the municipality. The symbiosis networks in Sotenäs showcase many small and medium sized companies as well as large companies in collaboration with each other. The combination of innovation, environmental

benefits, and job creation has been the driver for the municipality's strong engagement (Fig 25).

Sotenäs is the base for several large seafood processing plants, which generate organic waste and contaminated water. This has traditionally been let out through sewage pipes into the ocean, causing problems with eutrophication, causing algal blooming and formation of toxic substances in coastal areas. Like the rest of the Swedish West coast, Sotenäs is also plagued by marine littering, mainly from sea-based sources such as merchant shipping and fishing vessels. Discarded or lost fishing nets also pose a big problem.

Sotenäs will also address the problem of traditional sea-based fish farming, which has many sustainability issues such as eutrophication, spreading of antibiotic resistance and genetic contamination of wild species. Sotenäs has plans for introducing land-based fish farming, where the waste will be part of the symbiosis, as a link in the circular chain.

The core of the industrial symbiosis network in Sotenäs is marine food processing and wastewater treatment. Biowaste from local food industries and sludge from the wastewater treatment plant are treated in an anaerobic digestion process, with biogas as the main output. The biogas is converted into electric power and hot water that can be returned directly to the industry. The solid residues become environmentally friendly fertilizers and are used by local farmers. There is also an emphasis on marine research, with a focus on recycling of beach litter and used fishing gear. Through the development of testbeds, the municipality creates the best possible conditions for companies and academia to test and develop their technologies and operations, to be able to take the step to large-scale commercialization.

5.1.2 History and set-up: The municipality as the driver of symbiosis

The Sotenäs municipality was motivated by the mindset of industrial symbiosis – that working together can bring benefits as compared to working individually. For the municipality, it is important to have strong local companies for job creation, and to minimise environmental impacts. The municipality is aware that Industrial Symbiosis as a concept can meet both aims, hence its interest in taking a proactive facilitating role.

A dedicated symbiosis centre was set up by the municipality of Sotenäs to drive the work of industrial symbiosis. The municipality wanted to establish a network of different people/organisations who could work together towards development of industrial symbiosis, and therefore a steering group was set up for the symbiosis centre. The steering committee includes various stakeholders such as politicians, the director of the municipality, representatives from large companies, SMEs, science centres and universities located in the region. The municipality has worked with these actors earlier in different development projects such as competence development with the university, and therefore, due to the established connections, it was easy to gather the steering group. In this way, the municipality brought together actors from different sectors and encouraged discussions on industrial symbiosis.

The Sotenäs Symbiosis Centre was inaugurated in 2015. The centre is in a building that is owned by a private company. The company did not require the space anymore as they moved a part of their operations to another area, and therefore were willing to rent it out to the municipality and to the other actors involved in symbiosis activities. The municipality could be seen as the architect of the way of working. The plan was actualized as the municipality found suitable collaboration possibilities with other actors.

5.1.3 Organisation: A unique setup that allows for flexibility, discussions, and connection-of-dots

The Symbiosis centre is a meeting place for companies, academia, schools and the public sector. The goal is to bring people together to create innovation, entrepreneurship, education, and employment. The centre features development of both industrial and social symbiosis, where social symbiosis refers to collaboration on competence development.

The financing for the symbiosis centre has mostly been obtained in the form of project work. Some of the main financiers who have supported the development of industrial symbiosis in Sotenäs are EU Interreg, Swedish Innovation Agency (Vinnova), Swedish Board of Agriculture (Jordbruksverket), Västra Götaland County, among others. The key to getting finance has been to, each time, apply for development of multiple projects that could be a part of the symbiosis development, and not just focus on one industrial symbiosis connection. Some of the projects, for example, focused on innovations in utilisation of marine waste. One project by itself might not result in industrial symbiosis, but the projects together contribute to development of networks. It is therefore important for the municipality to be able to connect the dots and see the bigger picture to find new opportunities.

Peter Carlsson from Sotenäs municipality describes the centre's work as follows: "At the symbiosis centre, we try to listen to different companies and try to attract new companies that can fit into the network. We work together with different research and innovation organisations to strengthen the business. We see opportunities and set up meetings with the right people to make things happen. In these ways, we facilitate the symbiosis work in the municipality".

The centre falls directly under the municipal board and therefore the decisions are prioritized at the highest level. About eight full-time people work at the symbiosis centre, but there is also collaboration with other departments in the municipality. There are people with various competencies at the centre; engineering, economics, architecture, teaching, leadership, organisational issues, administrative/finance questions as well as business development. Overall, the team is quite flexible in the roles. Two people currently are focusing on development of testbeds and a Marine Recycling Centre.

5.1.4 Testbeds and research centres that support new ideas and innovation

Most of the work at the symbiosis centre is carried out using a bottom-up approach where the municipality, together with stakeholders, develop new ideas and solutions. The centre actively works with testbeds and believes that such testbeds are valuable in testing prototypes to take the ideas to commercial scale. Testbeds are test and demonstration environments that enable efficient development and market introduction of new products, processes, and services. Sotenäs is currently developing two new testbeds - one for conversion of plastic waste from oceans to new products, and another for treatment of wastewater from fish farms. The municipality has supported by renting the land themselves from a private owner, so that the actors testing their solutions at the testbed do not have to pay for the facility.

The municipality has also set up a Marine Research Centre – the focus so far has been on used fishing gears. The municipality is now a part of a team that will create a national structure for recycling of fishing gears. In addition to these initiatives, the municipality also facilitates physical space for business discussions or activities.

5.1.5 Communication both internally and externally helps to bring together right competencies

The Sotenäs centre believes in the power of communication, both internal and external communication. Sotenäs is a comparatively small municipality and most of the people know each other, which makes it easy to communicate internally.

External communication mostly occurs via different collaboration projects. When asked about the way to share information, Peter mentioned, “We have been interviewed a lot and we attend a lot of seminars and conferences where we describe how we work, and our experience”. The centre also welcomes study visits and sees this as an opportunity for inspiration.

Networking skills are considered important in the context of industrial symbiosis since it involves a collaboration of multiple areas of expertise. The centre finds it valuable to involve people from outside the organisation for implementation of ideas and projects. They collaborate with about 10 universities and institutes including local, national and international actors such as University College Högskolan Väst, Linköping University, IVL Swedish Environmental Research Institute, RISE - Research Institutes of Sweden, Chalmers University of Technology in Sweden, Aarhus and Aalborg universities in Denmark, The University of South-Eastern Norway in Norway. The different actors contribute with different competencies, for example, Linköping University helped with setting up the symbiosis methodology, IVL with environmental assessments, and the Royal Institute of Technology (KTH) with Internet of Things.

5.1.6 Effective communication as a tool to overcome regulatory and other barriers

One of the main challenges so far has been a slow process for gaining environmental permits, which increases the lead time to commercialization of new technologies. The authority that is responsible for providing the environmental permit varies depending on the nature of the project. Sometimes, the application must go through multiple levels - the highest level is the national environmental court, but sometimes it could be the local or county administrative board who has to approve first. The administration of permits therefore took more time than expected. Another challenge was with the land allocation, where the allocation process took longer than expected due to longer administrative processes. This was solved by talking to the higher decision-making level in the municipality who could take a faster decision.

There are some companies that have failed to clearly see the business potential of IS and have therefore not become actively engaged. Another challenge has been a culture in some businesses of 'doing it alone' which reduces their willingness to collaborate with other companies. The management in these companies believe that they are better off working by themselves and have no need for external advice or inputs concerning how to best carry out their operations. To minimize these barriers, the municipality continues to work actively with communication – to show the business potential and inspire the companies to think in a symbiosis manner.

The latest development project in Sotenäs is a large land-based fish farming company. One of the reasons the company preferred Sotenäs as the location was because of the municipality's work with industrial symbiosis. The Sotenäs Symbiosis Centre hopes to welcome more of these types of companies who can see the potential of industrial symbiosis whilst creating local job opportunities.

5.1.7 Business models

This far, the Sotenäs Symbiosis Centre has been managed as a public operation, funded by the municipality and by project grants. There have been discussions on whether to turn the Centre into a commercial operation, but so far, there have been too few advantages identified to justify this step. The symbiosis relations between companies in the Centre have been regulated on a case-by-case basis.

With the advent of the planned fish farming operation, this may change, as the company behind the fish farm aims to set up an industrial park, including fish processing, feed pellet production, wastewater handling, logistics and green energy production. To achieve this, partners and suppliers will be invited to establish operations in the park and contribute to the symbiosis under the management of the main firm. In that way, the industrial symbiosis will be an integral part of the offer and business case for settling in the park (Fig 26, *subject to*

approval).

Figure 26 Ideas for symbiotic business models

5.2 Portugal: Eco Parque do Relvao

In 2001, the Ministry of Labour and Social Security classified the Chamusca region, in Portugal, at risk of social death: high aging rate, low population density, low education level, with an increasing unemployment rate and a risk of increased isolation from erosion in the secondary and tertiary sectors. In this context, the City Council sought to identify the region's strengths, in order to develop sustainable regional development strategies and revitalize its economic and social fabric, encouraging regional competitiveness, concluding that the region had a long experience in the area of waste management, having two waste landfills (one for solid urban waste and the other for ordinary industrial waste), in addition to an eco-centre and a material sorting centre. Thus, the Chamber proposed the creation of an industrial park, in the north of the municipality, whose development is based on the Industrial Ecology paradigm.

Eco Parque do Relvão (fig. 20) was indeed established as a national cluster for the environment and energy, with a growing and sustainable business community, based on collective efficiency, innovation and knowledge strategies, and with a fundamental contribution to environmental protection and economic and social development of the region and country.

Figure 20: Eco Parque do Relvão (http://aepr.pt/)

The Eco Parque aims to:

- increase the competitiveness, attractiveness, and environmental image of companies in the region.
- reduce the environmental impacts of existing and future industrial activities.
- increase the efficiency of the use of materials and energy.
- reduce the amount of waste sent to landfill and emissions and create and market innovative products and methods.

The principles of Industrial Ecology and Symbiosis, although still in an initial and undeveloped phase, are verified in the exchange of materials between companies present at Eco Parque (fig. 21), with the expectation that this situation will be increasingly present in the way companies work.

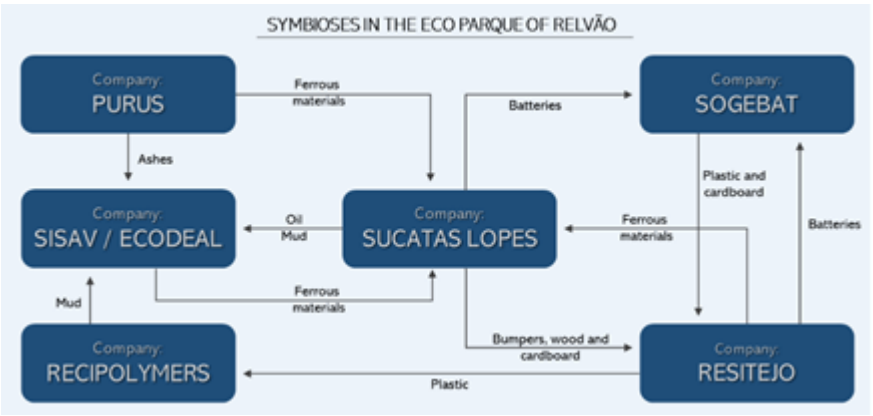

Figure 21: Examples of industrial symbiosis in the Eco Parque (https://www.apambiente.pt/_zdata/Politicas/EcoInovacao/Apresenta_WS_RES_set13/Eco%20Parque%20Relvo_Joo%20Rodrigues.pdf)

5.2.1 EPR.Colab Project

An industrial Eco Park is constituted as a community of companies or activities that cooperate with each other and with the local community, through an explicit, systematic, and integrated process, which seeks to guarantee an efficient use of available resources (information, materials, water, energy, infrastructure and habitat) leading to economic gains, improvements in environmental quality and equitable job creation / distribution (UN, 2011).

With this in mind, and to increase the amount of symbiosis in the Park, the Associação do Eco Parque do Relvão (AEPR) created and started in 2017 the EPR.Colab Project, a Circular Economy and Industrial Symbiosis project. The Project is financed by the Environmental Fund within the framework of the Support the Transition to Support the Circular Economy Program.

The EPR.Colab Project - Management System for the promotion of **industrial symbiosis** in the EPR, brings environmental, economic, and social benefits to the region and to Eco Parque companies, reinforces interactions between companies and the adoption of best practices in the management of resources.

The Project is configured as a set of processes and good practices with the aim of promoting industrial symbiosis in its various aspects (eg, exchange of materials, sharing of infrastructure, sharing of information).

The Project has as specific objectives: (a) the development and implementation of a management model for IS in Eco Parque through a pilot project; (b) evaluation of the technical and economic feasibility of implementing an IS model at Eco Parque; (c) evaluation and dissemination of the economic, environmental, and social benefits of the IS implementation at Eco Parque; (d) development of a management model implementation plan for IS on a large scale.

5.2.2 Synergies and symbiosis identified and methodology

The Project identified a network of potential industrial symbioses in Eco Parque and the surrounding region, namely 179 potential synergies, considering activities in Eco Parque and complementary activities (donors and recipients of material and energy flows) (fig. 22).

Most of the synergies involve 12 activities, with emphasis on the production of electricity from thermal sources and the recovery of metallic waste.

57 industrial activities were also identified with potential for complementing material flows in the region (main flows: reuse of industrial water, mineral waste for fuel and / or compost, use of exhaust gases (CO2) or water vapor for energy, extraction of water for energy, chemical extraction and increased productivity); and 6 types of “key” materials, such as: water (cooling, heating, process), gases, steam and electricity (heating, cogeneration, process),

biomass (transformation, for example for the animal feed industry; fuel, compost, building materials and packaging), sludge and minerals (building materials, filler, fuel), chemicals (fuels, regeneration and building materials), and recyclable materials (with specific flows with known market).

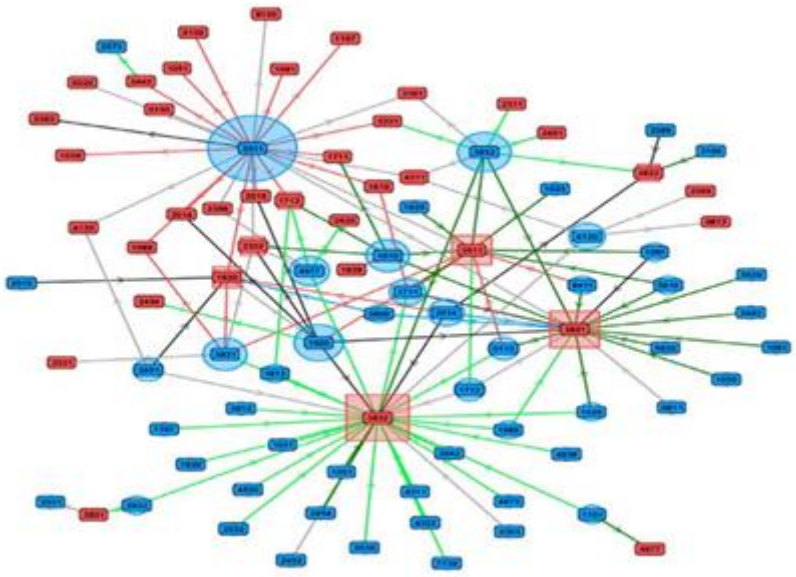

Figure 22: Network of potential industrial symbioses in Eco Parque in the scope on the EPR.Colab Project (http://aepr.pt/epr-colab/workshop-1/)

In addition to the synergies identified within Eco Parque, opportunities were also identified possible cooperation with industrial networks that already exist in the region, mainly linked to the agricultural and forestry industry.

To obtain the indicated conclusions, the project established a previous methodology based on several stages.

- Preliminary diagnosis and analysis (preliminary work such as the identification and characterization of companies and the regional context and the planning of activities).
- Public Workshops (publicize the project, report its evolution, and motivate the involvement of companies and stakeholders; allows first communications between companies and the collection of contributions at a strategic level).
- Working meetings with companies (with support tools provided by facilitators to the participating companies, for preparation prior to the meeting, such as a list of materials).
- Evaluation of the potential of industrial symbiosis (based on information from previous phases, the potential of exchanged resources and sharing of services and infrastructure, by company, is estimated; the potential is translated into economic, environmental and social benefits through methodologies of evaluation; evaluation performed without direct interaction with stakeholders).

- Facilitation meetings (facilitators promote and participate in 1: 1 meetings between companies; this process allows to refine the previous steps, identifying potential methodological limitations or aspects to be explored).
- Implementation / evaluation (allows monitoring of the implementation of industrial symbiosis and collective efficiency measures; reports / indicators of success produced, easily communicated to stakeholders; identified constraints and possible corrective actions; results communicated to local, regional, and national administrations as ways to solve barriers of symbiosis development).

This methodology can serve as an example for other industrial parks, as well as for Science and Technology Parks that intend to establish a more circular model based on symbiosis between companies, being necessary its adaptation to their reality.

5.2.3 Strategic Plan Eco Parque do Relvão Association 2017 – 2027

In 2017, the Eco Parque do Relvão Association presented the Strategic Plan for the decade 2017 - 2027 that establishes the vision, the main objectives, and the initiatives to be implemented.

Within the horizon of the Plan, several objectives are proposed, including boosting the regional network of industrial symbioses as a way of promoting competitiveness and environmental protection.

Seven strategic axes were defined:

- Planning and Management.
- Financing.
- Accessibility and Infrastructure.
- Synergies.
- Communication and knowledge

Within the scope of the “Synergies” axis, it is intended to promote synergies between different industrial activities to promote its competitiveness and environmental protection. To this end, four objectives / areas of activity are defined, described in detail in the table 1 below.

Objectives / Areas	Activities
Survey and establishment of opportunities in Industrial Symbiosis	• Analysis of industrial activity at the regional level - identification of the main companies. • Analysis of information available at local and regional level - articulation with industrial and local development associations on input and output resources. • Approach to EPR companies to identify entities associated with their value chain and identify immediate opportunities for synergies. • Identification of potential synergies through the application of methodologies and tools already developed. • Accounting for materials and associated costs to calculate the economic and environmental impact, reporting to the companies involved. • Formal triple-bottom line analysis of synergy in the pre-implementation phase and support to the companies involved;
Interactions with companies (Park companies and outside companies)	• Approach to the main companies for presenting projects, first contacts and building professional relationships. • Training in tools for implementing circular economy principles, industrial symbiosis, and identification of opportunities. • Networking and teamworking events in an informal environment to foster interpersonal relationships. • Interactive workshops to identify macro-opportunities with participating companies and entities (also open to public institutions, associations, NGOs). • Facilitation and technical support for collaboration projects between companies with an impact on the use of resources (e.g., integration of clean technologies, recycling, symbiosis). • Identification of test projects, in the short term and low investment, to be presented as a case study for visibility gains (articulation with the communication axis). • Identification of technical constraints / opportunities for research and development in waste, water, and energy management to establish projects with research units (e.g. universities, polytechnic institutes);

Reaching out	• Interactive workshops to identify opportunities in resource management with entities present in the local and regional community - e.g., network of public schools, day care centres and homes, fire brigades, etc. - together with some partner companies. • Approach to the main regional associations and coordinating entities to establish partnerships, foster institutional relations, and collaborate in the identification of synergies. • Definition of incentive mechanisms for companies that are proactive in seeking and establishing synergies;

Monitoring	• Identification of the context conditions leading to the establishment or not establishing or not establishing proposed synergies (barriers and incentives) and issuing a report for information to the adhering companies.
	• Classification of synergies regarding typology (water, energy, waste), feasibility (potential, achieved, not achieved) and associated benefits (connection with the communication axis).
	• Accounting for capital gains associated with established synergies and conversion of measurable indicators (link to communication axis), for example:
	  ◦ Landfill deviation (tons).
	  ◦ Emission of Greenhouse Gases (tons of CO2).
	  ◦ Avoided costs / Gains obtained (€).
	  ◦ Investment cost (€).

Table 1: http://aepr.pt/associacao/plano-estrategico/

6 Role of Science and Technology Parks in the Transition to Circular Economy

Science and Technology Parks (STP's) are well situated to accelerate the transition to a circular economy, since they often occupy roles as property managers, community leaders and networking hubs for areas and clusters of firms.

The situation today, as experienced by the respondents, seems to leave room for improvement (Figure 11). The level of support also seems to differ between countries. In Spain, none of the respondents rate their local STP as "very supportive", whereas in Portugal, this percentage is over 40 %. If Portuguese STP's have developed successful models for supporting CE in their companies, this should be investigated and if feasible, replicated elsewhere.

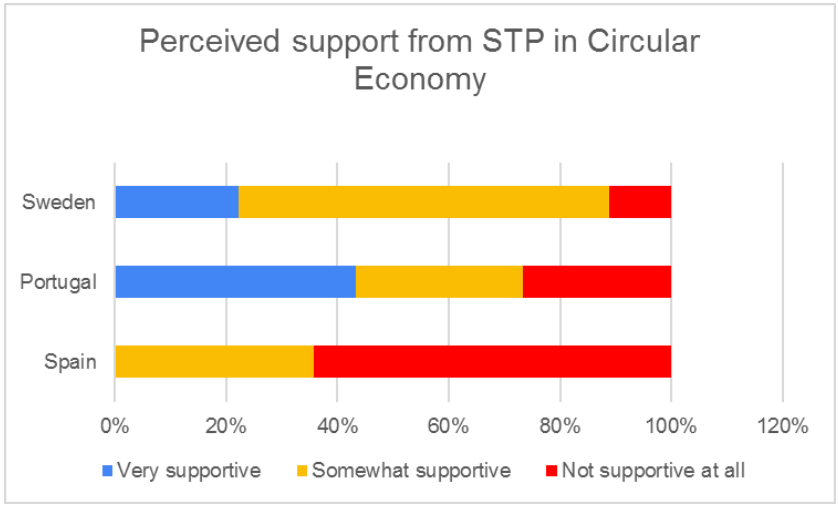

Figure 19. Degree of perceived support for CE by STP's by country

When asked, companies have several suggestions how STP's could improve, the most frequent being

- Improving the collection system (more containers, better classification, clean points)
- Creation of maps of potential connections between companies (competences, wastes generated) and creation of specific applications where the companies can see the flow of resources and waste
- Awareness raising campaigns and training

Whereas putting more containers in place and generally improving the physical infrastructure for waste handling seem rather natural and easy steps, the second suggestion, concerning the creation of "industrial symbiosis maps" is certainly more qualified and more

interesting from a STP point of view. Particularly for industrially oriented STP's this idea could prove very valuable and should be a subject of further investigation.

6.1 Ideas for Science and Technology Parks

With reference to the survey results and the topics examined in previous chapters, the following simple suggestions might provide a starting point for any STP wishing to improve the circular aspects of the park's activities.

6.1.1 Plastics waste

6.1.1.1 Office

- Provide incentives for reducing plastics waste amount – choose reusable before disposable, repair faulty items, find second life uses for obsolete items, etc.
- Provide clearly marked receptacles for plastic waste – separate different kind of polymers.
- If no waste sorting/recycling system available – arrange in the STP
- Educate staff about plastics and plastics recycling

6.1.1.2 Industry

- Provide incentives for reducing plastics waste amount – choose reusable before disposable, reduce waste in production, fine-tune procurement procedures
- Discuss how more recycled plastics can be used within the company
- Set up procedures for recycling in-house

See Figure 18.

Plastic recycling two potential closed-loop models

	1 Small-loop recycling	2 Large-loop recycling
Characteristics	—Distinct recycling loops for each type of material —Predominantly mechanical recycling —Many participants in the recycling chain —Recycled material re-entering the value chain further downstream as polymer/plastic	—Common loop(s) across materials and involving multiple plastics —Predominantly chemical recycling —Fewer participants in the recycling chain —Recycled material re-entering the value chain further upstream as feedstock or monomer
Requirements	—Collaboration within the loop —Incentives for consumers —Standards for recycled plastic content —Mechanical recycling technology	—Chemical recycling technology —Incentives for consumers —Standards for recycled feedstock and monomer content

Source: Kearney analysis

Figure 18. Characteristics of the plastics recycling loops (from Kearney)

6.1.2 Food waste

- Enrol local restaurants in “food rescuing” schemes
- Educate staff about how to reduce food waste
- Partner with local farmers to use food waste as animal feed
- Connect STP to collection system for biogas or fertiliser production, if applicable
- Start local composting

6.1.3 How to start

The process to carry out the transition from current economic science and technology models to models of a more sustainable nature is complex and needs to make progress in several areas, both at internal level, within the science and technology parks themself, and at the Technopolis level, together with their members. Next you will find a series of steps that can be launched, as an example:

- First, the decision to move forward circular economy or at least to study the possibility to move, must be taken by the executives of the science and technology parks based on a detailed analysis.
- A search for local/regional/other good and relevant examples of companies and/or organisations that are practising circular economy that can serve as inspiration and knowledge resources for the work in the STP

- Creation of a circular economy working group with representative from start-ups and companies, public institutions, university and the science and technology park which meet regularly to discuss about the strengths, weaknesses, opportunities, and threats related to the implementation of circular economy measures in the park and to rethink the actual business models

- Establishment of “SMART” indicators and targets for the circular economy activities (“SMART”: Specific, Measurable, Attainable, Relevant and Time-bound)
- Establishment of a roadmap/handbook of means for the Technopolis and within the park

- At transversal level, design and implementation of an awareness and promotion campaign