



TREASURE

D8.6: Report on business model identification

30/11/2023 (M30)

Author: Laila El Warraqi (POLIMI), Daniele Perossa (POLIMI),
Laura Pomo (POLIMI)

Technical References

Project Acronym	TREASURE
Project Title	leading the TRansition of the European Automotive SUPply chain towards a circulaR future
Project Coordinator	POLITECNICO DI MILANO (POLIMI)
Project Duration	36 months as of 1 June 2021

Deliverable No.	8.6
Dissemination level ¹	PU
Work Package	8
Task	8.5
Lead beneficiary	POLIMI
Contributing beneficiary(ies)	All partners
Due date of deliverable	30 th November 2023
Actual submission date	30 th November 2023

Document history		
V	Date	Beneficiary partner(s)
V1.0	03/11/2023	POLIMI
V2.0	27/11/2023	POLIMI

DISCLAIMER OF WARRANTIES

This document has been prepared by TREASURE project partners as an account of work carried out within the framework of the EC-GA contract no 101003587. Neither Project Coordinator, nor any signatory party of TREASURE Project Consortium Agreement, nor any person acting on behalf of any of them:

- a. makes any warranty or representation whatsoever, express or implied,
 - i. with respect to the use of any information, apparatus, method, process, or similar item disclosed in this document, including merchantability and fitness for a particular purpose, or
 - ii. that such use does not infringe on or interfere with privately owned rights, including any party's intellectual property, or
 - iii. that this document is suitable to any particular user's circumstance; or
- b. assumes responsibility for any damages or other liability whatsoever (including any consequential damages, even if Project Coordinator or any representative of a signatory party of the TREASURE Project Consortium Agreement, has been advised of the

¹PU= Public

PP= Restricted to other programme participants (including the Commission Services)

RE = Restricted to a group specified by the consortium (including the Commission Services)

CO = Confidential, only for members of the consortium (including the Commission Services)

possibility of such damages) resulting from your selection or use of this document or any information, apparatus, method, process, or similar item disclosed in this document.



EXECUTIVE SUMMARY

In this deliverable will be presented the conducted analysis of the current state of the art of Circular Business Models (CBMs) related to electronics, with a particular focus on recycling practices. The aim is understanding what of the CBMs that currently exist may be useful for developing TREASURE CBMs. TREASURE CBMs will need to be consistent with the three main categories of project results that have been identified: (i) Product-Service Systems, (ii) Teaching and Consultancy services, and (iii) Digital products and services. The results that were found related to CBMs were obviously limited to the information that are disclosed to the public.

In the first section of the deliverable, the results of the academic literature review about CBMs are presented. Relevant concepts and definitions are drawn from the literature, but practical information related to development of CBMs regarding electronics was not found. In the second section, an analysis related to the CBMs of enterprises operating with waste electric and electronic equipment (WEEE) is presented. Among them, eleven CBMs, more consistent with TREASURE activities, are analysed in depth. Finally, the aspects of each CBM more relevant to TREASURE are highlighted. In the third section, an analysis of ongoing and concluded Projects co-funded by the European Commission is conducted. Eighteen projects were identified as possibly relevant for TREASURE, but information related to CBMs was disclosed for only five of them. They are analysed and main take-aways relevant to TREASURE are underlined. Since the information found by analysing companies and European Projects did not present information useful for digital products and services, in the fourth section an analysis of current digital tools offered for sharing of information and data to support circularity in the Automotive industry is presented. A total of eleven tools was spotted and analysed. Relevant information potentially useful for TREASURE are highlighted. Finally, the fifth section of the deliverable is dedicated to the analysis of the economic, environmental, and social benefits that can be expected by TREASURE results.

Two workshops with all project partners have been conducted to gather all the indications, feedback, suggestions, and information to create the content presented in this deliverable.

TABLE OF CONTENTS

DISCLAIMER OF WARRANTIES	2
EXECUTIVE SUMMARY	4
TABLE OF CONTENTS	5
1. Introduction	7
2. CBMs State of the Art.....	8
2.1. Literature Review	8
2.2 Assessment of the Current Landscape of Companies Business Models	10
2.2.1. Companies Sectors and Geographical distribution	10
2.2.2 Product Service Systems Business Models.....	14
2.2.3 Business Model Canvas Representation	14
2.3 Companies' business models	18
2.3.1 AMQ Ambiente: WEEE collection and treatment	18
2.3.2. Dismeco – Automated handling and pre-sortin plant.....	19
2.3.3. Chimet Spa: Printing heating circuits	21
2.3.4. Ecotic: platform for collecting and managing WEEE	23
2.3.5. Aurubis: Metals for Progress: Driving Sustainable Growth.....	27
2.3.6. Boliden – Electronics recycling and lead extraction from car batteries.....	29
2.3.7. HKS – The Metal Company: Ferrous, non-ferrous and electronics materials recycling	30
2.3.8. Umicore: Circular materials technology company	31
2.3.9. STENA Recycling: advanced recycling processes.....	32
2.3.10. Sim Green Srl: final treatment of electrical and electronic equipment.....	33
2.3.11. Kuusakoski Recycling Oy: Advanced pyrometallurgical and hydrometallurgical processes.....	34
2.3.12. Companies CBMs: Results	35
2.4 Analysis of the current state of the art of Circular Business Models in European Projects.....	39
2.4.1 Introduction to EU projects CBMs.....	39
2.4.2 CABRISS CBMs Information and analysis	40
2.4.3 CIRC4Life CBMs information and analysis.....	42
2.4.4 C-SERVEES CBMs Information and analysis.....	43
2.4.5 HR-Recycler CBMs information and analysis	44
2.4.6 SustainablySMART CBMs information and analysis.....	45
2.5 Analysis of the current state of the art of business models of digital tools enabling circularity in Automotive industry.....	45



3	Analysis of the main economic and environmental benefits impactable by TREASURE results	
	47	
4	Conclusions	51
5	References.....	53



1. Introduction

In this introductory section of Deliverable 8.6, will be delineated the diverse categories of Circular Business Models (CBMs) applicable to the Treasure project expected results. Based on the exploitable results documented in D8.1, three distinct results typologies have been identified as starting points for the development of a CBM pertaining to the project: Product-Service Systems (PSS), Consulting and Teaching Services, and Digital Services and Products. They were defined starting from the list of TREASURE Exploitable Results (ERs) in D8.1, as the ERs appeared to be potentially clustered in these three categories. The identification of the three categories of results was discussed and defined with all TREASURE partners. The three typologies of results can be defined as follows:

- Product-Service Systems (PSS): it is referred to all the ERs related to the offering of a bundle of a product and services related to it. Three kinds of PSS can be defined: (i) Product-oriented PSS are those offerings mainly related to a product with associated services increasing the value of the offer, like a product offered with post-sales services, (ii) Service-oriented PSS are the offerings where customers mainly pay for exploiting a service that may be associated to a product or asset, like an offering of a given number of minutes of phone-call per month with associated the renting of a mobile phone, and (iii) Capacity-oriented PSS, when customers pay for accessing to a capacity made available to them (e.g., paying a fee for accessing a disassembly line belonging to the supplier and using it to disassemble a certain number of components).
- Digital services and products: it is referred to the ERs related to a digital tool or asset fostering or supporting the implementation of circularity and recycling practices mainly by enabling sharing of information and data.
- Teaching and consultancy services: it is referred to all the ERs related to creating or improving activities of teaching or consultancy referred to circularity topics.

In this regard, two pivotal chapters will delineate the deliverable. Firstly, after a brief introduction of the objectives of the deliverable, a comprehensive examination of the existing landscape of business models will be conducted, involving a literature review on current state of the art of CBMs focusing especially in the electronics sector and an analysis of different solutions implemented by different companies which could be relevant to analyse the state-of-the-art of the implemented practices and could serve as a starting point for the development of new CBMs in TREASURE. In this particular scenario, the business model canvas model has been used in order to summarize the companies' practices.

Additionally, an analysis of European projects linked to TREASURE's thematic areas and an in-depth analysis of existing digital platforms will be provided, with a focus on the possibility of implementing a modular model divided into various packages accessible to the supply chain stakeholders.

The deliverable will also include the presentation of findings derived from an inquiry conducted in collaboration with industrial and academic partners of the project. This will encompass information related to which aspects of a corporate business model and drawn from European projects and existing digital platforms can be beneficial for the development of a business model aligned with the Treasure project.

As a concluding step, the deliverable will expound upon the industrial benefits, which have been discerned thanks to workshops which involved the collaboration with partners, and which can be contemplated and attained within a prospective circular business model related to the realms of Product Service System, Consulting and Teaching Services, and Digital Services and Products.

2. CBMs State of the Art

2.1. Literature Review

The circular economy concept has gained an increased attention on the policymaker's agendas around the world, resulting in different practices, including the European Circular Economy package, and attracting the attention from the private sector, which lead to different initiatives by major companies (Geissdoerfer *et al.*, 2020). In the industrial context, the business model innovation is seen as a key leverage to implement the circular economy on the organizational level, as it allows for a systemic shift in the core logic of businesses and the alignment of incentives of different stakeholders' groups (Geissdoerfer *et al.*, 2020). Indeed, the concept of circular economy is considered as a solution for harmonizing ambitions for economic growth and environmental protection (Lieder and Rashid, 2016). Circular economy systems require the design and implementation of business models that are based on using as little resources for as long as possible, while extracting as much value as possible in the process. As a matter of fact, companies that are willing to adopt the circular economy model need to shift from traditional business models by rethinking their value propositions and developing value chains that offer feasible cost efficiency, production effectiveness, and business performance (Lieder and Rashid, 2016). A shift from the traditional "take, make dispose" economic model into CBMs is relevant for cost savings, reduced environmental impact and improved competitiveness. Specifically, the concept of CBMs, is the combination of the traditional business models and circular economy including recycling measures (closing), efficiency improvements (narrowing), use phase extensions (extending), a more intense use phase (intensifying), and the substitution of product utility by service and software solutions (dematerializing) (Geissdoerfer, Vladimirova and Evans, 2018). (Rosa, Sassanelli and Terzi, 2019) conducted a systematic literature review on existing CBMs and their classification by selecting the most promising ones. In their research, they identified five sub-categories to CBM best practice - paradigm-based, service-based, product-based, sector-based, pattern-based- and by analysing different documents they identified different CBMs classification methods which can be divided into the ReSOLVE framework (proposed by The Ellen MacArthur Foundation (2015)), the Business Model Canvas (BMC) methodology (proposed by Osterwalder and Pigneur (2010)) and hybrid models. Besides, CBM challenges related to the adoption of circular economy paradigm have been considered. Such study allowed to make considerations on the enablers for circular economy, such as the usage of ICT and digital technologies, as well as lean production which could be used to tackle remanufacturing process challenges and contribute to shorter lead times. Overall, key findings demonstrate that Product-Service Systems (PSSs)-oriented and Reuse, Remanufacturing and Recycling (3R)-based CBMs are the most common archetypes.

Considering the electro-electronic sector, the adoption of CBMs is relevant as it brings to different benefits such as: (i) the environmental impact reduction, as the manufacturing and

disposal of electronics often involves material and energy-intensive processes, (ii) cost reduction, since adopting a circular approach can encourage designing products with longevity in mind, to reduce possible frequent upgrades, (iii) extension of products lifecycle thanks to circular strategies such as repair and refurbishment. Indeed, the amount of waste from electrical and electronic equipment (WEEE) generated globally increased from 44.7 Mt in 2016 to 53.6 Mt in 2019 and is anticipated to reach 74.7 Mt by 2030 (orti, V., Balde, C.P., Kuehr, R., Bel, 2017). Electronics are adopted widely nowadays and also in different sectors, including the automotive one. Indeed, car electronics is also one of the most valuable sources of Critical Raw Materials (CRMs) in cars. A modern medium-sized car can embed up to 15 electronic systems on average and luxury cars can reach up to 50 among microcomputers and electronic components (Wang and Chen, 2011). From 2000 onwards, electronics saw an increased penetration in the automotive sector (Restrepo *et al.*, 2019). A Markets and Markets research report² quantified the automotive microcontrollers market in about \$989.2 Million in 2017, with a projection to \$1,886.4 Million by 2022, at a CAGR of 13.78%. However, the lack of interest of car manufacturers (and the whole automotive sector in general) towards the recovery of valuable components from End-of-Life Vehicles (ELVs) is remarkable. Arguably, the complex set of barriers (e.g., regulatory, governance-based, market, technological, cultural, societal, gender, etc.) result in difficulties for companies to implement Circular Economy (CE) by limiting potential benefits. At products End-of-Life (EoL) level, companies must cope with the adoption of circular practices within their well-established business models to turn into CBMs, often PSS-based. However, in very limited cases this transition is supported by a real exploration and detailing of the elements and assets needed to address the specific circular value propositions, even more by a quantification and continuous monitoring of their real implementation and business model canvas is a valuable method to make the first step. It helps to determine, also for CBMs, the key partnerships, resources and activities related to the costs to be sustained, and the channels, customers relationships and segments that could be capable to generate revenues (Sassanelli *et al.*, 2022). In literature few studies show the characteristics of CBMs implemented by companies, especially studies on the automotive sector are lacking, but the focus is mainly devoted to electronics components in general. Indeed, research such as the one presented by (Suppipat and Hu, 2022) show a study, made through interviews, to comprehend how the participating companies from the ICT and electronic industry can move from a business-as-usual model to a more sustainable business by design. Companies need to tackle major challenges related to organizational culture, social reputation and communication, resource availability, service at the end of life, and effective waste treatment. (Moreau *et al.*, 2021) highlights the importance of digital technologies in supporting sustainability in electronics sector. It is assessed that digital technologies cannot support long-term sustainability if their only purpose remains the optimization of the current system, but instead a long-term strategy should be adopted and new business models, as CBMs are necessary. In the transition from a linear to a circular economy (Pollard *et al.*, 2022) showed that circularity indicators for all products' lifecycle stages could be useful to answer how electrical and electronic manufacturers can measure products' circular economy performance. (Williams and Shittu, 2022) highlights the need to research new possibilities in sustainable and recyclable printed electronic devices, analysing challenges to be addressed in order to implement a transition to circularity for the electronics sector. Adopting CBMs requires the electronics industry initiate and develop disruptive technology and business concepts that focus on product longevity, renewability, reuse, recycle, repair, upgrade,

² <https://www.marketsandmarkets.com/pdfdownloadNew.asp?id=162948952>

refurbishment, servitization, capacity sharing, and a shift towards dematerialization. Indeed, the reuse and recycling of WEEE can contribute to sustainability and climate goals. (Marke *et al.*, 2020) highlighted the importance of better e-waste management and the scale of e-waste problem in China. Considering the ReSOLVE framework, eleven generic CBMs have been refined to suit the context of e-waste reduction. In them, are considered six CBMs-defining actions which are practiced in many companies: lifecycle extension, collection services, optimise resource value, circular supplies, resource recovery, and industrial symbiosis. Nonetheless, Circular Economy is still at an early stage in the industry. Additionally, it has been identified that the key to building successful CBMs to eliminate e-waste is multi-stakeholder collaboration across the mobile electronics industry, which involves effective collection, reuse, and recycling systems.

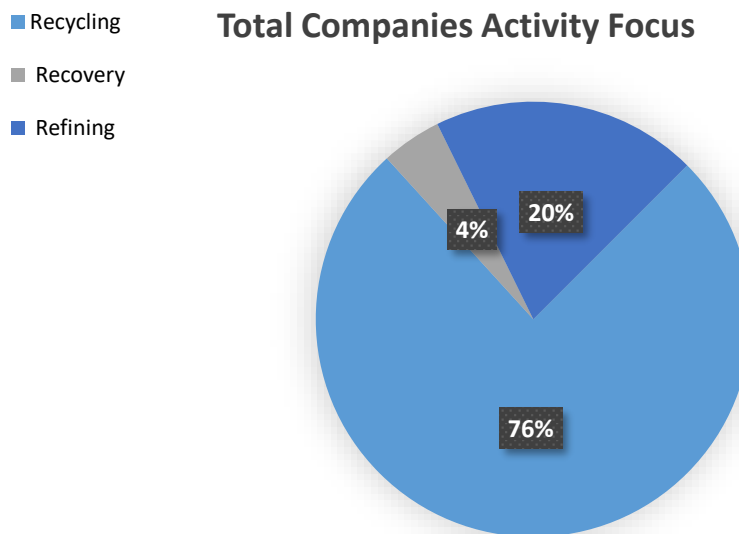
In this technological era, digital technologies can be an optimal tool to support circularity. TREASURE can offer a good opportunity for testing innovative technologies to make the automotive sector more circular, focusing on the electronic components of cars. Consulted academic literature materials did not focused on the development of CBMs related to recycling materials of electronics. Consequently, in the next paragraph, by focusing on such sector, existing companies and their circularity practices will be defined to assess the state of the art of existing CBMs. After it, an additional attention will be given to EU projects that developed new CBMs. These analyses will serve as a starting point for the future assessment and development of new CBMs.

2.2 Assessment of the Current Landscape of Companies Business Models

2.2.1. Companies Sectors and Geographical distribution

For the analysis and study of CBMs related to the themes addressed and developed in TREASURE, 250 initial companies have been considered. Among them, 76% operate within the materials recycling sector, 4% are involved in materials recovery, and 20% are engaged in the refinement of precious metals ([Figure 1](#)). Despite the relevance of the activities implemented, not all of the consultable content from each companies' website has been considered as relevant for the analysis of CBMs applicable to TREASURE. Therefore, the focus has been devoted to few of them, deemed more consistent with TREASURE activities and objectives.

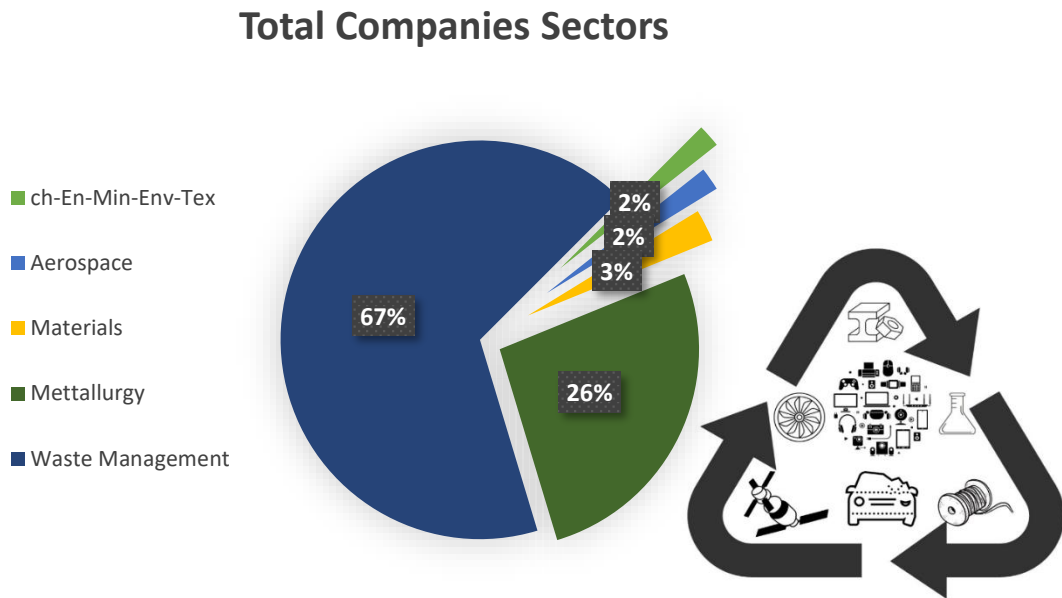
Figure 1. Percentage of recycling, recovery, and refining rates of the analysed companies.



In the present deliverable, 11 companies will be analysed, and their implemented activities will be described. Such examined companies operate in various fields, where the ability to recycle, recover, and refine materials and components is distinguishable, ensuring an approach towards circular economy and waste reduction. As represented by the below chart (Figure 2), 2% operate in the Aerospace sector, 2% work in the Chemical, Textile, Energy, Mining, and Environmental sectors, 3% are engaged in the Materials sector, 26% in the Metallurgical sector, and 67% operate in the Waste Management sector.

As shown in Figure 3, in the multitude of companies studied in depth, Europe stands at the forefront of global sustainability, and within its borders exists a vibrant and dynamic ecosystem of companies dedicated to the recycling and recovery of WEEE. What stands out about this landscape is the sheer number of companies that have arisen to address the environmental impact of electronic waste in Europe. The continent is home to a multitude of these pioneering organizations, each playing a crucial role in reducing the environmental footprint of discarded electronics.

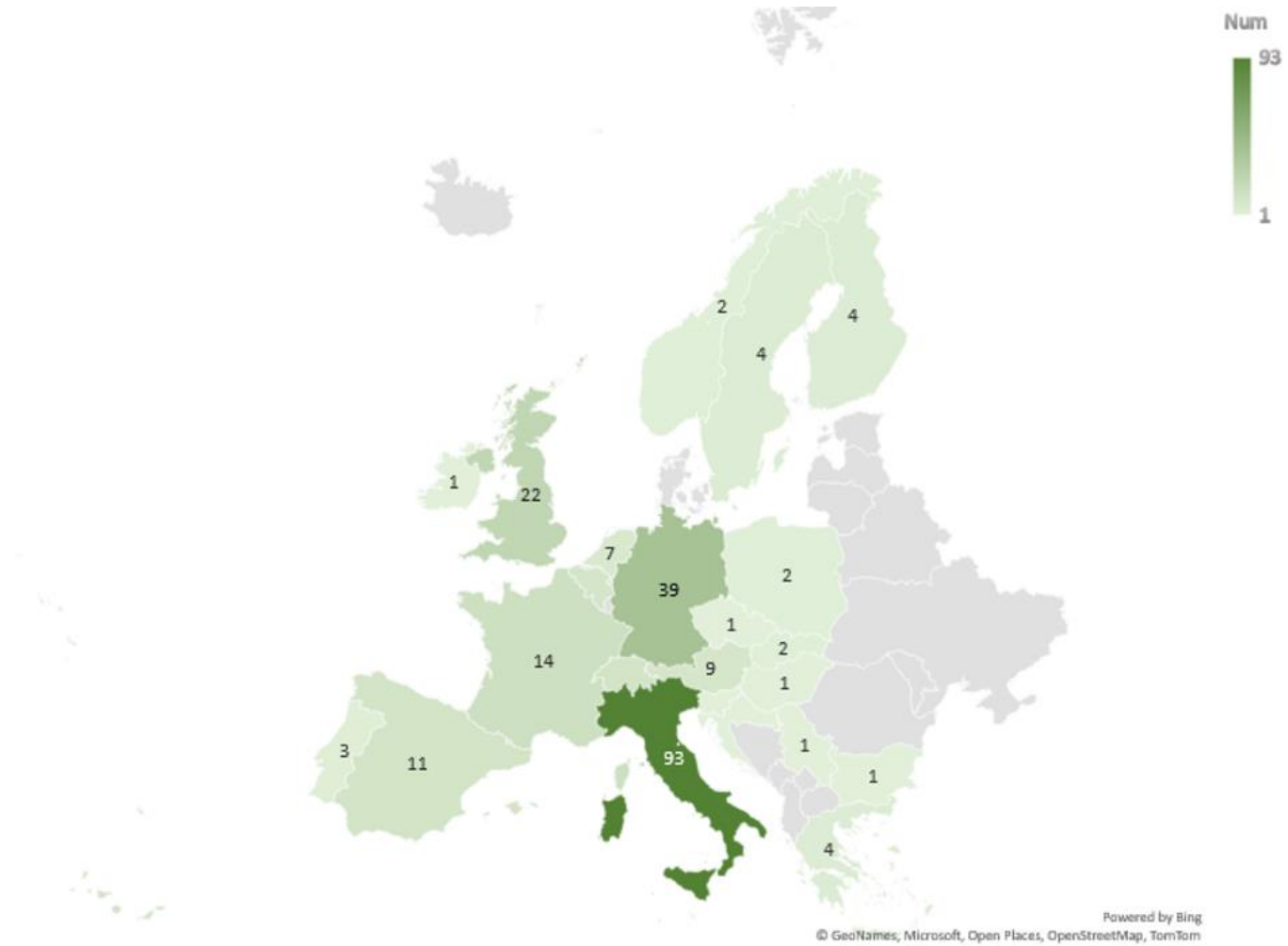
Figure 2 - Reference sectors of the considered companies.



In the realm of precious metals and WEEE recycling and recovery across Europe, numerous companies have emerged to champion the cause of environmental sustainability. Notably, in the context of our analysis, a substantial proportion of these enterprises, a total of 93 to be precise, are headquartered within Italy ([Figure 3](#)).

These companies share a common commitment to waste management values, tirelessly striving to recover and reuse the highest percentage of raw materials possible. By harnessing innovative technologies and adhering to stringent recycling processes, these enterprises exemplify the principles of a circular economy, aiming to minimize waste while maximizing resource efficiency. Drawing upon existing information available on websites, it becomes evident that these enterprises in Italy and throughout Europe are pivotal players in the broader sustainability landscape. Their endeavours are integral to not only reducing the strain on our planet's resources but also fostering economic growth and employment opportunities. [Figure 3](#) illustrates the distribution in Europe of the companies under analysis. Companies from Russia, Japan, United States, Brazil, and the Emirates were also examined; however, the image has been deliberately confined to Europe as it provides a more precise assessment representation.

Figure 3. Geographical areas of the considered companies.



2.2.2 Product Service Systems Business Models

In the examined cases, the companies operate within the realm of PSS, considering the already defined three subcategories: Product-oriented PSS, Service-oriented PSS, and Capacity-oriented PSS.

The key points related to Product-Service Systems (PSS) are essentially five.

1-Product and Service Integration: Within PSS models, companies go beyond selling products alone and offer comprehensive packages that encompass the product itself along with a range of related services. For instance, rather than merely selling a printing machine, a PSS company may provide the printer along with maintenance services, consumable supplies replenishment, and technical support. **2-Outcome-Based Provision:** PSS models often prioritize the delivery of outcomes or benefits to the customer over the sale of the product itself. For instance, a company providing heating and cooling services might guarantee a comfortable temperature within a building, as opposed to selling HVAC equipment exclusively. **3-Circular Economy Focus:** PSS models endorse the concept of a circular economy, wherein products are designed for durability, repairability, and recyclability. This approach minimizes waste and environmental impact. **4-Customer Loyalty:** By offering continuous services and ensuring the proper functioning of products, PSS companies can cultivate longer-term relationships with customers, fostering loyalty and repeat business. **5-Environmental and Economic Benefits:** The adoption of PSS models can lead to reduced operational costs and decreased waste generation. This can benefit both the company, through improved efficiency, and the environment, through reduced waste production and more efficient resource usage.

Product-Service System-based business models are increasingly pertinent in an era where sustainability and resource management have become significant priorities for both companies and consumers.

2.2.3 Business Model Canvas Representation

As already mentioned in the previous paragraphs, to present the characteristics of the activities and the corporate value intended to be conveyed through them, the business model canvas (BMC) has been chosen.

Differing from other frameworks utilized to identify the guidelines of a business model, such as the 'ReSOLVE' framework, which outlines a set of six activities facilitating a company's transition to a Circular Economy, the BMC accentuates the economic and strategic significance of the activities put into practice to achieve virtuous objectives. Moreover, as an extra reason for the choice, the Canvas model distils and enhances the information available in the companies' websites.

An example of a BMC applied to a general circular business is presented in [Table 1](#) and [Table 2](#) with the objective of showing how such model could be used to include relevant information, providing insights through a high-level analysis. As shown, the BMC is a framework that uses blocks to represent the 9 foundational components of a business: 1) Key partners: Relevant collaborations and partnerships necessary for carrying out activities, the resources acquired from these relationships, and the activities that enable partners to perform. 2) Key activities: The core activities of the company that best express the value proposition. 3) Value proposition: The primary value a company aims to convey to its customers, the promise the company makes to those who rely on its services. 4) Customer relationship: How the relationship with customers manifests and is maintained. 5) Customer segments: The consumer segments to which the

company targets. 6) Key resources: Tangible and intangible resources, people, knowledge, assets—everything that enables the company to conduct its activities. 7) Channels: The channels the company uses to present itself, contact customers, and convey the value proposition. 8) Cost structure: All expenses incurred in carrying out the company's activities. 9) Revenue streams: Total revenues and different income models.

In the case of the analysed companies' business models, it was not possible to fill all the fields of such model due to the lack of information available. However, the main purpose will be to show the value proposition and the implemented activities proposed and implemented by the companies in line with the circularity objectives.

The company business models have been, as far as it was possible, reconstructed by analysing the information that were disclosed online.

Table 1. Example of business model canvas, with a focus on circularity (from C-SERVEES EU-funded project)-Part 1.

<p>Key partnerships:</p> <ul style="list-style-type: none"> Decrease business risks throughout establishing new alliances and/or improving existing partnerships that focus on circular practices in both forward and reverse supply chain. Participate in partnerships that ensure both private and public sector procurement practices are addressed to ensure organisation appeals to a broader customer base. Address partnerships' cultural issues that would encourage circular economy business models to be widely adopted 	<p>Key activities:</p> <ul style="list-style-type: none"> Diversify circular activities via market driven research. Embrace eco-design to ensure products circularity across life cycle stages. Adopt circular strategies in the production process. Develop circular logistics and distribution (forwards and reverse logistics) Provide repair and maintenance services, including new technologies such as 3D printing. Optimise end-of-life circularity. Implement and/or enhance practices and tools to track materials and components 	<p>Value proposition:</p> <ul style="list-style-type: none"> Adopt and/or enhance options of providing product as a service (selling functionality rather than ownership) or bundles of products and services. Introduce and/or enhance offerings of leased, rented, or shared product options. Introduce and/or enhance products or services that will improve sustainable consumption patterns and respective intangible benefits (e.g., energy efficiency, green impact) Introduce and/or enhance circular end-of life options for products; including where feasible the provision of take-back and collection services. 	<p>Customer relationship:</p> <ul style="list-style-type: none"> Adopt and/or enhance customer relationships initiatives to increase customer involvement (including, where appropriate, the use of ICT technologies) Engage in social media platform to enable customers to provide feedback on economy requirements and practices. Change traditional relationships with customers, for instance: Can a customer become a supplier? Provide and/or enhance after sales services, including improved guarantees or warranties for products. 	<p>Customer segments:</p> <ul style="list-style-type: none"> Adopt circular economy activities to suit B2B and/or B2C ensuring customer segments are wide and varied to capture additional market. Identify cultural patterns, taking advantage of certain customer segments such as the early adopters, niche markets and the eco-friendly "green". Target B2C different social classes and various demographic segments with offering tailored to different price brackets.
	<p>Key resources:</p> <ul style="list-style-type: none"> Devise competitive financing models and cost saving by using and/or purchasing fewer components and obtaining materials reused or recycled from other sources. Develop circular economy skills and training programmes. Introduce and/or expand the use of ICT to foster circular economy 		<p>Channels:</p> <ul style="list-style-type: none"> Embed ICT platforms into business operations to enable new or enhanced customer communications for offerings. Embed and/or enhance activities in organisations CSR to complement brand and organisation's image. Provide and/or increase information about products through eco-labelling and certifications. Adopt and/or increase commitments to ensure highest possible levels of data security. Adopt and/or enhance marketing strategies that raise awareness amongst customers about the economy and associated benefits 	

Table 2. Example of business model canvas, with a focus on circularity (from C-SERVEES EU-funded project)-Part 2.

<p>Cost structure:</p> <ul style="list-style-type: none"> • Mitigate against any possible additional costs associated with repair, refurbishment, remanufacturing, and preparation for reuse by reducing waste disposal costs. • Introduce and/or enhance manufacturing and sales processes to account for costs associated with the end-of-life and second life materials, components, and products. • Implement and/or enhance strategies and/or practices to address costs associated with take-back and return of end-of-life products. • Implement and/or enhance strategies and/or practices to address the challenges of promoting options with lower lifetime costs rather than lower initial costs. 	<p>Revenue streams:</p> <ul style="list-style-type: none"> • Introduce and/or enhance offerings that attract recurring revenues such as bundles of sales and services, rental services, leasing options, remanufacturing through enhanced take-back schemes. • Adapt financial administration to enable circular economy business models as leasing and renting options for both B2B and B2C customer segments. • Introduce and/or enhance activities that obtain value from waste (e.g., part exchange options for products, take-back schemes for remanufacturing, preparation for reuse or resale and/or recycling)
---	--

2.3 Companies' business models

2.3.1 AMQ Ambiente: WEEE collection and treatment

AMQ Ambiente, based in Mariano Comense (CO), is an Italian company that adopts a Product-Oriented Circular Business model, placing a strong emphasis on sustainability and responsible waste management. The company specializes in the recovery of waste electrical, electronic, and computer equipment (WEEE), and its operations are rooted in circular economy principles.

AMQ Ambiente's dedication to responsible waste management and resource recovery contributes significantly to a more sustainable and environmentally conscious business environment.

On the company's website, visitors can access articles and valuable insights related to electronic waste disposal, with a particular focus on Lombardia and the Como region. The website also offers detailed information regarding the authorizations held by the company, encompassing the transport of WEEE devices and the operation of a storage and recovery facility for both hazardous and non-hazardous waste.

The company engages in a range of activities that underscore its commitment to environmentally responsible practices:

Collection and Retrieval of WEEE: AMQ Ambiente is a leader in the collection and retrieval of WEEE, sourced from artisanal, commercial, and industrial activities. The process entails several meticulous steps, including the removal of any hazardous components. Subsequently, there is a Preliminary Material Separation phase, where equipment is carefully disassembled into individual components, making it easier to recover and reuse secondary raw materials. This is followed by a Shredding and Material Sorting procedure that ensures the efficient recycling of materials. **Material and Energy Recovery:** In this crucial phase, selected materials are reintroduced into production cycles, thereby contributing to a circular economy, and reducing the demand for virgin resources. For materials that cannot be directly reused, regulations necessitate energy recovery through incineration, aligning with sustainability principles. Any residual waste that cannot be reused or incinerated is disposed of in an environmentally responsible manner. **Comprehensive Management of Documentation:** AMQ Ambiente offers comprehensive documentation management, covering various compliance aspects such as FIR (Formulario di Identificazione dei Rifiuti, i.e., *Waste Identification Form*) and SISTRI (Sistema di Controllo della Tracciabilità dei Rifiuti, i.e., *Waste Traceability Control System*). This meticulous approach ensures that all necessary paperwork is accurately processed and maintained. **Specialized Transportation Services:** The company also provides specialized transportation services for both hazardous and non-hazardous special waste, customized to meet the unique needs of its clients. This tailored approach ensures the safe and compliant handling of waste materials, addressing each customer's specific requirements.

Hereafter, in [Table 3](#) the Business Model Canvas related to the analysed company is presented.

Table 3. BMC AMQ Ambiente.

Key partnerships: Artisanal, commercial, and industrial SME	Key activities: <ul style="list-style-type: none"> Collection and Retrieval of WEE Material and Energy recovery Comprehensive Management of Documentation Specialized Transportation Services 	Value proposition: The company is specialized in the recovery of waste electrical, electronic, and computer equipment (WEEE). Operations are based on circular economy principles	Customer relationship: <ul style="list-style-type: none"> Access to articles and valuable insights related to electronic waste disposal Access to detailed information regarding authorizations held by the company 	Customer segments: AMQ Ambiente is a Business to Consumer (BTC) and Business to Business (BTB) Company
	Key resources: <ul style="list-style-type: none"> Specialized transportation services, customized to meet the unique needs of its clients. selection of materials reintroduced into production cycles, thereby contributing to a circular economy and reducing the demand for virgin resources 		Channels: Option to fill out a form directly on its website to request the desired service	
Cost structure (Typical of a manufacturing company): N/A		Revenue streams: N/A		

2.3.2. Dismeco – Automated handling and pre-sortin plant

Dismeco is an Italian company specializing in the disposal and treatment of electrical and electronic equipment waste (WEEE), operating within the framework of an environmental project dedicated to maximizing material recovery. Established in Bologna in 1977, Dismeco was the pioneer in Italy in the specific management of WEEE and is now housed in its state-of-the-art facility located in the neighboring municipality of Marzabotto. The company operates under a Product-Oriented Circular Business model.

The company's commitment and activities extend far beyond conventional waste disposal. They are part of a larger, ambitious project focused on implementing an environmentally sustainable industrial model in various applications. Dismeco firmly believes in contributing tangibly to the 'Green Economy,' with a vision to create new opportunities and employment.

The 'Ecological Village' Project, known as 'Borgo Ecologico', is physically located in the former 'Cartiera Burgo' area in Lama di Reno, which has existed for centuries. Dismeco occupies over a third of this industrial site, having entirely refurbished an area that was previously abandoned while preserving its original structural and architectural context. This 'Ecological Village' is a unique multipurpose platform where a wide range of WEEE types are treated. Innovative, specialized equipment allows the processing of various WEEE, with an impressive capacity, for example, reaching up to 600 units per day for washing machines. Furthermore, clean energy is produced on-site through the utilization of renewable energies, including a cutting-edge 1 MW peak power photovoltaic system.

The company's core operations are dedicated to the treatment and recovery of materials from various types of WEEE, with a steadfast commitment to optimizing raw material yields while systematically addressing public health risks.

One of Dismeco's particularly innovative features is an automated handling and pre-sorting plant, entirely developed and engineered by the company. This facility enables the extraction of significant components from WEEE equipment before the final destruction phase, departing from the typical methodology employed in most traditional plants.

The destruction process at Dismeco involves a two-step shredding procedure, followed by the separation of resultant materials through a system of conveyor belts.

Dismeco's WEEE treatment encompasses a wide range of equipment types, including large and small appliances, computers, and various computer-related devices. For instance, not only does Dismeco perform selective recoveries of significant components in computers, such as power units, motherboards, and various printed circuits, but upon request, it also physically destroys internal disks, providing customers with a certified and secure solution. To achieve this, the shredding equipment is specially configured to handle the destruction of disks, ensuring that no commingling with other customers' materials occurs.

Regarding authorizations and regulations, Dismeco ensures full compliance and meticulous adherence to all necessary requirements related to its WEEE treatment activities. This comprehensive approach ensures the proper handling and disposal of WEEE in accordance with environmental laws and regulations.

Dismeco's service excellence is well-recognized by its clients. The company is known for its prompt material collection, professional execution of various operations, precision in administrative matters, and adherence to sector-specific regulations. In the field of ecological dismissal, where both environmental compliance and operational know-how are essential, Dismeco distinguishes itself as a comprehensive, reliable partner.

The company has also established strategic collaborations with the Public Administration, universities, and correctional institutions. These partnerships reflect the company's commitment to fostering cooperation with governmental, academic, and correctional entities to advance in the sustainable management of electrical and electronic waste and the development of innovative solutions in the field of WEEE treatment. These synergies demonstrate Dismeco's holistic approach to ecology and sustainability, contributing to a more responsible and forward-thinking business environment.



Figure 4. Dismeco's installations

Subsequently, the Business Model Canvas related to the analysed company is presented below in [Table 4](#).

Table 4. BMC Dismeco.

Key partnerships: <ul style="list-style-type: none"> Public Administration Universities Correctional institutions 	Key activities: <ul style="list-style-type: none"> Collection of WEEE Treatment and recovery of materials from various types of WEEE. Use of Automated handling and pre-sorting plant 	Value proposition: DISMECO srl is a company specialized in the disposal and treatment of WEEE (Waste Electrical and Electronic Equipment), operating within an environmental project, to achieve the highest yield in terms of raw materials through the most suitable technological solutions for each agreement of public health risks.	Customer relationship: <ul style="list-style-type: none"> Social Media activity Offer of full compliance and meticulous adherence to all necessary requirements related to its WEEE treatment activities 	Customer segments: Dismeco is a Business to Business (BTB) Company
	Key resources: <ul style="list-style-type: none"> holistic approach to ecology and sustainability, contributing to a more responsible and forward-thinking business environment contribution to 'Green Economy,' with a vision to create new opportunities and employment 		Channels: Option to fill out a form directly on its website to request the desired service	
Cost structure (Typical of a manufacturing company): N/A		Revenue streams: N/A		

2.3.3. Chimet Spa: Printing heating circuits

Chimet is an Italian company that embraces a Product-Oriented Circular Business model. Founded in 1976, Chimet opened its first facility in Badia al Pino, followed by another in Vicinaggio in the 1980s, both located in the province of Arezzo. This reflects the long-standing connection between the company and its local region.

The acronym "Chimet" stands for "Chimica Metallurgica Toscana," underlining its commitment to traditional metalworking processes that have been used for centuries in refining gold and other precious metals.

In recent years, the company has developed its ecological division, backed by substantial scientific and technological investments, dedicated to waste management and disposal in accordance with the latest environmental protection regulations.

Chimet has established numerous collaborations with universities, research centers, and public institutions, ensuring the highest standards in precious metal recovery and refining for its clients. Precious metal recovery and refining form the core of Chimet's business.

These processes have evolved in response to the international market's demands and the need to recover industrial byproducts, allowing the company to reclaim pure precious metals that re-enter the production cycles of companies worldwide.

Chimet's forward-thinking approach has enabled the development of closed-loop processing, minimizing environmental impact and waste.

Chimet's mission is unequivocal: to recover and refine precious metals from industrial processing waste, enabling their recycling in the production of catalysts, thick film, and chemical

products. Simultaneously, the company is dedicated to the responsible disposal of waste generated during the recovery processes, complying with all current regulations.

Their expertise extends to metals recovery and refining. Additionally, they manufacture high-quality functional inks for various electronic applications. Chimet established its Thick Film Division in 1984 and has since become a renowned authority in the field of functional inks and pastes for different applications. This recognition is attributed to its extensive knowledge and expertise, as well as its diverse product range. Chimet's exceptional quality and profound understanding of ink technology have propelled the company to a position of global leadership in the realm of silver-based materials for automotive glass and its active involvement in the evolving field of Printed Electronics (PE).

The Thick Film Division specializes in the creation and production of high-quality functional inks for various electronic applications. Chimet boasts a wide range of materials ideally suited for printing heating circuits and antennas on automotive glass, human-machine interfaces (HMI) like membrane keyboards and switches, stretchable electronics for wearables and sensors, and thermoformable electronics (IME).

Chimet's inks are meticulously formulated to facilitate optimal deposition through screen printing or other printing methodologies, ensuring the necessary microstructure, design, and precision. These inks are also meticulously designed to pass all the requisite tests in different application sectors and are accompanied by appropriate technical and safety documentation, enabling their immediate and effective use.

The Analysis Laboratory specializes in determining precious metals in diverse materials, including alloys, industrial scraps, waste materials, spent catalysts, sludges, electroplating solutions, and electronics. It employs highly specialized in-house techniques and procedures, providing quick and reliable results that foster trust between Chimet and its clients. Chimet regards sustainability as the key to maintaining its position as a leading company providing an industrial service based on a closed-loop system for precious metal recovery, refining, and the production of metal-based chemical products.

The company's website proudly displays a multitude of certifications that bear testament to its unwavering commitment to environmental stewardship, engagement with the local community and adherence to stringent quality processes.

570 EI				R&D	chloride matrix
D PASTE 200 EI	-	Polyester	PET	Printed Electronics, R&D	T curable transparent ink for component encapsulation
D PASTE 202 EI	-	Acrylic	PET	Printed Electronics, R&D	UV curable transparent ink for component encapsulation
AG PASTE 550 EI	SILVER	Polyurethane	PC or PET	In-Mold Electronics	Excellent 3D forming silver material < 50mΩ/□
AG PASTE 555 EI	SILVER	Polyurethane	PC or PET	In-Mold Electronics	Good 3D forming silver material < 15mΩ/□
					Low resistance silver

Figure 5. Flexible electronics and thermoformable applications inks (Chimet Spa).

Subsequently, the Business Model Canvas related to the analyzed company is presented below in [Table 5](#).

Table 5. BMC Chimet Spa.

Key partnerships: <ul style="list-style-type: none"> Public Administration Universities Correctional institutions Precious metal refining Companies Electronic, photographic, galvanic, pharmaceutical, chemical, petrochemical, and goldsmith industries 	Key activities: <ul style="list-style-type: none"> Precious Metals Recovery and Refining Production of inks, catalysts and chemical products Metal Recycling 	Value proposition: Chimet's mission is clear and precise: to recover and refine precious metals from industrial processing waste, facilitating their recycling in the production of catalysts, thick film, and chemical products. At the same time, the company is committed to disposing of waste resulting from recovery processes with the utmost care and in compliance with current regulations.	Customer relationship: <ul style="list-style-type: none"> Social Media activity Multitude of certifications that bear testament to its unwavering commitment to environmental stewardship, engagement with the local community and adherence to stringent quality processes 	Customer segments: Chimet is a Business to Business (BTB) Company
	Key resources: <ul style="list-style-type: none"> responsible disposal of waste generated during the recovery processes, complying with all current regulations Environmental sustainability approach: <p>#Minimizing the impact of activities on the environment.</p> <p>#Managing the company in a socially and ethically responsible manner.</p> <p>#Growing and enhancing the company's assets to ensure the reinvestment of capital and the adoption of innovative technologies for continuous improvement</p>		Channels: Option to fill out a form directly on its website to request the desired service	
Cost structure (Typical of a manufacturing company): The company has developed its ecological division, backed by substantial scientific and technological investments, dedicated to waste management and disposal in accordance with the latest environmental protection regulations		Revenue streams: N/A		

2.3.4. Ecotic: platform for collecting and managing WEEE

ECOTIC is a Spanish not-for-profit foundation founded on March 7, 2005, with the encouragement of major companies in the consumer electronics industry. It adopts a Service Oriented circular business model. Its primary mission is to defend the environment, promote sustainable development, raise awareness, and provide training for manufacturers, distributors, and users of electrical and electronic equipment. ECOTIC's core focus is on the proper management of waste electrical and electronic equipment (WEEE) for organizations that participate in its Extended Producer Responsibility System (EPRS), in compliance with legal obligations for producers and distributors of such equipment. The foundation is dedicated to efficient and economically responsible recycling, optimizing resources for sustainability and long-term durability.

ECOTIC has established itself as a leading organization in Spain for electronic waste disposal. Its objectives revolve around environmental protection, sustainable development, and various initiatives. These initiatives encompass the collection, treatment, and management of waste electronic appliances, as well as conducting research in the field. ECOTIC disseminates

information about WEEE management, conducts scientific and technology activities, and promotes a culture of sustainable development.

The foundation operates under the patronage of major companies in the consumer electronics industry and is a part of AMETIC, the cross-industry association for electronics, ICT, telecommunications, and digital technologies. Its leadership is responsible for achieving founding goals and efficient asset management, focusing on performance and usefulness. ECOTIC's activities include approving management plans and programs, establishing criteria for new areas of activity, and setting guidelines for fund distribution.

The organization is structured into three functional areas: 1. Projects & Companies Area: This team manages market control, company engagement, technical project management, and participation in national and international forums. 2. Operations Area: Responsible for logistics, WEEE processing, contract negotiations, authorizations, and relationships with regional governments and local authorities. 3. Finance Area: Coordinates and controls the foundation's financial and administrative operations and provides information to the board and decision-making body.

The foundation follows an Integrated Quality and Environment Policy, adhering to ISO 9001 and ISO 14001 standards. Its commitment includes complying with legal requirements, continuous improvement, understanding client needs, maintaining an integrated management system, and ensuring staff satisfaction and motivation.

ECOTIC's core values include ethics, environmental sensitivity, quality service, and commitment to compliance with legal requirements, continuous improvement, client needs, and staff well-being.

Its added value lies in its passion for service, innovation, resource optimization, management efficiency, and transparency.

ECOTIC has contributed to the recovery and recycling of a substantial amount of materials, mitigating the environmental impact of waste. It also collaborates on R&D activities to improve WEEE recycling techniques and processes, participating in initiatives like the WEEE Forum and the HTWT project. ECOTIC's efforts have not only helped conserve finite natural resources but have also prevented potential environmental harm and health risks associated with electronic waste.

ECOTIC collaborates with a variety of stakeholders, including manufacturers, distributors, installers, and local authorities, to ensure proper management of Waste Electrical and Electronic Equipment (WEEE). The collaboration with these entities is crucial to ensure the correct disposal and recycling of WEEE and compliance with environmental regulations. In doing so, ECOTIC contributes to the promotion of environmental sustainability and sustainable development.

From the moment a producer engages with ECOTIC, the foundation undertakes responsibility for their waste-related obligations, which encompass administrative disclosure processes, registration under the appropriate registers, submission of production declarations to the Ministry, and comprehensive management of waste electrical and electronic equipment (WEEE).

ECOTIC is responsible for: 1. Collection and Management: This entails the establishment, development, and oversight of the collection, processing, and management of end-of-life WEEE. The organization ensures that waste is handled correctly and manage clients' legal responsibilities. 2. Equipment End-of-Life Management: This includes collection at the producer's premises or load grouping centre, transportation, storage, and on-site processing. 3. Administrative Procedures: ECOTIC handles various administrative requirements, including registration in the equipment producer register and the submission of production declarations

to the Ministry's register. In addition to working with producers, ECOTIC provides a platform for the collection and management of waste electrical and electronic equipment, tailored to meet each company's specific requirements. It also offers guidance to clients on the requirements and conditions outlined by the Royal Decree.

The services provided for distributors include:

1. **Equipment End-of-Life Management:** This encompasses the collection of WEEE at the distributor's premises or assigned load grouping centre, its subsequent transportation, and processing by authorized management companies.
2. **Logistical Optimization:** Guidance is offered to optimize collection and transportation conditions for enhanced logistical efficiency.
3. **Storage Recommendations:** Guidance is provided for the proper storage of WEEE before its transfer to authorized management companies.
4. **Traceability:** Electronic tags are employed to identify WEEE, ensuring complete traceability up to its final destination.
5. **Regulation Compliance:** ECOTIC provides support in identifying producers who comply with relevant regulations, reducing the risk of regulatory irregularities.

ECOTIC is the esteemed partner of prominent associations representing electrical and temperature-control system installers in Spain. This is evident through the numerous agreements it has established with various entities, which facilitate the collection and environmentally responsible processing of waste materials (such as air conditioning and lighting) on behalf of installers.

For professionals, ECOTIC extends the opportunity to utilize its Extended Producer Responsibility Organization (PRO) for waste management, all without incurring any costs. This comprehensive service includes:

1. **Equipment End-of-Life Management:** This covers the collection of WEEE at the installer's premises or designated load grouping centre, its subsequent transportation, and processing by authorized management companies.
2. **Logistical Optimization:** ECOTIC provides expert advice to optimize collection and transportation conditions, tailored to meet specific logistical requirements.
3. **Storage Guidance:** Recommendations are offered to ensure the proper storage of WEEE and meet collection facility requirements before the material is transported to authorized management companies.
4. **Traceability:** Electronic tags are utilized to identify WEEE, ensuring complete traceability of waste materials as they are managed by ECOTIC's partner companies.

Furthermore, ECOTIC actively promotes the Ecoinstaladores program, a pioneering initiative aimed at increasing the collection of waste related to temperature-control and refrigeration equipment. Given that the annual volumes for such waste are relatively lower compared to other categories, the program seeks to engage installers due to their crucial role in the recycling process. For further details on participating in this initiative, please refer to our Ecoinstaladores section.

In addition to its services for businesses, ECOTIC serves as the trusted partner for numerous local authorities. These local authorities have chosen ECOTIC to assist them in recycling municipal household waste. This waste originates from various collection points, including recycling centres, waste disposal sites, alternative waste collection locations, green parks, and other designated collection points.

ECOTIC has established partnership agreements with local authorities for the management of WEEE based on two primary alternatives:



Framework Agreement with OfiRAEE: ECOTIC participates in this framework agreement as a member of OfiRAEE, a virtual office, alongside other Extended Producer Responsibility Organizations (PROs). This platform is equipped with a tool that automatically manages requests for WEEE collection originating from municipal recycling points.

Bilateral Agreements: ECOTIC has also entered into bilateral agreements directly with local authorities. These agreements involve the management of waste collection and treatment through the municipal collection points under the jurisdiction of the collaborating authorities. ECOTIC facilitates this process using its PRO.

Through these agreements, ECOTIC actively contributes to the sustainable and responsible management of municipal household waste, playing a crucial role in environmental preservation and waste recycling in collaboration with local authorities.

ECOTIC provides a comprehensive range of services aimed at streamlining the management and collection of Waste Electrical and Electronic Equipment (WEEE) from municipal collection points. These services are designed to enhance efficiency, standardization, and traceability while contributing to effective WEEE management:

1. Automated WEEE Management: ECOTIC automates the process of WEEE management and collection from municipal collection points. This automation ensures a systematic and organized approach to handling electronic waste.

2. Optimizing Resource Usage: ECOTIC facilitates the efficient utilization of loading and transportation resources provided by all Producer Responsibility Organizations (PROs). This optimization helps in cost-effective waste transportation.

3. Standardized Information and Traceability: ECOTIC establishes standard criteria for information and traceability concerning WEEE collected from municipal recycling points. This standardization ensures consistency and reliability in data management.

4. Data Collection: ECOTIC actively collects and compiles comprehensive, reliable data on the amount of WEEE collected and managed by municipal collection points at the local, regional, and national levels. This aggregated data is a valuable resource for decision-making.

5. End-of-Life Equipment Management: ECOTIC manages electronic equipment at the end of its useful life, encompassing collection at the local authority's premises, transportation, and processing by authorized management companies. This holistic approach ensures environmentally responsible disposal.

6. Logistical Optimization: ECOTIC provides advice on optimizing collection and transportation conditions to meet logistical requirements effectively.

7. Storage Guidance: ECOTIC offers recommendations on storage conditions for WEEE and collection facility requirements. Proper storage ensures the safe and efficient handling of waste before transportation to authorized management companies.

8. Electronic Tagging for Traceability: ECOTIC utilizes electronic tags to identify WEEE, ensuring complete traceability of waste through the management companies associated with ECOTIC.

These services collectively contribute to the effective, efficient, and environmentally responsible management of WEEE from municipal collection points, aligning with ECOTIC's commitment to sustainable waste management practices.

Subsequently, the Business Model Canvas related to the analyzed organization is presented below in [Table 6](#).

Table 6. BMC Ecotic.

Key partnerships: Companies operating in the electronics and WEEE sector	Key activities: <ul style="list-style-type: none"> Collection and Management of WEEE End-of-Life Equipment Management Logistical Optimization WEEE Storage Guidance Traceability with tags 	Value proposition: The primary focus is on the effective management of waste electrical and electronic equipment (WEEE) by companies and affiliated entities within our Extended Producer Responsibility Collective System (SCRAP)	Customer relationship: ECOTIC provides information regarding procedures related to electronic device management and recovery processes, as well as news, articles and documentation from previous years regarding the work performed	Customer segments: Companies, manufacturers, distributors, installers, and local authorities, to ensure proper management of Waste Electrical and Electronic Equipment (WEEE)
	Key resources: ECOTIC places great importance on environmental respect and compliance with current regulations		Channels: Option to fill out a form directly on its website to request the desired service	
Cost structure (Typical of a manufacturing company): N/A		Revenue streams: N/A		

2.3.5. Aurubis: Metals for Progress: Driving Sustainable Growth

Aurubis, a German company with a rich history dating back to 1866, adopts a Product Oriented PSS and specializes in metal recycling and the recovery of raw materials from the mining industry. It has a global presence with various plants located across Europe and the US, committed to providing solutions to the growing recycling market. With their expertise and assets, they are well-positioned to meet the needs of this evolving market, offering a comprehensive approach to the recycling business. An additional facet of Aurubis' operations involves the production of metal profiles for electronic and industrial applications.

The heart of Aurubis' business lies in its unique positioning within the metal value chain, which encompasses three main pillars:

1 Raw Materials from Mining: Aurubis processes raw materials sourced from the mining industry. This step involves accepting and assessing materials, followed by pyrometallurgical and hydrometallurgical processing, ultimately resulting in the creation of high-quality products.

2 Recycling Materials: Aurubis actively participates in recycling. The company recovers copper and precious metals from electrical and electronic scrap, contributing to a more sustainable world. With state-of-the-art facilities and groundbreaking environmental standards, Aurubis has established itself as a leading global copper recycler.

3 Product Business: The company produces more than 1 million tons of copper cathodes each year, characterized by their exceptional quality. These cathodes can be sold on metal exchanges, but Aurubis also processes them into various intermediate products made of copper and copper alloys. Additionally, by-products such as sulfuric acid, iron silicate, and synthetic minerals complement their product portfolio.

As a real multimetal provider, in addition to copper, Aurubis deals in precious metals like gold, silver, and platinum group metals, as well as lead, nickel, tin, zinc, and selenium.

Within their specialized division, electronic scrap procurement at Aurubis adheres to stringent standards, given the intricate device structures and material compositions found in electronic

devices. The company offers comprehensive solutions for manufacturers, importers of electrical and electronic appliances, and specialized recycling firms. Copper and precious metals are recovered from the delivered electronic scrap using environmentally responsible methods. Their business relationships encompass strategic partnerships with extensive contract packages and individual contracts for precious metal-bearing raw materials.

Aurubis' broader position within the metal value chain ensures the sustainability of their results and the robustness of their business model. They are a company deeply rooted in history, yet at the forefront of addressing modern societal challenges through recycling and responsible resource management. Their commitment to sustainability and diversified approach places them at the forefront of the industry.

Aurubis' mission is to responsibly transform raw materials into value, thereby supplying metals for an innovative and sustainable world. Sustainability encompasses their core values in Economy, Environment, and People.

Aurubis aspires to achieve carbon neutrality well in advance of 2050. Alongside their sustainable products, they are making a significant contribution to the energy transition through modern production technologies and processes. Sustainability is at the core of their mission and an integral component of their business activities. Responsible resource management is their established benchmark for success. Their approach involves evaluating new investments based on clearly defined objectives, with the ultimate goal of reaching carbon neutrality long before 2050.

Aurubis' strategic approach is meticulously aligned with the prevailing trends and dynamics in its relevant markets. The company maintains constant vigilance over global market trends, specific market evolutions, the flow of raw materials and goods, and pertinent regulatory matters. These observations serve as the basis for their continuous monitoring of the markets for promising opportunities. To ensure sustainable growth, they proactively address the key topics that are consistently gaining prominence. Notably, these areas include recycling and sustainability, reflecting their commitment to responsible practices.

Aurubis' robust core business forms a central pillar of its strategy. As the world's need for metals increases, their expertise in processing raw materials that contain metals, including concentrates and recycling materials, provides a solid foundation. Their differentiation is rooted in high productivity, cost efficiency, and effective sales channels for their products. This core business is fortified through continuous expansion of processing capabilities across their group-wide smelter network, aligning with their corporate strategy. Selective expansion of their multimetal capacities through dedicated projects and initiatives further secures and strengthens their core business.

The strength of Aurubis' business model lies in the fact that the main profitability factors partially offset each other. This means that they can relatively well manage the volatility of different market prices.

Subsequently, the Business Model Canvas related to the analyzed company is presented below in [Table 7](#).

Table 7. BMC Aurubis.

Key partnerships: Companies operating in metal, recycling, and chemical sectors	Key activities: <ul style="list-style-type: none"> processes raw sourced from materials the mining industry actively participates in recycling produces more than 1 million tons of copper cathodes each year, characterized by their exceptional quality 	Value proposition: The company follows its mission of responsibly transforming raw materials into value, thereby supplying metals for an innovative and sustainable world. Their understanding of sustainability encompasses the focal points of Economy, Environment, and People.	Customer relationship: <ul style="list-style-type: none"> Social Media activity The company's website features articles and in-depth content about its operations, along with information for investors and shareholders. 	Customer segments: Aurubis is a Business to Business (BTB) Company
	Key resources: Aurubis aspires to achieve carbon neutrality well in advance of 2050. Alongside their sustainable products, they are making a significant contribution to the energy transition through modern production technologies and processes		Channels: Option to fill out a form directly on its website to request the desired service	
Cost structure (Typical of a manufacturing company): <ul style="list-style-type: none"> investments based on clearly defined objectives, with the ultimate goal of reaching carbon neutrality long before 2050 The company maintains constant vigilance over global market trends, specific market evolutions 		Revenue streams: N/A		

2.3.6. Boliden – Electronics recycling and lead extraction from car batteries

Boliden is a Swedish multinational metals, mining, and smelting company headquartered in Stockholm. With its Product-oriented PSS CBM, the company has been engaged in the exploration, extraction, and processing of both base and precious metals. Their production approach relies on expertise, innovation, and contemporary technology, fostered through partnerships with Nordic technology and engineering firms. Boliden stands as a front-runner in sustainable metal production, spanning from initial deposits to the recycling of utilized metals. The company extracts and produces high-quality metals with good climate performance. They produce copper, zinc, nickel, and lead which are all necessary for the climate transition and can be found in a number of innovation-critical areas such as production of electric cars or car batteries. With their extensive experience, their high level of skills and leading technology, Boliden works towards reaching their vision to be the most climate friendly and respected metal provider in the world. In fact, they make the lifecycle assessments of their main metals from cradle to gate, without counting carbon credits and offsets. This improves their possibilities to see in which scope they need to make efforts to reduce our carbon dioxide footprint.

The value chain begins in exploration and through their mines, concentrators, and smelter they create the metals that make climate transition possible. The main activities performed by Boliden include a) Exploration: they search for new mineral deposits through exploration. b) Mines: they extract ore from open pits and underground mines. Thanks to modern technological developments, mining methods and their expertise in mining design, their production is of the highest class from drilling and blasting to loading and crushing. They separate minerals from crushed ore in their concentrators. Exhausted parts of the mine are refilled, and sand from the concentrators is collected in tailing dams. c) In their smelters they refine mineral concentrates from their own and other mines into pure metals which are delivered to their customers. The

end products are various mineral concentrates that are shipped to smelters for further processing.

Boliden holds a dominant position in electronics recycling and the extraction of lead from car batteries. Additionally, Boliden is considered one of the world’s leading zinc producers and is the leader in Europe when it comes to production of copper and nickel as well as is considered as a major player in the recycling of electronics. The circular approach allows Boliden to consistently generate value from residual products. Indeed, the company allocates investments into inventive solutions aimed at optimizing metal extraction from raw materials, simultaneously curbing waste deposition. This positions them as a pivotal contributor to the circular economy.

The main products that Boliden produces include a) The base metals they produce are zinc, copper, lead and nickel – four products that are very important for infrastructure and the construction and automotive industries. b) They produce gold and silver, which are two of the most common precious metals. In addition to the jewellery industry and the financial sector, gold and silver are used mainly in electronics manufacturing. c) Metal concentrates, i.e. enriched ore, are Boliden mines' end products, which for the most part go to their own smelters. In addition to finished metals, their smelters also produce other products such as sulphuric acid used in the manufacture of paper.

The Business Model Canvas related to Boliden is presented below in [Table 8](#).

Table 8. BMC Boliden.

Key partnerships: <ul style="list-style-type: none"> Geological experts and software providers for exploration. Suppliers of mining equipment and technology. Joint Ventures for exploration projects. Collaborators in waste disposal methods. Environmental organizations and sustainability advocates. 	Key activities: <ul style="list-style-type: none"> Exploration: Geologic investigations, environmental assessments, technological advancements. Mining and Concentrating: Underground and open-pit mining, ore processing, remote control operations. Metal Production: Smelting, calcination, leaching, purification, electrolysis. Circular Material Management: Maximizing by-products, waste disposal innovation. Carbon Footprint Assessment: Life-cycle assessments, transparency in emissions. 	Value proposition: Work to be the most climate friendly and respected metal provider in the world by contributing to sustainable metal production and a reliable supply of metals for society.	Customer relationship: <ul style="list-style-type: none"> Collaborative and transparent relationships. Commitment to responsible and circular sourcing. Continuous improvement in methods and sustainability. 	Customer segments: <ul style="list-style-type: none"> Sustainable industries and manufacturers. Environmental and sustainability-focused organizations. Society at large concerned about responsible metal sourcing. Governments and regulatory bodies.
	Key resources: <ul style="list-style-type: none"> Geological knowledge and expertise. Advanced mining and processing equipment. Innovative waste disposal methods. Carbon footprint assessment tools and expertise. Circular material management strategies. 		Channels: <ul style="list-style-type: none"> Sustainable Exploration and Mining: Innovative exploration methods. Circular Processing: Maximizing by-products and waste reduction. Responsible Metal Production: Ethical and transparent processes. Carbon Footprint Assessment: Transparent measurements. 	
Cost structure: <ul style="list-style-type: none"> Operational costs for exploration, mining, and processing. Research and development for innovative methods. Environmental and sustainability initiatives. Costs associated with carbon footprint assessment. Circular material management costs. 		Revenue streams: <ul style="list-style-type: none"> Income from metal sales (zinc, copper, lead, gold, silver). Revenue from by-products (sulphuric acid, zinc clinker, sulphur dioxide, palladium concentrate). Potential revenue from carbon footprint assessment services. Government incentives for responsible sourcing. 		

2.3.7. HKS – The Metal Company: Ferrous, non-ferrous and electronics materials recycling

HKS was born to take care of processing ferrous, non-ferrous and electronics materials as they believe that every scrap could make a difference, therefore they take on any challenge working efficiently to create great impacts. HKS presents itself as a forward-thinking company which operates sustainably in the recycling business supported by its expertise. Specifically, HKS is

specialized in recycling iron and metals: cutting, shredding, burning, sorting are different ways used to optimise the recycling of metals. Indeed, HKS has a unique position as a shredder company since their specialised shredders maximise the return on the materials and ensure a clean flow of iron.

Additionally, they collect non-ferrous materials such as copper and aluminium at all locations near them. Regarding non-ferrous materials, for optimal processing they use high-tech separation techniques such as Infrared, X-ray, CAT scans and colour sorting.

Table 9. BMC HKS-The Metal Company

<p>Key partnerships:</p> <ul style="list-style-type: none"> Extensive network of clients, partners, and purchasers. Product designers, manufacturers, and industrial design students for collaborative efforts. 	<p>Key activities:</p> <ul style="list-style-type: none"> Processing Ferrous, non-Ferrous, and electronics materials Collection, distribution, separation, sorting, and processing of ferrous and non-ferrous materials and electronics. Utilizing advanced high-tech separation techniques. Maintenance of good relationships with clients, partners, and purchasers. Hosting knowledge-sharing sessions to promote sustainability. Continuous innovation in recycling techniques. <p>Key resources:</p> <ul style="list-style-type: none"> Expertise in metal recycling. 100 years of experience in the industry. National coverage. Certified processes and standards (ISO 14001, ISO 9001, WEEELABEX). CSR achievement ladder Level 4 (MVO-prestatieladder Niveau 4). Team of 450 passionate employees. Affiliation with TSR, the European market leader in metal recycling. 	<p>Value proposition:</p> <p>With a clear focus on the future, the aim is to add to a sustainable production process setting up the practices for the processing of discarded materials to make a significant contribution to the reduction of waste winning more new raw materials</p>	<p>Customer relationship:</p> <ul style="list-style-type: none"> Industries requiring metal recycling services. Manufacturers looking for sustainable material sources. Clients seeking efficient and responsible recycling solutions. Individuals and organizations disposing of electronic waste. <p>Channels:</p> <ul style="list-style-type: none"> Communication channels for reaching and serving clients. Knowledge-sharing sessions with partners and students. Existing network and affiliations within the recycling industry. 	<p>Customer segments:</p> <ul style="list-style-type: none"> Industries requiring metal recycling services. Manufacturers looking for sustainable material sources. Clients seeking efficient and responsible recycling solutions. Individuals and organizations disposing of electronic waste.
<p>Cost structure:</p> <ul style="list-style-type: none"> Operating costs for processing facilities and equipment. Employee salaries and benefits. Investments in high-tech separation techniques. Maintenance of environmentally friendly practices. Expenses related to certifications and compliance. 		<p>Revenue streams:</p> <ul style="list-style-type: none"> Revenue generated from processing and recycling services. Income from the sale of high-quality recycled materials. Potential revenue from knowledge-sharing and collaborative projects. 		

Their knowledge is however spread also to electronics components. Indeed, HKS is a recycling partner for small household appliances, IT devices, consumer appliances, electric and electronic tools. The company uses their specific production processes to regain precious materials from electronics and complete IT and medical equipment dismantling. In order to allow the recycling of these kind of products, the company is equipped with the WEEELABEX certification which describes the working method for the treatment and processing of discarded electrical and electronic equipment in compliance with the European Directive 2002/96/EC. company uses high-tech separation techniques with the most advanced equipment available, based on magnetic properties, shape, colour, spectral analyses, and density. [Table 9](#) shows the business model canvas of HKS, grouping all the relevant information on the specific role and purposes of the company.

2.3.8. Umicore: Circular materials technology company

Umicore is a leading circular materials technology company with an extensive expertise in the fields of material science, chemistry, and metallurgy. They are determined to leverage their unique position and mutually reinforce portfolio of activities to accelerate the global transformation of mobility, respond to the growing need for advanced materials and contribute to the pursuit of a global circular economy.

The company uses the most sophisticated, eco-efficient recycling processes available to treat not just their own production scrap but also industrial waste. Indeed, they close the loop and

recover over 20 different precious and other critical metals, drastically reducing their customers' ecological footprint and giving them a competitive edge. In particular, Umicore suppliers can ship their end-of-life materials, production scrap or by-products to the company for recycling and further refining. For easy-to-recycle materials like gold and silver, Umicore uses a short recycling loop, fully integrated in their product offering. Instead, for complex products such as industrial residues, Umicore uses long loops. Once materials are recycled, the supplier can either decide either to take back the metals, or to allow the company sell them to other parties.

Regarding their expertise, Umicore relies on their broad know-how in chemistry, material science and metallurgy in order to transform metals into high-tech custom-made, fully recyclable materials. Indeed, their eco-efficient recycling facilities offer the highest metal yields and comply with world-class quality standards, whether it's industrial waste or a by-product from non-ferrous industries. Additionally, their advanced materials coupled with technological know-how enable more scalable, more efficient and more sustainable solutions to tackle current and future societal challenges. Umicore is taking efforts in also developing the next generation of sustainable advanced materials including: - Electro-Optic Materials which creates material solutions for optical and electronic applications to customers around the world; - Precious metals-based coatings to enhance the economic efficiencies of semiconductors. Below in [Table 10](#), the Business Model Canvas of the company summarizes all the relevant activities implemented.

Table 10. BMC Umicore

Key partnerships: <ul style="list-style-type: none"> Research and academic institutions. Industrial partners. Start-ups and innovation collaborators. Suppliers of sustainable and ethically vetted primary metal sources. Recycling service providers. Customers seeking advanced materials. 	Key activities: <ul style="list-style-type: none"> Research and innovation in material science, chemistry, and metallurgy. Development of sustainable products and process technologies. Recycling of critical metals. Collaborations and partnerships with industrial and academic entities. Investment in start-ups. Attracting top scientific talent. Scaling new technologies through New Business Incubation (NBI) unit. 	Value proposition: Continuous research and innovation in the core of all the activities to provide 'materials for a better life'. Their success relies on maintaining their technological advantage and value creation.	Customer relationship: <ul style="list-style-type: none"> Collaborative partnerships. Continuous innovation and technology advancement. Ethical and sustainable sourcing. Recycling services for end-of-life materials. Customer-focused development of advanced materials. 	Customer segments: <ul style="list-style-type: none"> Industries in need of advanced materials. Manufacturers in the clean mobility sector. Companies in various industries. Academic and research institutions. Recycling service seekers. Ethical and sustainability-focused customers.
	Key resources: <ul style="list-style-type: none"> Expertise in material science, chemistry, and metallurgy. International R&D team. Recycling facilities. Sustainable metal sourcing. Ethical procurement practices. Research and innovation pipeline. 		Channels: <ul style="list-style-type: none"> Research and innovation collaborations. Recycling services. Sustainable metal sourcing. Marketing of advanced materials. Academic and research partnerships. 	
Cost structure: <ul style="list-style-type: none"> Research and development costs. Talent acquisition and retention costs. Recycling and processing expenses. Ethical metal sourcing costs. Costs associated with partnerships and collaborations. Sustainable procurement costs. 		Revenue streams: <ul style="list-style-type: none"> Sales of advanced circular materials. Recycling services revenue. Licensing of innovative technologies. Revenue from collaborations and partnerships. Sales of sustainable and ethically sourced metals. 		

2.3.9. STENA Recycling: advanced recycling processes

STENA Recycling is one of Europe's leading recycling companies operating in different European countries and has a long history within material recycling. Their objective is to create a truly circular society where nothing goes to waste. They provide reliable waste collection, innovative reuse services and advanced recycling on an industrial level, and they also offer comprehensive recycling solutions and circular services, which play a key role in the transition to a circular economy. The company aims at contributing to a circular economy helping companies finding the hidden value in the waste material. Indeed, they offer a comprehensive range of advanced

recycling and waste management solutions and offers a reliable supply of high-quality recycled raw materials for use in new products.

With their advanced recycling processes, Stena Recycling transforms huge quantities of complex waste into high-quality recycled raw materials for use in production instead of the Earth’s natural resources. These recycled raw materials include ferrous and non-ferrous metals, plastics and paper and are resold for use in the manufacturing of new products.

Their circular economy approach aims at repairing, refurbish and reuse worn-out products in new applications – or to recycle them into high-quality raw materials for use in new products. These new products are also designed to be fully reused or recycled when they reach end-of-life.

Such circular approach aims at minimizing landfill, reducing the consumption of finite natural resources and saving energy.

For the electronics recycling different steps are followed including: (i) the collection of electronic waste including mobile phones, flat screens, computers, small appliances, refrigerators, air conditioners and more; (ii) the recycling of electronic waste, as well as the reuse of functioning products and components to extend product life and make the best use of resources; (iii) manual disassembly and decontamination are performed: batteries, components with mercury, PCB capacitors and other hazardous waste are safely taken care of; (iv) automated sorting: Metals and stainless steel are sorted by size. Plastics are sorted into bromine and non-bromine. Wet tables sort precious metals, while camera technology sorts certain metals and components.

Below, in [Table 11](#), is represented the Business model canvas of STENA Recycling, which has been classified as a Product-oriented PSS CBM.

Table 11. BMC Stena Recycling

Key partnerships: <ul style="list-style-type: none"> • Electronics recyclers • Steel mills, smelters, foundries • Plastics manufacturers or other manufacturers 	Key activities: <ul style="list-style-type: none"> • Electronics recycling and reusing. • Collection of electronic waste including mobile phones, flat screens, computers, small appliances, refrigerators, air conditioners and more. • Recycling of electronic waste and reuse functioning products and components to extend product life and make the best use of resources. • Removal of hazardous waste through manual disassembly and decontamination. Batteries, components with mercury, PCB capacitors and other hazardous waste is safely taken care of. • Automated sorting of metals and stainless steel. Plastics are sorted into bromine and non-bromine. Wet tables sort precious metals, while camera technology sorts certain metals and components. • Creation of new high-quality raw materials ensuring that used products are recycled responsibly. 	Value proposition: <ul style="list-style-type: none"> • Advanced processes to increase the recycling rate of electronics by providing different services including collection, sorting, reusage and recycling of electronics waste safely and efficiently. 	Customer relationship: <ul style="list-style-type: none"> • N/A 	Customer segments: <ul style="list-style-type: none"> • Electronics recyclers
	Key resources: <ul style="list-style-type: none"> • Advanced processes which allow to recycle over 90% of all electronics. • Expertise and methods required to remove hazardous waste safely and sustainably. 		Channels: <ul style="list-style-type: none"> • N/A 	
Cost structure: <ul style="list-style-type: none"> • Investments in new improved recycling processes and technology. 		Revenue streams: <ul style="list-style-type: none"> • Revenues from selling metals recovered from electronic recycling and from providing electronic recycling services. 		

2.3.10. Sim Green Srl: final treatment of electrical and electronic equipment

Sim Green operates in Italy and offers efficient and specialized collection of electro-electronic waste. Specifically, it offers to customers the collection, transport, storage, and final treatment services for WEEE. It also offers services on behalf of third parties aimed at companies and public bodies that intend to destroy electronic material.

Sim Green is one of the few companies in Italy equipped to carry out the final treatment of electrical and electronic equipment and their components through a process of decomposition, selection, shredding or grinding, mixing and sample testing of the raw/secondary materials to recover, in total compliance with environmental parameters and regulations.

The main services that the company offers include: (i) Collection and transport since it uses vehicles to carry out a widespread collection service at a local level to companies that sell and maintain electronic equipment for private individuals and public bodies; (ii) Selective process for all the collected materials; (iii) Treatment: after disassembling the components and selecting the materials, Sim Green proceeds to the shredding, grinding and storage phases by type. The materials, divided by type, are sent to companies for the recovery and use of raw and secondary materials.

Given its main activities and services offered, the company’s CBM has been classified as Service-oriented PSS. In [Table 12](#) below is reported the business model canvas of the company.

Table 12. BMC Sim Green Srl

Key partnerships: <ul style="list-style-type: none"> Symbiosis with electronics companies. 	Key activities: <ul style="list-style-type: none"> Electronics recycling. Collection of pieces from electronic companies at local level. Selective processes of the collected materials. Materials disassembly. Materials shredding, grinding and storage by type. Materials sending to companies which recover it and reuse it as raw materials and/or to create secondary materials. 	Value proposition: <ul style="list-style-type: none"> Company specialized in the final treatment of electrical and electronic equipment and their components. 	Customer relationship: <ul style="list-style-type: none"> Electronics waste is directly collected from the customers locally. 	Customer segments: <ul style="list-style-type: none"> Electronics companies for the recovery and use of raw materials and secondary raw materials.
	Key resources: <ul style="list-style-type: none"> Equipment which allows to carry out the final treatment of electrical and electronic equipment and their components through a process of decomposition, selection, shredding or grinding of recovered materials. 		Channels: <ul style="list-style-type: none"> N/A 	
Cost structure: <ul style="list-style-type: none"> N/A 		Revenue streams: <ul style="list-style-type: none"> N/A 		

2.3.11. Kuusakoski Recycling Oy: Advanced pyrometallurgical and hydrometallurgical processes

Kuusakoski Recycling Oy is a company based in Finland with an expertise in restoring waste materials to their original value by collecting, processing, and producing new raw materials, and delivering them to customers worldwide. The company buys many types of materials from companies including electronic and electrical whole units and item components from IT, industrial and household appliances - both in waste and reusable condition.

They carry out a needs assessment for clients and offer effortless recycling solutions for industrial needs. Based on the needs assessment, clients receive a customised offer which guarantees the most economically efficient recycling services possible. When customers order recycled materials from the company, they get exactly what they need. Additionally, they achieve cost efficiency by minimizing material storage and optimizing logistics. At the heart of their sales service indeed are the long-term customer relationships.

Recyclable electrical and electronic equipment includes computers, printers, mobile phones, lamps, and various power tools. If reuse is not a viable option, they will recycle the equipment as raw material.

Their state-of-the-art technology ensures efficient material yield. Specifically, they use advanced pyrometallurgical and hydrometallurgical processes in the recovery of precious metals and additionally, their own accredited laboratory provides support when more detailed analysis is needed. If necessary, they can tailor the methods to suit each company’s needs.

Such company’s CBM has been classified as Product-oriented PSS. The detailed business model canvas is reported in [Table 13](#) below.

Table 13. BMC Kuusakoski Recycling

Key partnerships: <ul style="list-style-type: none"> IT, industrial and household appliances. Symbiosis with electronics industry. 	Key activities: <ul style="list-style-type: none"> Electronics recycling. Precious metals recovery. Plastics recycling. Recovery: Advanced pyrometallurgical and hydrometallurgical processes in the recovery of precious metals Dispose: Safe dispose of electric and electronic equipment: sensitive data containing material is delivered to the company using sealed security containers. 	Value proposition: <ul style="list-style-type: none"> Restoring value - waste materials are restored to their original value by collecting, processing, and producing new raw materials keeping cost efficiency by minimizing material storage and optimizing logistics. Sales service that nurtures the long-term relationships with customers. 	Customer relationship: <ul style="list-style-type: none"> Needs assessment for customers to customize each offer and guarantee the most economically efficient recycling services. Effortless recycling solutions for many industrial needs. 	Customer segments: <ul style="list-style-type: none"> OEMs. International market. Refineries, steel mills and foundries.
	Key resources: <ul style="list-style-type: none"> Recycling expertise over 100 years: material know-how, specialist expertise. 		Channels: <ul style="list-style-type: none"> N/A 	
Cost structure: <ul style="list-style-type: none"> N/A 		Revenue streams: <ul style="list-style-type: none"> Revenues from the sale of recycled raw materials. 		

2.3.12. Companies CBMs: Results

After presenting and describing the companies’ CBMs, in this paragraph the aim is to highlight the main results obtained from such analysis in order to align them with the objectives of TREASURE.

As already reported in D1.1, TREASURE can help: a) companies by reducing non-circular resource consumption and on lifecycle carbon emissions. The increased use of remanufactured components instead of new components reduces the non-circular influx of cars and reduces CO2 from materials due to the lower carbon intensity of remanufactured components; b) OEMs and suppliers to cooperate to increase the efficiency of disassembly, sorting and reverse logistics processes and enable recovery at the highest possible value. Components and materials are channelled to remanufacturing facilities with greater awareness. The following table ([Table 14](#)) showcases key aspects of the companies’ business models presented and illustrates how the findings in the business models of the companies align with the content presented in Figure 19 of deliverable D1.1.

Table 14. Results of companies' CBMs

Company name	Type of PSS	Main results	Relevant points for TREASURE (/D1.1 related)
AMQ Ambiente	Product-oriented	<p>The company is specialized in the recovery of WEEE. Operations are based on Circular Economy principles. AMQ Ambiente activities can be summarized as:</p> <p>Collection and retrieval of WEEE from artisanal, commercial, and industrial activities;</p> <p>Comprehensive management of documentation (FIR, SISTRI, asset discharge).</p> <p>Transportation of hazardous and non-hazardous special waste, offering customized solutions based on customer needs.</p>	<p>AMQ Ambiente proposes solutions that align with the concept of the circular economy, promoting environmental respect, and falling within the archetypal business model of 'Resource Recovery' with the aim of reducing production waste (solutions: minimized production scraps). Regarding the business "enablers", AMQ Ambiente utilizes recyclable materials and cutting-edge technologies.</p>
Dismeco	Product-oriented	<p>DISMECO srl is a company specialized in the disposal and treatment of WEEE, operating within an environmental project. Dismeco firmly believes in contributing tangibly to the 'Green Economy,' with a vision to create new opportunities and employment. Particularly innovative is an automated handling and pre-sorting plant – completely engineered by DISMECO which enables the extraction of significant components from WEEE equipment "prior" to the final destruction phase, a departure from the approach of most traditional plants.</p>	<p>Dismeco Srl is a company that strongly and clearly supports sustainability. Not only it aims for circularity in electronics, operating with a state-of-the-art facility entirely engineered by the company itself (enablers), with the goal of achieving circular products, but it has also established the 'Ecological Village,' a frontier of innovation where operations are carried out with almost zero emissions, promoting the use of renewable sources. Business model archetype: Resource Recovery.</p>
Chimet Spa	Product-oriented	<p>Chimet's mission is clear and precise: to recover and refine precious metals from industrial processing waste, facilitating their recycling in the production of catalysts, thick film, and chemical products. At the same time, the company is committed to disposing of waste resulting from recovery processes with the utmost care and in compliance with current regulations. They perform:</p> <p>Metals Recovery and refining</p> <p>The production of high-quality functional inks for various electronic applications, ideal for printing heating circuits and antennas on automotive glass, human-machine interfaces (HMI) like membrane keyboards and switches, wearable electronics and sensors, as well as thermoformable electronics (IME).</p> <p>Analysis for the Determination of Precious Metals from Various Matrices: Alloys, Scraps, and Industrial Waste such as Exhaust Catalysts, Sludges, Galvanic Solutions, and Electronics, Utilizing Highly Specialized In-House Techniques and Procedures</p>	<p>Chimet Spa is a leading company in the field of precious metal recovery and refining. It utilizes state-of-the-art facilities and is renowned worldwide for its laboratory of metal analysis. One of the enabling aspects of Chimet's business is certainly its advanced recycling and recovery technologies. Chimet provides solutions that prioritize progress with a vision that places the circular economy at the forefront. Business model archetype: Resource Recovery.</p>
Ecotic	Service-oriented	<p>Ecotic objectives revolve around environmental protection and sustainable development. Its primary focus is on the effective management of waste electrical and electronic</p>	<p>Ecotic is an organization that specializes in the management of electronic waste and end-of-life logistics. This characteristic positions it in the "resources recovery" business model</p>

Aurubis		<p>equipment (WEEE) by companies and affiliated entities within an Extended Producer Responsibility Collective System (SCRAP).</p> <p>The activities carried out are: <u>Collection and Management of WEEE</u> <u>End-of-Life Equipment Management</u> <u>Logistical Optimization</u> <u>WEEE Storage Guidance</u> <u>Traceability with tags</u></p> <p>ECOTIC has contributed to the recovery and recycling of a substantial amount of materials, mitigating the environmental impact of waste.</p>	<p>archetype, in which, starting from recyclable materials and a robust infrastructure (enablers), excellent results are achieved in the management of electronic waste, logistics optimization, and storage. Through its services, it facilitates the circularity of materials and raw materials used in electronic devices.</p>
	Product-oriented	<p>The company follows its mission of responsibly transforming raw materials into value, thereby supplying metals for an innovative and sustainable world. Their understanding of sustainability encompasses the focal points of Economy, Environment, and People. Aurubis aspires to achieve carbon neutrality well in advance of 2050. Alongside their sustainable products, they are making a significant contribution to the energy transition through modern production technologies and processes. The main activities they perform are: <u>Mining Raw Materials processing;</u> <u>Metals recycling</u> in which they perform pyrometallurgical and <u>hydrometallurgical process</u>. <u>Production of metal profiles</u> for electronic and industrial applications</p>	<p>Aurubis prioritizes sustainability as a fundamental element. Notably, they already hold a leading position in the industry with their exceptional focus on energy efficiency and environmental preservation. Aurubis has outlined an ambitious objective to attain carbon neutrality in their production processes by the year 2050, demonstrating their unwavering dedication to sustainable practices. They are actively exploring innovative technologies, including the utilization of hydrogen in their production methods.</p>
Boliden	Product-oriented	<p>The gathered information is mainly not related to the electronics sector. However, the activities performed could serve as additional information on possible product-oriented PSS CBMs. Boliden's activities can be summarized as:</p> <ol style="list-style-type: none"> <u>Exploration, extraction and processing of metals in a responsible way.</u> In their smelters, <u>mineral concentrates from their own and other mines are refined into pure metals</u>. Additionally, they hold <u>a dominant position in electronics recycling and the extraction of lead from car batteries</u>. Ongoing optimization and consistent processes enable them to optimize the output of metals and by-products. This strategy results in a diversified product portfolio, reduced waste in production, and enhanced competitiveness. Boliden is one of the world's leading zinc producers and is the leader in Europe when it comes to production of copper and nickel. Globally, we are also a major player in the recycling of electronics. Boliden produces also gold and silver, which are two of the most common precious metals. 	<p>Through its activities, Boliden aligns with the resource recovery business model archetype. The circularity is enabled by its advanced recycling technology and infrastructure.</p>

<p>HKS - The metal company</p>	<p>Service-oriented</p>	<p>Recycling activity: HKS <u>collect, distribute, separate, sort, and process ferrous and non-ferrous materials as well as electronics</u>. They make a real impact by striving for the most efficient, innovative, and sustainable working methods. <u>Every offered solution for processing discarded remnants is custom, and no request is too complex</u>. They can always offer fitting solutions to serve the interest of all stakeholders – with operational excellence that benefits their clients, people, and the planet. The company works with <u>advanced high-tech separation techniques, specializing in processing, separating, and sorting iron, rest fractions, and electronics</u>. Ultimately, what is left are valuable materials they can offer to metal producers as high-quality resources. Processing discarded materials for recycling is very sustainable; moreover, HKS ensure that each step of the process has as little impact on the environment as possible.</p>	<p>HKS offers minimized production scrap solutions. Its business model archetype can be classified as resource recovery.</p>
<p>Umicore</p>	<p>Product-oriented</p>	<p>Umicore offers <u>eco-efficient recycling and refining services for precious metal-bearing materials such as by-products from other non-ferrous industries</u> (e.g., drosses, mattes, speiss, anode slimes), consumer and industrial recyclable products (e.g., electronic scrap, spent auto catalysts, spent industrial catalysts, sweeps, and bullions). The Precious Metals Operations (PMO) focus on fast throughput and maximized yields at optimized cost. They are fully tuned for the <u>efficient refining of an extended range of complex and valuable raw materials, containing precious metals</u>. The Base Metals Operations (BMO) focus on flexibly processing by-products from the PMO at the lowest possible cost and with optimal throughput times. Both PMO and BMO enhance the basic success factors of our business model: flexibility, reliability and complexity. <u>Major investments have been completed to develop, install, and operate new chemical and metallurgical operations, completely shifting their focus from concentrates to recyclable materials</u> and industrial by-products over the past decade</p>	<p>Umicore offers recycling at scale solutions and minimized production scrap solutions enabled by recoverable and recyclable materials and advanced recycling technology and infrastructure. Therefore, it fits in both product use extension and resource recovery business model archetypes.</p>
<p>STENA Recycling</p>	<p>Product-oriented</p>	<p>STENA offers a complete range of market-leading services, <u>recycling processes and equipment to help customers increase the electronic waste recycling and reuse</u>. The organization also offers: <u>safe transportation of electronic waste to the recycling facilities for safe dismantling and sorting and safe methods to remove products with hazardous waste (e.g., PCB capacitors)</u>. Their activities include: the reuse of the functioning electronic components in</p>	<p>STENA Recycling follows a product use extension and resource recovery business model archetypes as it provides recycling and reuse solutions and minimized production scraps through recoverable and recyclable materials and advanced recycling technology.</p>

Sim Green Srl		new electronic products, the destruction of confidential information, advanced recycling and reuse processes to create new value and continuous investment in new processes and technology, and in advanced sensor technology.	
	Service-oriented	<p>The company performs the <u>collection, transport, storage and final treatment services for WEEE</u>.</p> <p>Their available <u>equipment is able to carry out the final treatment of electrical and electronic equipment and their components through a process of: decomposition, selection, shredding or grinding of the recovered raw/secondary materials, complying with the environmental regulations</u>.</p> <p>For the recycling: first the pieces are collected from electronic companies at local level, then the collected material is subjected to a series of selective processes. Components are disassembled and after disassembly they are subject to the phases of shredding, grinding and storage by type. The material is sent to companies which recover it and reuse it as raw materials and/or to create secondary materials</p>	Sim Green Srl fits in the resource recovery business model archetype thanks to the minimized production scrap allowed by advanced recycling technology and infrastructure and recoverable and recyclable materials .
Kuusakoski Recycling Oy	Product-oriented	<p><u>Restoring of waste materials to their original value</u> by collecting, processing, and producing new raw materials, and delivering them to the customers worldwide while maintaining cost efficiency.</p> <p>The company uses <u>advanced pyrometallurgical and hydrometallurgical processes in the recovery of precious metals from electronics</u>.</p> <p><u>The metal content can be customized from low to very high-grade quality according to customer specification</u>.</p> <p>Cost efficiency thanks to the minimization of the material storage and the logistics optimization.</p>	The recovery and recycling solutions implemented by Kuusakoski, place its business model archetype as product use extension. Additionally, thanks to its advanced recycling technology , another relevant archetype which can be identified is resource recovery.

2.4 Analysis of the current state of the art of Circular Business Models in European Projects.

2.4.1 Introduction to EU projects CBMs.

In this section, the performed analysis of the CBMs relevant for TREASURE found among ongoing and finished European projects is described. The projects have been investigated in a two-steps approach:

1. A first preliminary analysis conducted on the European Commission CORDIS portal, to spot all the projects related to circularity applied to electronics.
2. A deeper investigation of each of the projects deemed as interesting after a first analysis on the portal. This analysis was performed by investigating information available on projects official websites and public deliverables related to CBMs.

After the preliminary analysis on CORDIS, eighteen projects were spotted as potentially relevant for TREASURE. The criteria according to which the projects were deemed as interesting were: (i) consideration of electronic devices and components and (ii) analysis and applications of circular practices on the treated devices and components. The full list of the considered projects is the following:

1. PolyCE: Post-Consumer High-tech Recycled Polymers for a Circular Economy.
2. sustainablySMART: Sustainable Smart Mobile Devices Lifecycles through Advanced Re-design, Reliability, and Re-use and Remanufacturing Technologies.
3. CABRISS: Implementation of a Circular economy Based on Recycled, reused and recovered Indium, Silicon and Silver materials for photovoltaic and other applications.
4. C-SERVEES: Activating Circular Services in the Electric and Electronic Sector.
5. UNICORN: Unveiling Innovation Potential of Circular Approaches in Automotive Electronics and Beyond.
6. REFORM PRINTED ELECTRONICS FOR THE CIRCULAR ECONOMY.
7. Sustain-a-Print: Sustainable materials and processes for green printed electronics.
8. NONTOX: Removing hazardous substances to increase recycling rates of WEEE, ELV and CDW plastics.
9. SUSMAGPRO: Sustainable Recovery, Reprocessing and Reuse of Rare-Earth Magnets in a Circular Economy.
10. CloseWEEE: Integrated solutions for pre-processing electronic equipment, closing the loop of post-consumer high-grade plastics, and advanced recovery of critical raw materials antimony and graphite.
11. CircEI-Paper: Circular Economy Applied to Electronic Printed Circuit Boards Based On Paper.
12. METALLICA: Metallurgical patented Process Transforming Residues from the Electronic Industry into Valuable Precious Metals.
13. CIRC4Life: A circular economy approach for lifecycles of products and services.
14. HR-Recycler: Hybrid Human-Robot RECYcling plant for electrical and eLEctRonic equipment.
15. CE-RISE Circular Economy Resource Information System.
16. FPD Recycling: CircularPro-Robust AI and robotics for the WEEE recycling sector.
17. PCBRec process: Waste Printed Circuit Board (WPCB) Recycling with Molten Salts.
18. PLATIRUS: PLATInum group metals Recovery Using Secondary raw materials.

Each of these projects was investigated through information recoverable from its websites and its deliverables. Nonetheless, for most of them, information deemed as relevant for the business models they had developed was unavailable. Only a limited subset of projects presented some relevant information that was analysed. The projects were specifically: (i) CABRISS, (ii) CIRC4Life, (iii) C-SERVEES, (iv) HR-Recycler, and (v) SustainablySMART.

2.4.2 CABRISS CBMs Information and analysis

Table 15. CARBISS BMC reconstruction.

Key partnerships: <ul style="list-style-type: none"> Symbiosis with electronics and metallurgy industries for transformation of recycled materials into usable products. Symbiosis with glass and aluminium industries for dismantling, extraction, and recovery 	Key activities: <ul style="list-style-type: none"> Collection of end-of-life modules & cells, PV waste Dismantling, extraction, and recovery. Purification of silicon and metallics Fabrication of silicon wafers using recycled materials Fabrication of silicon solar cells using recycled materials Transformation of recycled materials into usable products. 	Value proposition: <ul style="list-style-type: none"> Selling of m-Si solar cells and modules, HET solar cells and modules and CIGS solar modules coming from secondary materials. Selling of recovered Indium, Silicon and Silver. 	Customer relationship: <ul style="list-style-type: none"> N/A 	Customer segments: <ul style="list-style-type: none"> Solar Panels OEMs Other users of Indium, Silicon and Silver.
	Key resources: <ul style="list-style-type: none"> N/A 		Channels: <ul style="list-style-type: none"> N/A 	
Cost structure: <ul style="list-style-type: none"> N/A 		Revenue streams: <ul style="list-style-type: none"> N/A 		

For CABRISS it was not found an already prepared business model canvas. Nonetheless, starting from information found in the official project website, it was attempted to reconstruct at least partially its business model as portrayed in [Table 15](#). The value proposition of CABRISS is twofold: on the one hand, selling of recovered cells and modules to be sold to solar panels original equipment manufacturers, on the other selling of recovered materials (namely Indium, Silicon and Silver) to any potential customer that may use them. In the information they presented, big relevance was given to the key partnerships CABRISS business model pursuits. These partnerships appear as focused moreover on the necessity of partners that can disassemble the collected components and transform them into usable materials. This should not be a relevant need in TREASURE project, as among the involved partners is already present this kind of expertise referred to the Automotive sector.

2.4.3 CIRC4Life CBMs information and analysis

Table 16. CIRC4Life BMC reconstruction.

Key partnerships: <ul style="list-style-type: none"> N/A 	Key activities: <ul style="list-style-type: none"> Eco-accounting platform and impact assessment tools with eco-costs and eco-credits schemes with an online life cycle analysis to implement the eco cost calculation and with an impact assessment tool implementing eco-credits. Set up an ICT platform for eco-accounting that informs about the eco-impact of a product, eco-balance of a client and computes the eco-credits, accessible also through a smartphone app. Develop sustainable design methods and guidelines. Set up impact assessment tools based on circular economy requirements. A traceability architecture providing sustainable, transparent, comparable information at product level. An eco-shopping system providing information at the point of sale on the sustainability of products. An attractive sustainability label indicating the eco-costs of the product, enabling consumers to compare the environmental impact of different products. 	Value proposition: <ul style="list-style-type: none"> Product-Service Systems with the services listed in the key activities. 	Customer relationship: <ul style="list-style-type: none"> Involve stakeholders including end-users to gather feedback. 	Customer segments: <ul style="list-style-type: none"> End-consumers
	Key resources: <ul style="list-style-type: none"> Intelligent bins (already in place). 		Channels: <ul style="list-style-type: none"> N/A 	

For CIRC4Life a reconstruction of the business model canvas was also attempted, starting from information found on the project official website. The value proposition of the discussed business model is selling Product-oriented PSS to end-consumers, where the service part is related to an eco-accounting platform developed within CIRC4Life. The products are small electronic devices. The platform connects consumers with an IT architecture that counts eco-costs and eco-credits associated with consumers consumption behaviour. Consumers insert in the platform through a smartphone app all the relevant information related to the virtuous behaviours related to recycling and reuse of devices to gain eco-credits, and through label scanning they insert information about the products they consume, generating their eco-costs. Consumers with a particular virtuous behaviour (many eco-credits and few eco-costs) would receive some rewards. This engagement in the B2C environment though, is quite distant from TREASURE context, where the digital exploitable results are mainly related to a B2B context as already described in D8.1.

2.4.4 C-SERVEES CBMs Information and analysis

Table 17. C-SERVEES BMC

Key partnerships: <ul style="list-style-type: none"> Decrease business risks throughout establishing new alliances and/or improving existing partnerships that focus on circular practices in both forward and reverse supply chain. Participate in partnerships that ensure both private and public sector procurement practices are addressed to ensure organisation appeals to a broader customer base. Address partnerships' cultural issues that would encourage circular economy business models to be widely adopted 	Key activities: <ul style="list-style-type: none"> Diversify circular activities via market driven research. Embrace eco-design to ensure products circularity across life cycle stages. Adopt circular strategies in the production process. Develop circular logistics and distribution (forwards and reverse logistics) Provide repair and maintenance services, including new technologies such as 3D printing. Optimise end-of-life circularity. Implement and/or enhance practices and tools to track materials and components 	Value proposition: <ul style="list-style-type: none"> Adopt and/or enhance options of providing product as a service (selling functionally rather than ownership) or bundles of products and services. Introduce and/or enhance offerings of leased, rented, or shared product options. Introduce and/or enhance products or services that will improve sustainable consumption patterns and respective intangible benefits (e.g., energy efficiency, green impact) Introduce and/or enhance circular end-of-life options for products, including where feasible the provision of take-back and collection services. 	Customer relationship: <ul style="list-style-type: none"> Adopt and/or enhance customer relationships initiatives to increase customer involvement (including, where appropriate, the use of ICT technologies) Engage in social media platform to enable customers to provide feedback on economy requirements and practices Change traditional relationships with customers, for instance: Can a customer become a supplier? Provide and/or enhance after sales services, including improved guarantees or warranties for products. 	Customer segments: <ul style="list-style-type: none"> Adopt circular economy activities to suit B2B and/or B2C ensuring customer segments are wide and varied to capture additional market. Identify cultural patterns, taking advantage of certain customer segments such as the early adopters, niche markets and the eco-friendly "green". Target B2C different social classes and various demographic segments with offering tailored to different price brackets.
	Key resources: <ul style="list-style-type: none"> Devise competitive financing models and cost saving by using and/or purchasing fewer components and obtaining materials reused or recycled from other sources. Develop circular economy skills and training programmes. Introduce and/or expand the use of ICT to foster circular economy 		Channels: <ul style="list-style-type: none"> Embed ICT platforms into business operations to enable new or enhanced customer communications for offerings. Embed and/or enhance activities in organisations' CSR to complement brand and organisation's image. Provide and/or increase information about products through eco-labelling and certifications. Adopt and/or increase commitments to ensure highest possible levels of data security. Adopt and/or enhance marketing strategies that raise awareness amongst customers about the economy and associated benefits 	
Cost structure: <ul style="list-style-type: none"> Mitigate against any possible additional costs associated with repair, refurbishment, remanufacturing and preparation for reuse by reducing waste disposal costs. Introduce and/or enhance manufacturing and sales processes to account for costs associated with the end-of-life and second life materials, components, and products. Implement and/or enhance strategies and/or practices to address costs associated with take-back and return of end-of-life products. Implement and/or enhance strategies and/or practices to address the challenges of promoting options with lower lifetime costs rather than lower initial costs. 		Revenue streams: <ul style="list-style-type: none"> Introduce and/or enhance offerings that attract recurring revenues such as bundles of sales and services, rental services, leasing options, remanufacturing through enhanced take-back schemes. Adapt financial administration to enable circular economy business models as leasing and renting options for both B2B and B2C customer segments. Introduce and/or enhance activities that obtain value from waste (e.g., part exchange options for products, take-back schemes for remanufacturing, preparation for reuse or resale and/or recycling) 		

In the case of C-SERVEES, besides on the official project website, information was found available on several public deliverables. In this project, was developed a business model canvas for a generic circular business model (see [Table 17](#)). While, by being generic, it surely cannot be entirely adaptable to TREASURE, it may be that some points of the canvas will provide useful cues for TREASURE CBMs when they will be developed. Furthermore, C-SERVEES disclosed information related to four pilots conducted within the project. All four of them were related to PSS, namely:

- One hundred washing machines provided to users through ownership transfer with after-sales services or through renting. This pilot was though more focused on remanufacturing and refurbishing, while TREASURE project is more focused on recycling.
- Two hundred laser printers and one thousand toner cartridges. In this case, the pilot focused on both remanufacturing and recycling. One of the main key activities was reported being eco-design. This is something applicable also to some PSS present in TREASURE, moreover ER#12, ER#3, and ER#19. Engagement of consumers is viewed as an urgent activity in this pilot, to understand needs and requirements and make them more aware about advantages of recycled and refurbished products. Also, data and information sharing are deemed as relevant. QR codes on the printers are used to communicate with customers. The need of maintaining high level of data security is highlighted. Maintenance, repair, and control services are offered as well. This kind of service offerings, included in PSS, is relevant to be defined for TREASURE PSS as well.
- Two hundred advanced link monitoring for optical networks. For this pilot, further information related to the eco-design features of the product were disclosed. It appeared that the main tackled points were improvement for recycling efficiency and

longevity and improvement of energy efficiency. As another crucial point emerged the sharing of materials data with recyclers. In this sense, TREASURE is partially tackling this point, by providing actors data about recyclability and sustainability assessment through ER#13 (TREASURE platform), ER#4 and #5 about sustainability & circularity assessment and advisory methodologies and ER#10 about recyclability analysis and recycling rate calculations and design for recycling feedback and advice. Customer relationships were mentioned to be exploiting dedicated and strategic long-term contracts. Indeed, in this case, the context was B2B, as in TREASURE, and this kind of approach may be applicable also in TREASURE itself. Maintenance and support services were involved as well. This kind of service offerings, included in PSS, is relevant to be defined for TREASURE PSS as well.

- One hundred television sets. In this case, the pilot is again focused on B2C. The value proposition involves as before good quality, durable and circular products with associated after-sales services. The TVs though were in some cases sold, and in others provided through a rental or leasing model. The usage of blockchain to increase circularity is also mentioned and emphasis is put on increasing recycled content in the components. Among the urgent activities to be performed, is mentioned the developing of a training programme for dismantling of products.

2.4.5 HR-Recycler CBMs information and analysis

Table 18. HR-recycler BMC.

Key partnerships: <ul style="list-style-type: none"> • N/A 	Key activities: URGENT ACTIVITIES: <ul style="list-style-type: none"> • Development of a robotic platform. • Development of AI-enabled perception tools, robotic actions planning and control, human-robot collaboration schemes and factory -level modelling and cognitive perception. 	Value proposition: <ul style="list-style-type: none"> • Recovery and sorting of components. 	Customer relationship: <ul style="list-style-type: none"> • N/A 	Customer segments: <ul style="list-style-type: none"> • N/A
	Key resources: <ul style="list-style-type: none"> • N/A 		Channels: <ul style="list-style-type: none"> • N/A 	
Cost structure: <ul style="list-style-type: none"> • N/A 		Revenue streams: <ul style="list-style-type: none"> • N/A 		

In HR-Recycler, the project focused on the development of a semi-automated process for the dismantling of components by means of a robotic platform and AI-based perception tools. This is similar to what in TREASURE is performed for ER#1 and ER#2. Nonetheless, except for this generic information, no other detail was found about business model development in HR-Recycler.

2.4.6 SustainablySMART CBMs information and analysis

Table 19. SustainablySMART BMC.

Key partnerships: <ul style="list-style-type: none"> N/A 	Key activities: <ul style="list-style-type: none"> System design for modularity and economic efficiency 	Value proposition: <ul style="list-style-type: none"> System with lower initial costs or lesser leasing rates for machinery compared to high volume automation solutions. Modularity and flexibility of the system enabling different degrees of disassembly. 	Customer relationship: <ul style="list-style-type: none"> N/A 	Customer segments: <ul style="list-style-type: none"> Medium sized smartphone recyclers
	Key resources: <ul style="list-style-type: none"> N/A 		Channels: <ul style="list-style-type: none"> N/A 	
Cost structure: <ul style="list-style-type: none"> N/A 		Revenue streams: <ul style="list-style-type: none"> N/A 		

In SustainablySMART, a line for fully automated disassembly of smartphones was developed. Among the main advantages of the developed line, it was mentioned the lower initial costs or lesser leasing rates for machinery compared to high volume automation solutions. Another key concept that was highlighted was the modularity and flexibility of the developed system. This is something that can be extremely relevant for TREASURE as well. Indeed, the modularity of disassembly, recovery and recycling processes is defined as the ability of a process to adapt to different components to be disassembled or different materials to be recovered. In a market like metallic materials, where price fluctuations are usually strong and significant, the flexibility to adapt to different typologies of components disassembly and materials recovery and recycling is crucial. Indeed, this can shield the business against metals price fluctuations, as it becomes possible to move to the recovery of the materials that are more required by the market in any given moment. In TREASURE this applies to POLIMI disassembly process, to UNIVAQ metals recovery process, and to TNO IMEs production process from recycled materials. Indeed, in D1.3 and D1.4 they were defined, respectively, as the DIS use case (POLIMI), REC use case (UNIVAQ), and ECO use case (TNO). The three of them, brought together, could become the main parts of a unique process of disassembly of components, recycling of metals embedded in them, and production of IMEs starting from them.

2.5 Analysis of the current state of the art of business models of digital tools enabling circularity in Automotive industry

Since it was not found neither in the literature nor among the European projects information related to the business models for digital instruments enabling circularity in the Automotive industry by sharing information and data with actors along the value chain, a further analysis was conducted on the existing business cases. Indeed, this is relevant for few TREASURE ERs that are mainly related to a digital offer, namely ER#13 and ER#11. A preliminary search focused on Automotive digital tools enabling information and data sharing to achieve a higher circularity level was conducted in the literature. Nonetheless, information related to business models was

not found. Afterwards, the investigation related to existing business cases led to uncover eleven cases related to digital tools providing and sharing information and data to enable or support circularity in the Automotive industry. The found digital tools are:

- WF-RepTool.
- Circularity platform.
- The Circular Cars Initiative (CCI).
- Catena-X.
- Circunomics.
- Afteriize.
- One data.
- Ottobee.
- Wejo Adept.
- Otonomo.
- Caruso Dataplace.

Not much information was disclosed about the proper business models of the listed tools. Nonetheless, some information could be found analysing their official websites, moreover by analysing their offering. Most of the offered services were related to sharing of real-time data and information, differently from ER#13 in TREASURE. Nonetheless, some potentially interesting recurrent features were spotted:

- Modularity of the offer: often, the offerings are articulated in few packages with different functionalities and prices, and it is possible to purchase only one or more of them. This modularity enables a distinction of the offering to different customer segments, that may be interested to different packages. A further example of segmentation of the offerings may concern the development of offerings of licences for non-commercial purposes.
- DEMO version: often was also offered the possibility of accessing to a free DEMO version with reduced functionality and limited time-window for access, with the goal of letting potential users test it before choosing if purchasing it or not.
- Benchmarking functionality: many of the analysed digital tools offered different sorts of benchmarking functionalities. This may be something relevant to be included in a value proposition, as users may be interested in benchmarking their performance (of any kind) with the comparable best practices or the comparable sectors average performance. This functionality is sometimes offered in exchange of an extra-price to be paid.
- Revenues sharing: in a minority of cases, it was cited the sharing of some of the revenues coming from the digital tool with databases access providers.

In TREASURE context, it will be crucial considering the impact of the developed digital tools on teaching and consultancy services that may be offered. Indeed, these tools can be used as a support to train and test students. Concerning consultancy services, the tools developed within TREASURE may provide a knowledge basis for supporting scenario evaluations for consultancies focused on assessment and improvement circularity practices of companies. The tools can also contain the knowledge needed to quantify, assess, and improve circularity practices. In consultancies for companies, the tools can also create knowledge on product data to truly assess and improve disassembly, recyclability, and overall circularity. Furthermore, they can be used also for generating useful insights for also NGOs and legislators into aspects affecting circularity.

3 Analysis of the main economic and environmental benefits impactable by TREASURE results

An analysis has been performed to evaluate the typologies of benefits that can be impacted by TREASURE project results. The considered benefits concern positive economic, social, and environmental impacts related to a generic business. The framework adopted to identify the benefits came from the FENIX project, financed by the European Commission, where the framework was developed and validated. FENIX project was also about circularity practices referred to electronic components. Thus, FENIX scope is consistent with TREASURE scope. The framework was adapted to TREASURE, and it is portrayed in [Table 20](#).

Table 20. Framework used to identify benefits impacted by TREASURE results.

	Product-Service Systems	Consultancy & Teaching services	Digital services & products
Reducing overall costs			
Reducing business risks			
Opening new revenue streams			
Improving competitive advantage			
Complying with environmental regulations			
Reducing environmental impacts			
Improving resource efficiency			
Improving supply chain visibility and provisioning			
Reducing supply chain complexity			
Enhancing reputation and brand value			
Reaching new markets			
Developing innovative skills and knowledge			

On the columns of the framework are presented the main typologies of results expected by TREASURE. On the rows are presented the benefits that can be achieved. The results are those already defined in the introduction paragraph. The benefits can be defined as follows:

- Reducing overall costs: an economic benefit about the reduction of the costs required to perform the activities related to the considered business.
- Reducing business risks: reduction of the generic economic risks related to the conducted business, due for example to disruptive and unforeseen external events (like supply risks) or due to mistakes done conducting business, etc. That may lead to the reduction of revenues and market share.
- Opening new revenue streams: opening to the possibility of differentiating the sources of revenues achievable through the considered business.
- Improving competitive advantage: introduction of innovations through TREASURE ERs can lead to improving competitive advantage of the partners.
- Complying with environmental regulations: under this point are considered both compliancy with current regulations and anticipation of future regulations. ERs that improve circularity can obviously be helpful in achieving this.
- Reducing environmental impacts: adoption or improvement of circularity practices through project ERs can obviously lead to reduction of the overall environmental impacts caused by the conducted business activities.
- Improving resource efficiency: the improvement of the efficiency of the resources used to conduct business activities may mean improvement of materials efficiency or energy efficiency. It can be achieved in any stage of the product life cycle by leveraging product or process improvements.
- Improving supply chain visibility and provisioning: the introduction of circularity practices enables the possibility of having closer and safer sources of raw materials compared to traditional linear supply practices. This translates into having a better visibility and provisioning of the supply chain.
- Reducing supply chain complexity: for the same reasons mentioned in the point above, supply chains can become less complex through circularity practices and thus easier to be managed.
- Enhancing reputation and brand value: improvement in circularity performances, if properly planned and conducted, lead to improvement in environmental sustainability performances that can be leveraged to improve brand value and reputation among customers and stakeholders.
- Reaching new markets: improving efficiency and environmental impacts may open the possibility of accessing new markets and market segments.
- Developing innovative skills and knowledge: development of innovative solutions often leads those involved in their development to acquiring new skills and knowledge.

The partners were asked, referring to their ERs, to fill the table by stating the expected impact of their benefits on the different categories of benefits. Obviously, each partner was asked to fill only the column of the table referred to the result typology their ERs fell in. Partners were asked to respect the following indications when filling the table:

- Putting “1” if they thought that their ERs will have a low impact on the considered benefit.

- Putting “2” if they thought that their ERs will have a medium impact on the considered benefit.
- Putting “3” if they thought that their ERs will have a high impact on the considered benefit.

In the process, partners were asked to consider points of view of both ER provider and ER user, providing a grade that embedded the average of both. Together with the grade, comments were required.

After the partners compiled the table as described above, it was possible to draw some considerations on the benefits that are expected from TREASURE project results. It was built a table of benefits and results representing the average of the answers collected from the partners and is represented in [Table 21](#). This table represents a summary of the overall expected impact of TREASURE ERs on the listed benefits, to evaluate where major impacts can be expected.

Table 21. Summary of the expected impact of TREASURE results on the listed economic and environmental benefits.

	Product-Service Systems	Consultancy & Teaching services	Digital services & products
Reducing overall costs	2,5	1,3	1,5
Reducing business risks	1,5	1,3	1
Opening new revenue streams	3	2,8	2,5
Improving competitive advantage	3	2,5	2
Complying with environmental regulations	3	2	1,5
Reducing environmental impacts	3	2,5	3
Improving resource efficiency	3	2,3	2
Improving supply chain visibility and provisioning	2,5	2	3
Reducing supply chain complexity	2,5	1,2	1
Enhancing reputation and brand value	2	2	2,5
Reaching new markets	2	1,5	1,5

Developing innovative skills and knowledge	3	2,5	1,5
--	---	-----	-----

For what concerns TREASURE PSS results, it was noted that better disassembly solutions for products provide on the one hand lower disassembly costs, but on the other hand may bring higher production costs. This is something that should be evaluated carefully from case to case.

Concerning consultancy and teaching services, it was possible to distinguish a difference in the expected benefits between partners providing consultancy and teaching services by directly leveraging a physical lab-scale plant in their ERs (POLIMI, UNIVAQ, and TNO) and the partners providing consultancy and teaching services without directly leveraging any plant (e.g., UNIZAR, SUPSI, UNI and MARAS). It emerged that according to the partners, from the former typology of teaching and consultancy services, could be expected a stronger impact on the benefits “improving resource efficiency”, “improving supply chain visibility and provisioning”, and “complying with environmental regulations”. On the other hand, for the latter typology of teaching and consultancy services, the benefit “enhancing reputation and brand value” emerged as expected to be more impacted. It was also highlighted how, for what concerns environmental regulations anticipation, only some of the regulations, related to recycling and circularity, are involved in the teaching and consultancy services expected from TREASURE. Nonetheless, it was also pointed out how currently and likely in the future many regulations from the European Commission are expected to be focused on recycling and recovery of materials (moreover Critical Raw Materials). Obviously, TREASURE expected results, being focused on materials recycling, are tackling this point. Finally, it was underlined how, for actors receiving the consultancy services, new revenues streams can be opened in a twofold way: on the one hand, improvement or enabling of circularity practices can enable the creation of value from waste. On the other hand, more sustainable products and processes may allow for asking a premium price to customers, increasing in this way revenues.

Concerning digital services and products expected from TREASURE, the focus was moreover on ER#13, called “TREASURE platform” in D8.1. It was highlighted how ER#13 may open new revenues opportunities for both the provider of the platform and the platform users: for the former, the platform may guarantee to its providers revenues coming from the users that access to it. For the latter, platform users may be supported by it in better dismantling components to be sold to recyclers, gaining revenues from this activity. In terms of supply chain sustainability and provisioning, the platform may have a double positive impact according to TREASURE partners. On the one hand, by providing information sharing, it may improve supply chain visibility. On the other hand, by supporting circularity practices, the platform may help in reducing dependency of supplies coming from outside European Union. Finally, according to the partners, the platform will have highly positive environmental impacts.

4 Conclusions

Deliverable 8.6 is a first work necessary for the identification of new CBMs to be adopted within TREASURE. First of all, a state-of-the-art analysis allowed to define the circularity concepts and how it could relate to businesses through the consideration of CBMs. Then, three categories of circular business models have been considered: Product service systems, Consultancy and teaching services, Digital services and products. In this deliverable, the analysis conducted on CBMs implemented by existing companies and in EU funded projects allowed to have a preliminary analysis to define practices that could be implemented in TREASURE to enhance circularity.

From the analysis of the CBMs implemented by companies offering PSS, the analysis focused on eleven relevant cases. Out of eleven companies, eight offered product-oriented PSS, while the remaining three offered service-oriented PSS. It was found no case of companies offering a capacity-oriented PSS. The main highlights of the business models description revolved around continuous striving for technological innovation, reduction of production scraps in synergy with recycling practices, and the centrality of other environmental sustainability aspects besides recycling, such as energy efficiency.

From the analysis of past and current EU funded projects emerged eighteen projects with topics and objectives similar to the ones of TREASURE. For five of them, it was possible to find information related to the CBMs they proposed. The main notions drawn from the analysed projects concerned: (i) the relevance of recycling modularity, which is the ability to adapting the process to recycling different typologies of materials, coping with their price fluctuations; (ii) relevance of exploiting long-term contracts when dealing in a B2B context; (iii) cruciality of information and data sharing to implementing circularity practices, coupled with data safety and confidentiality.

From the analysis of the existing digital tools supporting information and data sharing for circularity in Automotive, emerged as recurrent features: modularity of the offer in packages, the availability of a DEMO version, a model of revenues sharing with data suppliers, and the inclusion of a functionality for benchmarking with best practices or average industry values in the value proposition.

The workshops with partners have allowed the discussion on the work performed. Indeed, the support of the consortium was relevant also to evaluate the typologies of benefits that can be impacted by TREASURE project results. For PSS exploitable results, it emerged that the benefits with a higher expected impacts are: (i) opening new revenue streams, (ii) improving competitive advantage, (iii) complying with environmental regulations, (iv) reducing environmental impacts, and (v) improving resource efficiency. For consultancy and teaching services, the most impacted benefits are expected to be (i) opening new revenue streams, (ii) improving competitive advantage, and (iii) reducing environmental impacts. For digital products and services, the benefits expected to be most impacted are (i) opening new revenue streams and (ii) enhancing reputation and brand value.

The intent of D8.7 will be to define new types of CBMs applicable to TREASURE.



5 References

- Deviatkin, I. *et al.* (2022) 'Implementation of Circular Economy Strategies within the Electronics Sector: Insights from Finnish Companies', *Sustainability (Switzerland)*, 14(6). Available at: <https://doi.org/10.3390/su14063268>.
- Geissdoerfer, M. *et al.* (2020) 'Circular business models: A review', *Journal of Cleaner Production*, 277, p. 123741. Available at: <https://doi.org/10.1016/j.jclepro.2020.123741>.
- Geissdoerfer, M., Vladimirova, D. and Evans, S. (2018) 'Sustainable business model innovation: A review', *Journal of Cleaner Production*, 198, pp. 401–416. Available at: <https://doi.org/10.1016/j.jclepro.2018.06.240>.
- Lieder, M. and Rashid, A. (2016) 'Towards circular economy implementation: A comprehensive review in context of manufacturing industry', *Journal of Cleaner Production*, 115, pp. 36–51. Available at: <https://doi.org/10.1016/j.jclepro.2015.12.042>.
- Marke, A. *et al.* (2020) 'Reducing e-waste in China's mobile electronics industry: the application of the innovative circular business models', *Asian Education and Development Studies*, 9(4), pp. 591–610. Available at: <https://doi.org/10.1108/AEDS-03-2019-0052>.
- Moreau, N. *et al.* (2021) 'Could unsustainable electronics support sustainability?', *Sustainability (Switzerland)*, 13(12), pp. 1–7. Available at: <https://doi.org/10.3390/su13126541>.
- orti, V., Balde, C.P., Kuehr, R., Bel, G. (2017) *Global E-waste Monitor 2020: Quantities, Flows and the Circular Economy Potential*. Available at: https://collections.unu.edu/view/UNU:7737#.ZB20_WbyXz8.mendeley.
- Pollard, J. *et al.* (2022) 'Developing and Applying Circularity Indicators for the Electrical and Electronic Sector: A Product Lifecycle Approach', *Sustainability (Switzerland)*, 14(3), pp. 1–20. Available at: <https://doi.org/10.3390/su14031154>.
- Restrepo, E. *et al.* (2019) 'Historical penetration patterns of automobile electronic control systems and implications for critical raw materials recycling', *Resources*, 8(2). Available at: <https://doi.org/10.3390/resources8020058>.
- Rosa, P., Sassanelli, C. and Terzi, S. (2019) 'Towards Circular Business Models: A systematic literature review on classification frameworks and archetypes', *Journal of Cleaner Production*, 236, p. 117696. Available at: <https://doi.org/10.1016/j.jclepro.2019.117696>.
- Sassanelli, C. *et al.* (2022) 'Building PSS-based circular business model canvases: an application in the waste from electrical and electronic equipment context', *2022 IEEE 28th International Conference on Engineering, Technology and Innovation, ICE/ITMC 2022 and 31st International Association for Management of Technology, IAMOT 2022 Joint Conference - Proceedings*, pp. 1–9. Available at: <https://doi.org/10.1109/ICE/ITMC-IAMOT55089.2022.10033136>.
- Suppipat, S. and Hu, A.H. (2022) 'Achieving sustainable industrial ecosystems by design: A study of the ICT and electronics industry in Taiwan', *Journal of Cleaner Production*, 369(March), p. 133393. Available at: <https://doi.org/10.1016/j.jclepro.2022.133393>.
- Wang, J. and Chen, M. (2011) 'Recycling of electronic control units from end-of-life vehicles in China', *Jom*, 63(8), pp. 42–47. Available at: <https://doi.org/10.1007/s11837-011-0136-9>.

Williams, I.D. and Shittu, O.S. (2022) 'Development of Sustainable Electronic Products, Business Models and Designs Using Circular Economy Thinking', *Detritus*, 21, pp. 45–54. Available at: <https://doi.org/10.31025/2611-4135/2022.16228>.

