THE CURRENT AND FUTURE USE OF SECONDARY RAW MATERIALS IN PORTUGAL

STRATEGY DOCUMENT | September 2021

This project is funded by the European Union via the Structural Reform Support Programme and implemented by CLEAN in collaboration with its experts, in cooperation with the European Commission.

ACKNOWLEDGEMENTS

The authors of this report would like to thank the Government of Portugal for its engagement and commitment during the preparation of the "Draft Strategy Document - The Current and Future Use of Secondary Raw Materials in Portugal" and the Directorate-General for Structural Reform Support (DG REFORM) of the European Commission for continuous support during the implementation of this project co-funded via the Structural Reform Support Programme.

This report is the result of close collaboration with the Portuguese EPA, Agência Portuguesa do Ambiente (APA), currently under the supervision of the Ministry of Environment and Climate Action (MAAC). In particular, CLEAN and PlanMiljø would like to thank the Head of Unit of the Waste Department of APA, Mrs. Silvia Ricardo, the Head of the Sectoral Waste Division, Mrs. Inês Mateus, the Expert Technique within the Office of the Portuguese Secretary of State for the Environment, Mrs. Ana Sofia Vaz, and the Policy Officer of the Directorate-General for Structural Reform Support (DG REFORM), Mr. Christoph Klockenbring.

The authors would like to express their appreciation to all the stakeholders who participated in virtual meetings and interviews undertaken from March 2020 to March 2021 for producing this report.

This report was prepared under the guidance of Bjørn Bauer and Kia Rose Egebæk from PlanMiljø who drafted the content with the analytical support of the team of 3Drivers and inputs and direction from Maria Dominguez, project co-ordinator at CLEAN.

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TECHNICAL TERMS

Some of the key terms and abbreviations used in this document are explained in the following table:

TERM/ABBREVIATION	DEFINITION[1],[2],[3],[4]
AUDITOR	"Auditor" means, according to the 2018 guidelines for waste audits before demolition and renovation works of buildings, the expert or expert team performing the waste audit. The auditor can be the building owner or consultant acting on behalf of the owner.
BACKFILLING	According to the EU Waste Framework Directive 2008/98/EC (WFD), "Backfilling" means any recovery operation where suitable non-hazardous waste is used for purposes of reclamation in excavated areas or for engineering purposes in landscaping. Waste used for backfilling must substitute non-waste materials and be limited to the amount strictly necessary to achieve those purposes. Materials used for backfilling purposes are not considered recycled. The term backfilling falls under 'other recovery' under the WFD. There is no specification of the type of waste other than it must be suitable, meaning appropriate for the purpose and without causing environmental harm[5]. Backfilling is not considered an element in the circular economy since it is a permanent placement of waste on sites; the waste will not be returned to the economic material cycle[6]. There is no harmonised application of the definition of backfilling in the WFD so the dividing line between recycling and backfilling differs among Member States[7].
BY-PRODUCTS	Production residues which can be used as secondary raw material and fulfil the conditions in the WFD for by-products, e.g.: its further use is certain; the material can be used directly without any further processing other than normal industrial practice; the material is produced as an integral part of a production process; and its further use is lawful, i.e. all relevant product, environmental and health protection requirements for the specific use are fulfilled and the use will not lead to overall adverse environmental or human health impacts.
C&D	Construction and demolition

[1] EC (2016): EU Construction and Demolition Waste Protocol and Guidelines.
[2] JRC (2021): Level(s) Indicator 2.1 - Bill of Quantities, materials, and lifespans.
[3] JRC (2020): Level(s) Indicator 2.2 - Construction and Demolition waste and materials.
[4] EP (2008): Directive 2008/98/EC of the European Parliament and the Council of 19 November 2008 on Waste and repealing certain Directives.
[5] EC (2013): Guidance on the interpretation of the term backfilling.
[6] European Aluminum (2017): On the vote of the European Parliament's Environment Committee.
[7] Eurostat (n.d.a): Recovery rate of contruction and demolition waste.

CDW	Construction and demolition waste means, according to the EU Waste Framework Directive, waste generated by construction and demolition activities. The 2016 EU Construction and Demolition waste management protocol includes in the definition all waste generated at sites where construction, renovation or demolition takes place. In this paper, CDW only refers to industry waste and not post-consumer waste.
DECONTAMINATION	"Decontamination" means, according to the 2016 EU Construction and Demolition waste management protocol, the reduction or removal of chemical agents.
DISASSEMBLY / DECONSTRUCTION	According to ISO/FDIS 20887:2020, it refers the non-destructive separation of a construction works or constructed asset into constituent materials or components. The term "disassembly" should be considered as synonymous with "deconstruction," which in the 2018 Guidelines for waste audits before demolition and renovation works of buildings is defined as the "removal of building elements from a demolition site to maximise their recovery and reuse"[8].
HAZARDOUS WASTE	"Hazardous waste" means, according to the EU Waste Framework Directive, waste which displays one or more of the hazardous properties listed in Annex III (to the same Directive). The 2016 EU Construction and Demolition waste management protocol, further defines hazardous CDW as debris that has hazardous properties and that may prove to be harmful to human health or the environment. This comprises contaminated soil and dredging spoil, materials and substances that may include adhesives, sealants and mastic (flammable, toxic or irritant), tar (toxic, carcinogenic), asbestos-based materials in the form of respirable fibre (toxic, carcinogenic), wood treated with fungicides, pesticides etc. (toxic, ecotoxic, flammable), coatings of halogenated flame retardants (ecotoxic, toxic, carcinogenic), equipment with PCBs (ecotoxic, carcinogenic), mercury lighting (toxic, ecotoxic), systems with CFCs, insulation containing CFCs, containers for hazardous substances (solvents, paints, adhesives, etc.) and the packaging of likely contaminated waste.
IS	Industrial symbiosis (IS) is a circular economy strategy, where secondary raw materials from one or more companies become resource inputs to another company. Industrial symbioses are often located in industrial parks that foster innovation and collaboration between the companies[9].

[8] TC (2020): ISO 20997:2020 Sustainability in building and civil engineering works – Design for disassembly and adaptability – Principles, reguirements and guidance.
[9] Lander et al. (2020): Guide: How can municipalities support the development of industrial symbiosis?

INERT WASTE	"Inert waste" means, according to the 2016 EU Construction and Demolition waste management protocol, waste that does not undergo any significant physical, chemical or biological transformations (e.g., concrete, bricks, masonry, tiles). Inert waste will not dissolve, burn, or otherwise react physically or chemically, biodegrade, or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health.
MATERIAL EFFICIENCY	Material efficiency involves the pursuit of technical strategies, business models, consumer preferences, and policy instruments that can maintain existing levels of material services with significantly less material input or through the substitution with lower grade raw materials[10]. Material efficiency focuses on supply and use of raw materials, waste management, recycling, and reuse etc.
PREPARING FOR RE-USE	The EU Waste Framework Directive defines preparation for reuse as checking, cleaning, or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.
RE-USE	The EU Waste Framework Directive defines reuse as any operation by which products or single components (that are not categorised as waste) are used again for the same purpose for which they were originally conceived.
RECOVERY	The EU Waste Framework Directive defines recovery as utilising materials that would otherwise be wasted for a useful purpose by replacing other materials.
RECYCLING	The EU Waste Framework Directive defines recycling as recovery operations by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. This includes the reprocessing of organic material but excludes energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations. The common idea behind recycling is that a waste material is processed to alter its physicochemical properties allowing it to be used again for the original or for other purposes and thus closing the economic material circle.
REFURBISHMENT	Refurbishment is the modification and improvement of an existing building to improve its condition to acceptable level.
SCAVENGING	"Scavenging" means, according to the 2016 EU Construction and Demolition waste management protocol, the activity of identifying

[10] Allwood et al. (2011): Material efficiency: a white paper.

	usable materials that takes place after demolition; in this context, particularly re-usable and recyclable materials.
SRM	Secondary raw materials: The term 'secondary raw materials' covers materials that have served a purpose in the economy and are ready to be looped back into another active phase in the economy through **recycling** – as opposed to being disposed of, incinerated, or used for backfilling. It is the recycled materials that can be used in manufacturing, production, and construction in line with virgin raw materials[11]. Materials that are used in their original form are not considered secondary raw materials.
STRIPPING	"Stripping" means, according to the 2016 EU Construction and Demolition waste management protocol, the activity of removing valuable materials from a site, installation or building that takes place before demolition.
WASTE AUDIT	"Waste audit" means, according to the 2018 EU Guidelines for waste audits before demolition and renovation works of buildings, a qualitative and quantitative assessment of waste that will be produced from the construction, demolition/deconstruction or refurbishment activities including residual waste that is not part of the building. An important part of the waste audit is also the identification and removal of materials/components containing hazardous substances (note: the same principles can be applied to estimating waste generated during construction activities).
WASTE HOLDER	"Waste holder" means, according to the EU Waste Framework Directive, the waste producer or the natural or legal person who is in possession of the waste.
WFD	EU Waste Framework Directive

[11] EC (n.d.a): Raw Materials.

1. CONTEXT

The mission of the Directorate-General for Structural Reform Support (DG REFORM) of the European Commission, here in after referred to as "the Commission," is to provide support for the preparation and implementation of growth-enhancing administrative and structural reforms by mobilising EU funds and technical expertise. Portugal has requested support from the Commission under Regulation (EU) 2017/825 on the establishment of the Structural Reform Support Programme ("SRSP Regulation"). The request has been analysed by the Commission in accordance with the criteria and principles referred to in Article 7(2) of the SRSP Regulation, following which the Commission has agreed to provide technical support to Portugal in the area of environment, circular economy, water, land registry and spatial planning, with the purpose of:

- Contributing to 'closing the loop' of product lifecycles through greater recycling and re-use and
- Bringing benefits to both the environment and the economy.

In a circular economy (CE), waste that can be recycled is injected back into the economy as secondary raw materials[12]. These materials can be traded and shipped just like primary raw materials but, at present, they still account for only a small proportion of the materials used in the EU.

This project, 'Circular Economy: Closing the loop – from waste to resource – the key for the success in Portugal,' develops and presents strategies to promote the use of industrial residual materials, waste, and by-products as secondary raw materials in Portugal.

The project contributes to effective implementation of Portuguese waste policy and full compliance with EU legislation. It pays particular attention to reducing administrative costs for business and authorities by making economic operators more accountable, as well as identifying national and European legislative barriers to the effective implementation of a waste market. Addressing these issues requires specific expertise in assessing the multifaceted impacts on business.

Financing for this project has been made available as part of the Work Programme for year 2019 for Structural Reform Support Programme, under Regulation (EU) 2017/825 as amended by Regulation (EU) 2018/1671, published on 27.02.2019.

12 There is no general definition for secondary raw materials, but they typically include waste materials (e.g., mine tailings), side streams (e.g., slag and ashes), processing residues, material removed during product life cycle, and the products and their materials that have reached the end of their life cycle. http://scrreen.eu/discovering-the-unused-potential-of-secondary-materials/

2. INTRODUCTION

The Government of Portugal (GoP), represented by the Ministry of Environment and Climate Action Ministry (MAAC) and Portuguese Agency for Environment (APA), in 2017 launched the national Circular Economy Action Plan in pursue of a greener future.

Transitioning to a Circular Economy is a demanding task for all EU Member States. An important aspect of the circular economy is to keep resources in active loops for as long as possible. This topic is addressed in Circular Economy Action Plan, theme no. 5 A 'New life for waste', which highlights the importance of promoting efficient use of resources, including increasing the incorporation of waste into the economy. The overall goals of the theme are:

- To increase the introduction of secondary raw materials into the economy.
- To reduce waste production and associated costs for companies.
- To reduce the need for natural resource extraction.

The present project directly follows up on this national plan.

Eco-design and waste prevention can reduce waste from the manufacturing sector, but there will still be vast amounts of materials that could be captured as secondary resources and fed back into the material economy. The industrial ecosystem of a nation determines the kinds of industrial residues and waste created and the domestic capacity to re-introduce waste materials as secondary raw materials in the production system substituting virgin raw materials. Recovering resources embedded in by-products and waste streams requires a well-established waste management framework and infrastructure capable of collecting, handling and preparing for recycling the materials and waste generated.

This project, 'Circular Economy: Closing the loop – from waste to resource – the key for the success in Portugal' supports the Portuguese Action Plan on Circular Economy. The main objective of the project is to enable the Government of Portugal (GoP) to take well-informed decisions that generate socio-economic and environmental benefits from the increased utilisation of secondary raw materials and by-products in manufacturing, and more broadly strengthening the implementation of the EU Circular Economy Package in Portugal.

Increasing the uptake of secondary raw materials in an industrial framework is a complex matter involving economic, technical, and institutional factors. A thorough data analysis coupled with stakeholder involvement has allowed for informed and efficient policy decisions on turning waste into resources, and active engagement with companies of different sectors has been essential in complementing the statistical analysis with pragmatic analyses of factors impeding and enabling the use of secondary raw materials.

This report presents conclusions and recommendations of the project initiatives related to secondary raw material strategies.

3. METHODOLOGY

The project has applied the following methodologies to investigate how to increase the utilisation of secondary raw materials as basis for manufacturing in Portugal:

A. Identification of the most relevant industrial sectors in Portugal in terms of unexploited secondary raw materials.
B. Identification of best EU practices with bringing secondary raw materials back into active loops.
C. Accounting of the needs and wishes of Portuguese stakeholders in four key sectors in relation to increased utilisation of secondary raw materials and
D. Drafting national strategies for how the environmental authorities in Portugal can support increased utilisation of secondary raw materials in the country.

3.1. IDENTIFYING KEY SECTORS FOR SECONDARY RAW MATERIAL UTILISATION

The first phase of the study encompassed the following activities:

- Quantification of current industrial waste production and treatment (including by-products), including quantification of non-recycled amounts and
- Identification of hotspot industrial sectors in a strategic perspective.

The methodology includes the following steps:

- Statistics on waste and material flows are used to assess the potential for secondary raw materials from specific waste categories.
- Multiple data sources are complemented with qualitative information from stakeholder consultation and from literature.
- Material Flow Analysis (MFA) data is analysed to characterise the types of materials used in Portugal through direct material input and raw material consumption. These are then compared to EU27 average to identify significant deviations in resource consumption and resource productivity.
- A comparison to equivalent statistics for the EU28 average are used to generate a relative quantification of intensity in material use in the Portuguese economy. Given that up-to-date data on sectoral material inputs is unavailable we use secondary sources of information that account for material inputs by type and by economic activity.
- Hazardous waste, and waste originating from households, as reported in waste statistics, is excluded from this work. This does not mean that mixed household waste is excluded altogether, given that significant amounts of this waste typology is generated by services and manufacturing.
- EU and national waste statistics (from Eurostat and the Portuguese National Statistics Institute, INE - Instituto Nacional de Estatistica) and reports are reviewed to quantify resource use and waste generation in various industry sectors. For some specific sectors official data is supplemented by secondary sources of information.
- The report addresses the NACE sectors 13 -17 (including ten 2-digit manufacturing sectors) ranked in order of total waste generation and/or volume of selected waste types that have some potential value, for example recyclable wastes, metal wastes (ferrous, non-ferrous), plastic wastes, wood waste, textile waste, mineral C&D wastes.
- Material flow data and indicators (such as Domestic Material Input and Domestic Material Consumption) are briefly investigated. Given the budget frame, it is not possible to create environmentally extended input-output tables with MFA data.

- In section 4, the scope is narrowed to hotspot industries to obtain a more accurate estimation of material flows (inputs and output) through direct consultation and data collection (from relevant companies and business associations) to supplement information from task 1.1.

3.2. IDENTIFYING BEST EU PRACTICES

The project has identified best EU practices within the key areas of interest through an extensive literature review followed up by interviews and written communication with project holders and relevant authorities.

3.3. UNCOVERING STAKEHOLDER INTERESTS

Interviews have been conducted with stakeholders from each sector to gain an overview of material flows and activities within the industrial areas. Table 1 provides an overview of the main components and objectives of these interviews, and the relevance of the different stakeholders.

Section under each area	Objective of interview	Stakeholders
Waste amounts available	Validate the statistical data on the waste streams / get more accurate data on amounts and material composition in each waste streams and the management of such.	Associations and organisations representing the industries dealing with the four selected material flows for further work: Bio-waste from agroindustry, Textile waste from the textile industry, Construction and demolition waste, and Wood waste from furniture production.
	Due to lack of statistical data on waste composition and management, interviews with key players from the four industrial sectors are conducted to provide a picture of the amount and composition of each waste stream that are currently unutilised within the industries. This helps validate or question the statistics and discussions with associations and branch organisations. Furthermore, it helps explain what currently happens to unutilised materials – disposal or incineration with energy recovery.	A selection of large industrial players within the four material flows from the selected industries
Recycling potentials	Get a deeper understanding of why bio-waste from the agroindustry, textile waste from the textile industry, construction and demolition waste, and wood waste from furniture production are not used; what are the main barriers.	Associations, organisations, and large industrial players
Hotspots	Getting to know the hotspots – individual companies producing or (potentially) using the waste and by-products, and geographical hotspots facilitating secondary raw materials (SRM) utilisation.	Associations, organisations, and large industrial players
Possibilities of implementing best practice	Get ideas and perspectives on ways to move forward to achieve more use of secondary raw materials (SRM) –	Associations, organisations, and large industrial players

cases in Portugal	propose solutions/best practise cases found elsewhere and investigate if these would be replicable in Portugal.	

Table 1 - Overview of main interview components, objectives, and informants

Throughout the project, interviews have been held with more than 60 stakeholders to map the current possibilities and barriers for increasing the use of secondary raw materials in Portugal. After the initial assessment over a period of six months, almost 500 Portuguese stakeholders participated in four workshops tailored according to waste category and sector type: construction and demolition waste from the construction and demolition sector; Bio-waste from agricultural, fishing and food processing industry; textile waste from the textile sector and; wood waste from furniture production sector (the rationale behind selection of these material streams is provided in section 4 of this report). The stakeholders came from across the value chain and provided invaluable insights and inputs regarding the current barriers and possibilities of overcoming these barriers for each sector.

All four workshops were opened by Inês dos Santos Costa, the Portuguese Secretary of State for the Environment, providing an overview of the government approach to the specific topic and illustrating potential solutions, hereby contributing to the stakeholders' perception of the workshops' importance. Appreciating the challenges in actively involving participants in a workshop only using digital media, the workshops were designed using an interactive tool allowing for constant activity and feedback. Sequenced breakout rooms were facilitated by both Portuguese and English-speaking mediators with a deep understanding of the project context, enabling a constructive and knowledge-based dialogue in which individual interests could be expressed in an open atmosphere. Barriers and drivers for implementing novel solutions for increased use of secondary raw materials – as perceived by stakeholders – were mapped and clustered in four groups:

1. **Cultural factors,** how do our lifestyle, habits, and consumption influence recycling?
2. **Market factors,** how do economic conditions, prices of virgin materials, and demand for recycled materials influence recycling?
3. **Regulatory factors,** how do policies, laws, rules, and regulations, including control and enforcement, influence recycling?
4. **Technological factors,** how does the availability of effective demolition, sorting and cleaning technologies, demonstration projects and valid data influence recycling?

The workshops ended with a dedicated co-creation process with focus on barriers and solutions, including voting on options for increased utilisation of the secondary raw materials in question. The subsequent work on sector strategies fully benefits from the input gained from the workshops.

3.4. PREPARING STRATEGIES FOR SECONDARY RAW MATERIALS

Development and preparation of each of the sector strategies for increased utilisation of secondary raw materials have used the following pathway:

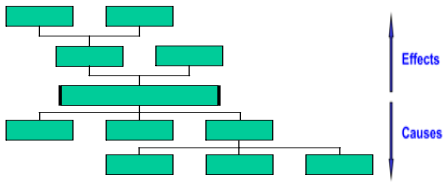
a) Vision

Structured discussion / formulation of a circular vision – the long-term goal – for the specific sector's increased utilisation of secondary raw materials. Factors to be discussed included, but were not limited to:

- Environment, climate, resource use/circular gains,
- Social factors, workplaces,
- Economy, costs for companies, competitive factors,
- Socio-economic costs and benefits,
- Regulatory ambitions and principles,

- Skills and competences.

b) Problem analysis



The problem analysis and the objective analyses are closely related.
A structured analysis of the inputs compiled through statistical analyses, literature reviews, and stakeholder consultations, identifying the causal links between the factors hindering the effective utilisation of secondary raw materials.
These 'problems' are structured in a 'problem tree,' as illustrated to the right, with the basic causes in the bottom and related causal links moving upwards in the tree. Behind the tree lies a thorough discussion and analysis of the causal linkages and each individual problem.

c) Objective analysis

With starting point in the problem analysis and the problem tree, development of an objective tree with systematic analysis of each of the identified barriers and hindrances and re-formulated into positive linking causes and effects, based on the problem tree:

- Objectives and sub-objectives/results of the RNR strategy are developed through positive formulation of the identified problems.
- Systematic review of each 'branch' of the objective tree, forming a solution space in its own right and being part of the total solution space forming background for prioritisations and the strategy
- Discussion and analysis – are anything missing?
- Initial prioritisation of key objectives and branches – the basic elements of the strategy.

d) Revisiting the vision, formulating the key objectives
- Review of the initial vision considering the objective tree and,
- Identification of 1-3 key objectives.

e) Identifying key outputs and assumptions
- For each objective (if more than one): Identification of key outputs, that – if delivered – will lead to achievement of the objective. Many outputs can be directly derived from the objective tree.
- Preparation of an overall Theory of Change (see figure below).
- Discussion of assumptions and
- Specification of the Theory of Change with assumptions.

f) Discussing strategy consequences
- Environment, climate, resource use/circular gains.
- Social factors, work places;
- Economy, costs for companies, competitive factors.
- Socio-economic costs and benefits and
- Regulatory ambitions and principles.

g) Discussing means to the end – means, measures, instruments

- For each output, discuss and prioritise relevant means, measures, instruments, responsibilities, including an assessment of relevant stakeholders.
- Discuss the institutional model – with vision, leadership, strategy, structure, systems, staff, culture, networks and communication.
- Coherence with other national and international frameworks.
- Consider local, regional, or national level and
- Amend the Theory of Change.

h) Preparing strategy model
- Prepare a draft strategy model reflecting decisions.
- Present to key stakeholders and
- Agree on draft strategy.

i) Involving stakeholders
a) Decide on model for stakeholder involvement.
b) Consult with stakeholders;
c) Discuss, listen, and note down.

j) Preparing final draft strategy
- Discuss findings from stakeholder involvement.
- Prepare final draft strategy;
- Identify indicators, how do we involve stakeholders in this?

3.5. THEORY OF CHANGE

The Theory of Change (TOC) is a method and an approach used for designing and monitoring development interventions and as a framework for evaluations. A Theory of Change of a project intervention describes the processes of change by outlining the causal pathways from ***outputs*** (*goods and services delivered by the initiative*) through direct ***outcomes*** *(changes resulting from the use of outputs by key stakeholders*) through other 'intermediate states' towards ***impact***, *long term changes that deliver (or lead to) environmental benefits and improved human living conditions.*

The identified changes are mapped as a set of interrelated pathways with each pathway showing the required outcomes in logical relationship with respect to the others, as well as chronological flow. Each 'step' in the pathway is a prerequisite for the next. The change processes between outcomes/ intermediate states may require certain conditions to hold (**assumptions**[13] - conditions that are beyond the direct control of the initiative) or may be facilitated by supporting actions or conditions (**drivers** - where the initiative has a measure of control and can make a

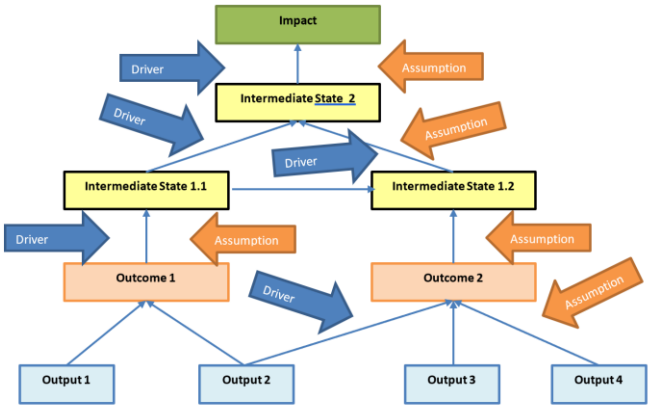


Figure 1 - Simple linear generic TOC diagram

[13] Note that assumptions are not just a negatively formulated risk, and they should be expressed as a contributing condition that needs to hold for a change process to happen.

meaningful influence). The TOC also clearly identifies the main stakeholders involved in the change processes and what role they play in, and/or how they are affected by, the changes.

In essence, a TOC reflects a negotiated understanding or interpretation of the strategic intervention logic – it is both contextual and temporal. It should be regarded as dynamic - subject to changes / modifications as contexts change over time.

Figure 1 shows a quite simple linear generic TOC diagram with two main causal pathways. The reality is seldom so simple: there are often many more pathways, and feedback loops etc.[14].

3.6. THE LOGICAL FRAMEWORK APPROACH

The Logical Framework Approach (LFA) is a methodology developed for planning of projects and programs. In light of a problem tree and an objective tree, the framework provides overview, structure and uniformity for the most relevant intervention selected by the proposers. The LFA has been required by the EC as part of its Project Cycle Management system since 1993.

The overall structure is completely in line with the Theory of Change; however, the wording of the levels differs slightly:

- **Overall objective, or Development objective, or Goal:** The broad development impact to which the project contributes – at a national or sectoral level (provides the link to the policy and/or sector programme context). *In TOC: Impact*.
- **Project objective, or Immediate objective, or Purpose:** The development outcome at the end of the project – more specifically the expected benefits to or change for the target group(s). *In TOC: Outcome.*
- **Outputs or Results:** The direct/tangible results (good and services) that the project delivers, and which are largely under project management's control. *In TOC: Output.*
- **Activities:** The tasks (work programme) that need to be conducted to deliver the planned results (optional within the matrix itself). *Typically not included in TOC.*
- **Input:** The resources needed to conduct the project.
- **Indicators** defines the performance standard to be reached.
- **Means of verification** specify how to measure indicators.
- **Assumptions** are events, conditions, or decisions necessary for project success, but largely or completely beyond the control of project management.

3.7. ORGANISATIONAL ANALYSIS

The analysis of the Portuguese governance system has taken advantage of PlanMiljø's *Model for Institutional Analysis* comprising eight closely interrelated organisational elements providing a clear picture of an organisation's strengths and weaknesses in terms of achieving desired outcomes. Based on the analytical model, a series of interconnected elements of the organisational setting surrounding the four sectors and material flows in Portugal have been identified and analysed: the visions, structure, leadership, employees, strategies, culture and systems. Together these elements constitute the institutional model.

The institutional model emphases that the institutional elements are closely interrelated in a dynamic entity, meaning that all elements are interdependent, thus making changes implemented within one institutional element imply consequences for other institutional elements. Simultaneously, it is rarely

[14] Figure and terminology adapted from the UN (2019): Evaluation Guideline.

sufficient to focus on one or only a few of the institutional elements if the overall performance is to be improved. The key elements for the analysis are:

1. **Vision and policy**: A vision and policy express the ambition for the national efforts at the medium and long term. In some – few – Member States a consolidated circular vision and policy with matching budget lines have been prepared; however, in most countries circular economy principles are incorporated in sectoral policies – typically with the environmental policy setting the framework. The clear vision points out the direction of central and decentral public institutions and for private businesses and the public.
2. **Leadership:** Since the government entities face different and often contradictory expectations from many stakeholders, leadership is needed to set the direction of the national organisations by expressing visions and values, allocating budgets, formulating strategies, and supporting staff in implementation. Good leadership, demonstrating organisational values and good use of delegation, inspires the staff to perform at their best.
3. **Strategy**: A national strategy spells out the priorities of the Member State and a roadmap outlining the way ahead – again, with matching budget. The strategy defines the way in which objectives are to be reached and can be seen as a framework management plan, involving four steps, all of which will be investigated and discussed during the present project: Where are we now? – Current state of play (including assessment of statutory obligations); Where do we want to go? - Definition of goals (based on the vision); How do we get there? - Formulation of targets, objectives, and actions; Are we succeeding? - Monitoring and review. The strategy illustrates the objectives and success criteria for all parts of the government and offers a benchmark against which the organisations' performance can be measured and reviewed.
4. **Staff:** Vision, policies, leadership, and strategy are crucial in creating staff (and stakeholder) motivation. Without competent, committed, and responsible staff, government will be unable to deliver environmental goals. Therefore recruitment, capacity building and motivation of staff are among the management's most essential functions.
5. **Structure**: An effective circular economy structure entails a transparent and conducive formal and informal division and coordination of activities and responsibilities. The main structural challenges concern the distribution of roles, decision mandate, and fields of knowledge within the government.
6. **Systems**: Well-functioning systems to support circular economy processes, activities, communication, and decision-making form the basis of a well-functioning Circular Economy (CE)-organisation. Systems can increase consistency and effectiveness in daily practices and help to avoid uncertainty and achieve the desired quality of the work. The present project will support systems by defining requirements for a platform to support secondary raw material transactions.
7. **Culture**: The culture makes the organisation stick together. It is important to foster a culture around CE so government, businesses and the public all draw in the same direction.
8. **Networks and partnerships**: The EU Member States all strive to harvest the benefits of circular economy and many ambitious initiatives have been launched in the individual Member States. Close networking with peers in other Member States can strengthen the probability of successful achievement of outcomes. Internally in the country, partnerships between authorities, research organisations and the business community have demonstrated to be effective means for reaching remarkable results.

4. INDUSTRIAL WASTE IN PORTUGAL

Analysing the potential for increased use of secondary raw materials implies considering waste generation and waste treatment operations and how these are linked to the national social and economic profile and resource use. This section starts with a brief analysis of the Portuguese material flow accounts and its comparison to its European Union counterparts. The way in which the economy transforms resources provides some clues as to the type of productive activities that pervade in the Portuguese economy. This is followed by the in-depth analysis of the national waste statistics and how these are compared to EU averages. Additional background information can be found in Annex II, specifically related to the socioeconomic profile of Portugal.

4.1. ENVIRONMENTAL ACCOUNTS

- The link between raw materials and economic activities is the cornerstone of an economy's structure, since it entails not only the capacity to transform matter and create value but also the ability to control the leakages arising in the form of waste as well as air and water emissions. This link allows us to assess the degree of circularity in material use and therefore the potential to absorb waste as secondary raw materials (SRM).
- The environmental accounts provide us with a sense of how the economy uses physical resources through a material flow analysis (MFA), describing the material flows through a set of indicators related to the input and output of materials.
- Figure 2 shows the evolution of material inputs, outputs, and additions to stock from 1995 to 2017 in Portugal, based on the detailed data provided in Annex I. Focusing on the last decade, Portugal has decreased inputs and, consequently, net additions to stock. This was partially a result of the financial and economic crisis of 2008-2013, but also due to a significant shift in material-intensive activities, such as the construction sector and the corresponding supply chain. This is supported by the reduction of non-metallic mineral extraction, around 26% in 2012 and another 4% in 2017, while other material types increased (e.g., biomass) or remained constant (e.g., metal ores).
- Changes in imports and exports are of smaller scale, yet these stages were important dimensions of the adjustment program implemented in Portugal from 2011-2013, namely the reduction in trade balance. Imports declined from 2006 to 2012 but resurged in 2017 to levels higher than the ones registered in 2006. Meanwhile exports increased steadily, having increased 40% over the period of 2006-2017. It is worth noting that in 2006 Portugal did not import any waste for final treatment and disposal whereas by 2017 it was importing 2 million tonnes. In the same period, waste exports surged from 121 thousand tonnes to over 1 million tonnes, a nine-fold increase.

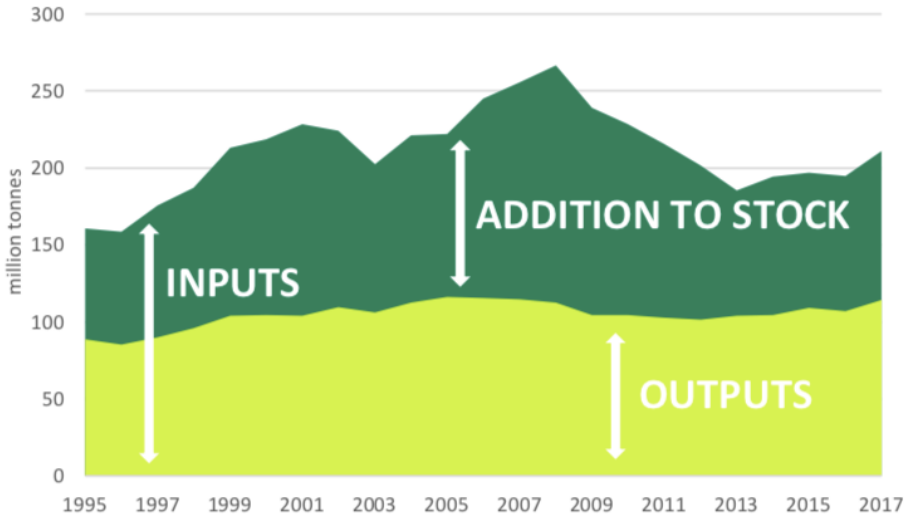


Figure 2: Evolution of material inputs, outputs, and net additions to stock in Portugal in tonnes. Source: INE (2020)

Figure 3 compares the raw material equivalent indicators used[15] in Portugal and in the EU27 average in 2017, measured in tonnes per capita. Raw material input, which represents the direct and indirect material requirements for a given region, is higher in Portugal than in the EU27 for three material categories (biomass, metal ores and non-metallic minerals), but not for fossil energy materials and

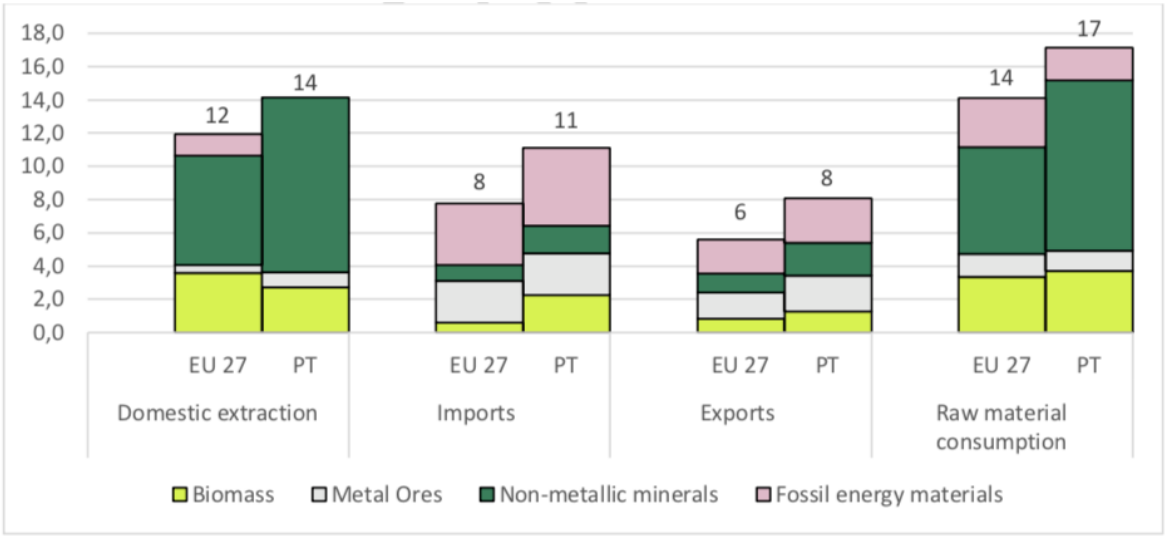


Figure 3 - Material Flow Accounts of Portugal and EU27 in Raw Material Equivalents in 2017. Unit: Tonnes per capita. Source: INE (2020); Eurostat (2021a)

carriers.

In domestic extraction, Portugal surpasses the EU27 by about 19% per capita, and figures are 92% and 60% higher for metal ores and non-metallic minerals, respectively[16]. Domestic extraction of

[15] Both directly and indirectly, using raw material equivalents includes estimates of all the resources required to produce and transport the goods in addition to their actual mass.

[16] A more detailed table with material categories is included in annex.

biomass materials in Portugal is below EU27 levels at about 75%, while evidently no extraction of fossil energy materials and carriers takes place in Portugal.

A more comprehensive view of Portugal's raw material use can be given by the Raw Material Consumption (RMC) indicator, which quantifies the raw materials necessary to satisfy domestic needs. For each inhabitant, Portugal requires 22% more raw materials than the EU27 average to satisfy domestic consumption – with a higher ratio for non-metallic mineral use, representing an extra 60% of the EU27 inhabitant, suggesting that this might be related to the country's economic profile. The intensity in the use of fossil energy materials is substantially lower, representing 67% of the EU27 equivalent, which can be attributed to a significant share of renewable energy sources in the national energy mix[17].

Portugal and the EU27 can also be compared in terms of resource productivity, which can be defined as the ratio between GDP and RMC, e.g., a measure of the amount of materials used by an economy in relation to GDP. It indicates whether decoupling between the use of natural resources and economic growth is taking place. Figure 4 shows that during the period between 2008 and 2017, Portugal's resource productivity was significantly lower than EU27, ranging from 49% in 2008 to 61% in 2013 of EU27's resource productivity.

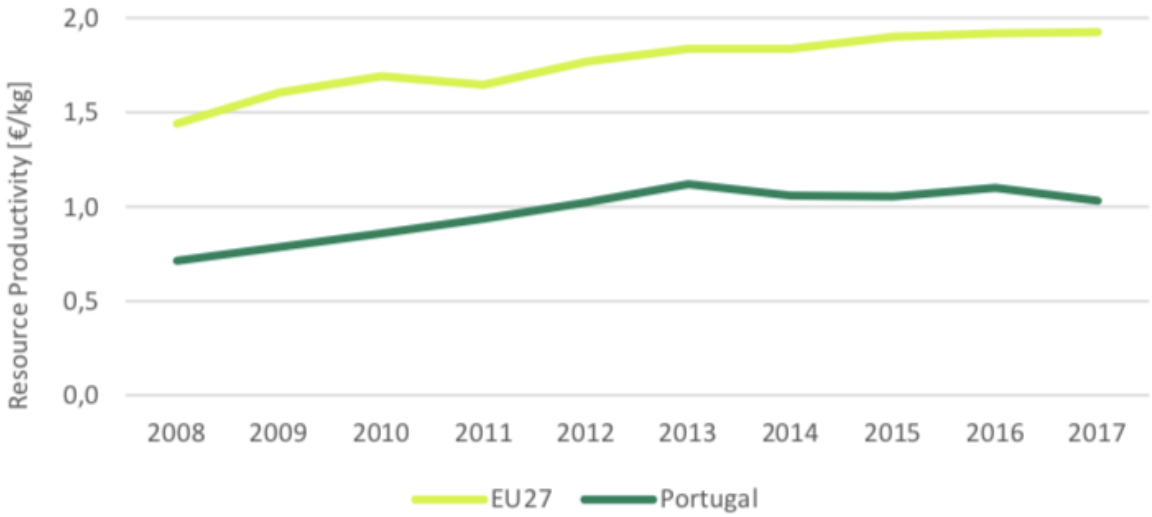


Figure 4: Resource productivity (GDP/RMC) in Portugal and EU27 Source: Authors, based on data from Eurostat (2021c)

4.1.1. KEY MESSAGES

- Portugal significantly reduced raw material consumption since 2008 though with a slight rise since 2013.
- Resource productivity in Portugal increased steadily since 2008 and peaked in 2013 but decreased to 1.0 EUR/kg by 2017.
- Despite having lower levels of fossil raw material inputs than the EU27 average, Portugal is dependent on fossil energy materials imports both for internal needs as well as for export industries.

[17] Eurostat (2021b): Share of energy from renewable sources.

4.2. WASTE STATISTICS

To assess the potential for closing material cycles within the Portuguese economy – e.g., increasing the use of secondary raw materials – it is necessary to analyse waste generation and waste treatment figures. Sections 4.2.1 and 4.2.2 present a comprehensive analysis of the national waste statistics for the latest reporting period, which allows to draw some conclusions on where the potential for increased use of secondary raw materials lies. In section 4.2.3 these figures are compared to the EU27 to determine if there are significant deviations and if these provide useful hints as to the potential information gaps in the waste statistics and potential shortcomings in terms of waste policies.

These analyses form the basis for identification of critical waste streams, potential sources of secondary raw materials, and hotspot industries in section 4.3.

4.2.1. WASTE GENERATION

Waste generation data in Portugal is published by the National Statistical Institute of Portugal (INE) and is communicated to Eurostat, which publishes the data sets with a 2-year delay[18]. The national data set is presented in three dimensions for which disaggregation of waste statistics are available: the economic sectors generating the waste; waste types according to the EWC-Stat/Version 4[19]; and waste treatment operations.

The waste statistics include data on materials with a high recyclability potential: all metallic, glass, rubber, paper and cardboard, plastic, wood, and textile wastes. The recyclable waste streams are highlighted in green in Figure 5. While the 'recyclable wastes' comprise a significant part of the total industrial waste generation, most of these waste streams will have well-functioning markets, with a few exceptions such as rubber and textile wastes, where outlets are insufficient. This makes them interesting for further analysis.

Over 10.5 million tonnes of industrial waste were generated in Portugal in 2018. The largest waste categories and sub-categories were respectively mineral and solidified wastes and ferrous metal wastes, which together represent just under 5 million tonnes or 47% of the total waste generated.

Mineral and solidified wastes account for 29% of total industrial waste generation. It is important to note that about half of this quantity is mineral waste from construction and demolition activities, as depicted in Figure 6. However, although being a significant waste stream within Portugal, generation of mineral waste from construction and demolition activities in Portugal is significantly below the EU27 average, which merits further investigation.

[18] The latest available national data refers to the year of 2018, and is available through INE website, while the latest data in Eurostat is from 2016.

[19] For more information on this topic see EWC-Stat/Version 4, as published in COMMISSION REGULATION (EU) No 849/2010 of 27 September 2010.

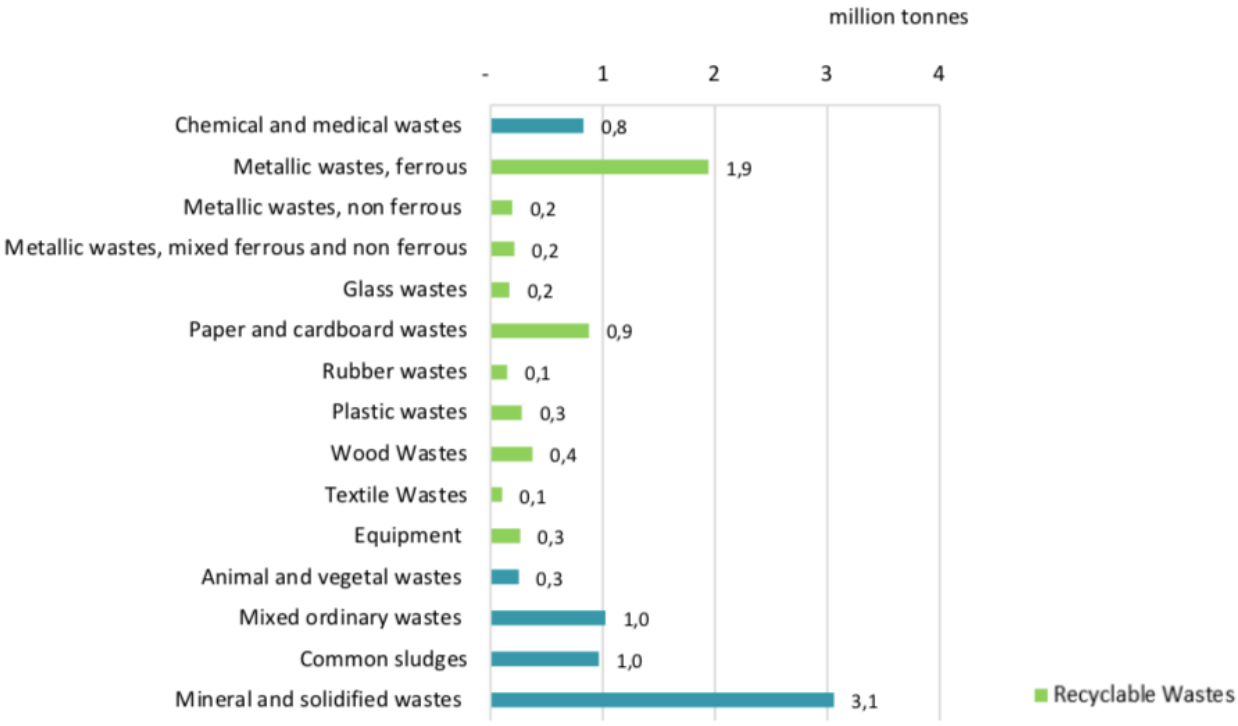


Figure 5 - Annual waste generated by waste category in Portugal in 2018. Source INE (n.d.)

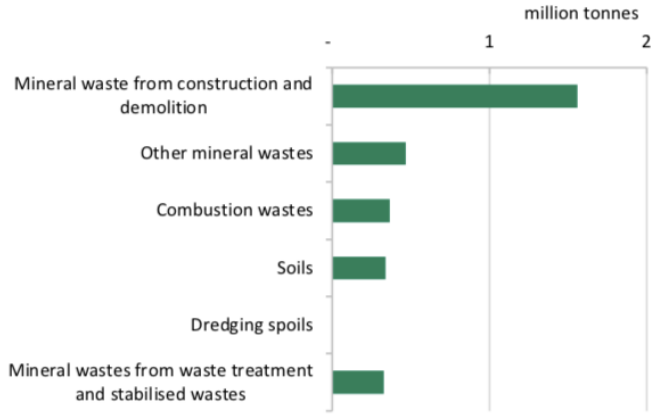


Figure 6 - Mineral and Solidified Wastes Generation by subcategory in 2018. Source: INE (n.d.)

4.2.2. WASTE GENERATING SECTORS

Figure 7 presents waste generation by aggregated economic sectors. Manufacturing is the most significant sector for waste generation, followed by the waste industry itself ('waste related activities & material recovery'), whereas agriculture, forestry and fishing, mining and the utilities sector on the other hand produce relatively little waste.

It is important to note that the results in Figure are significantly influenced by two particularities of the waste statistics:

- The 2.8 and 1.1 million tonnes of waste generated by Waste Related Activities and Wholesale of waste and scrap presumably represent to a large extent double counting related to transfers between waste management companies; these wastes also appear under other economic sectors prior to the transfer.
- Also, it is known that extraction activities (mining and quarrying, agriculture, forestry and fishing), do not report the full extent of waste that is generated as many wastes from these sectors are excluded from Waste Framework Directive (WFD), including biomass from agriculture and forestry used for energy and organic recovery (including indirect recovery as composting), extraction wastes and animal by-products from fishing activities depending on the destiny, as stated by WFD. Most of these waste materials are treated *in situ* and are not – in accordance with the WFD –registered as waste.

Considering the significant recycling potential, animal, and vegetal waste – biowaste – could be subject to further analysis.

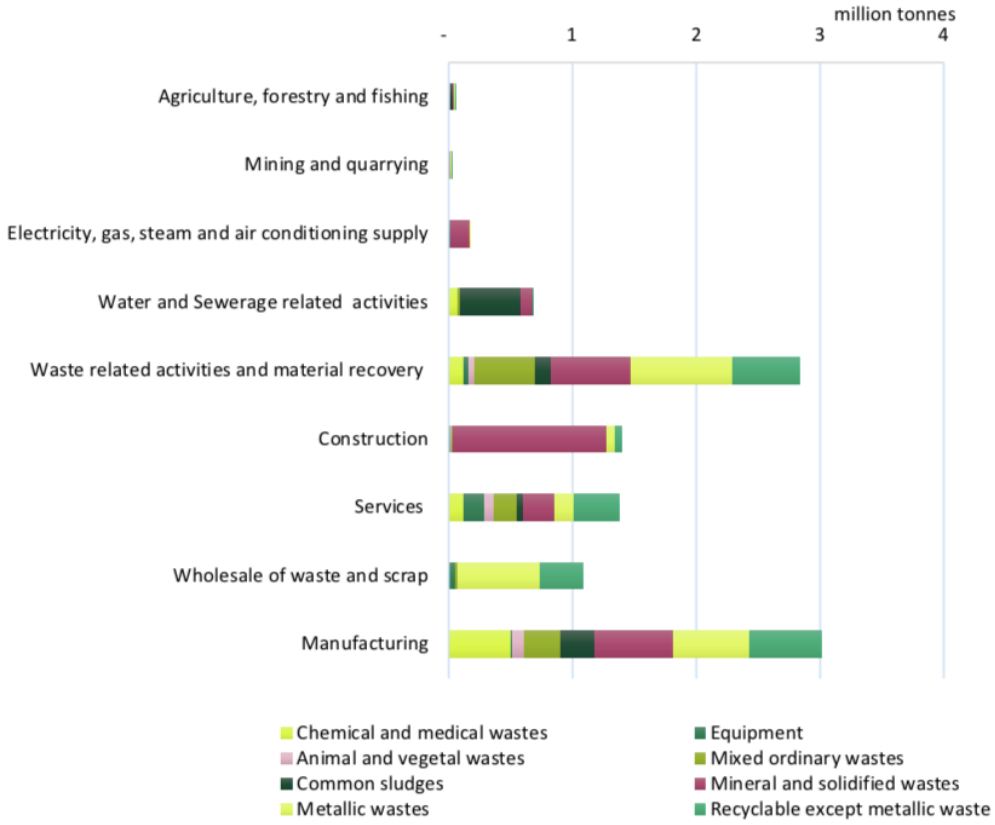


Figure 7 - Sectoral waste generation by waste category (tonnes). Source: INE (n.d.)

4.2.3. COMPARISON OF WASTE GENERATION IN PORTUGAL AND IN THE EU27

To complement the analysis of waste generation in Portugal, a comparison with the entire EU27 (excluding the UK) is presented. The latest available consolidated data for EU27 refers to 2016, hence the Portuguese data presented in this comparison (using the year 2016) will slightly differ from previous figures. To allow comparison of economies differing in dimension and population, two relative measures are used – waste generation per capita and waste generation per unit of GDP.

Figure 8 shows that total industrial waste generation per capita is only 20% of the EU27 average, or 32% if considering per unit GDP. However, this should not be understood as an indication that Portugal is more material efficient than the EU average, as there is some evidence to suggest that there is a certain level of underestimation of industrial waste. These reasons are further detailed in this section.

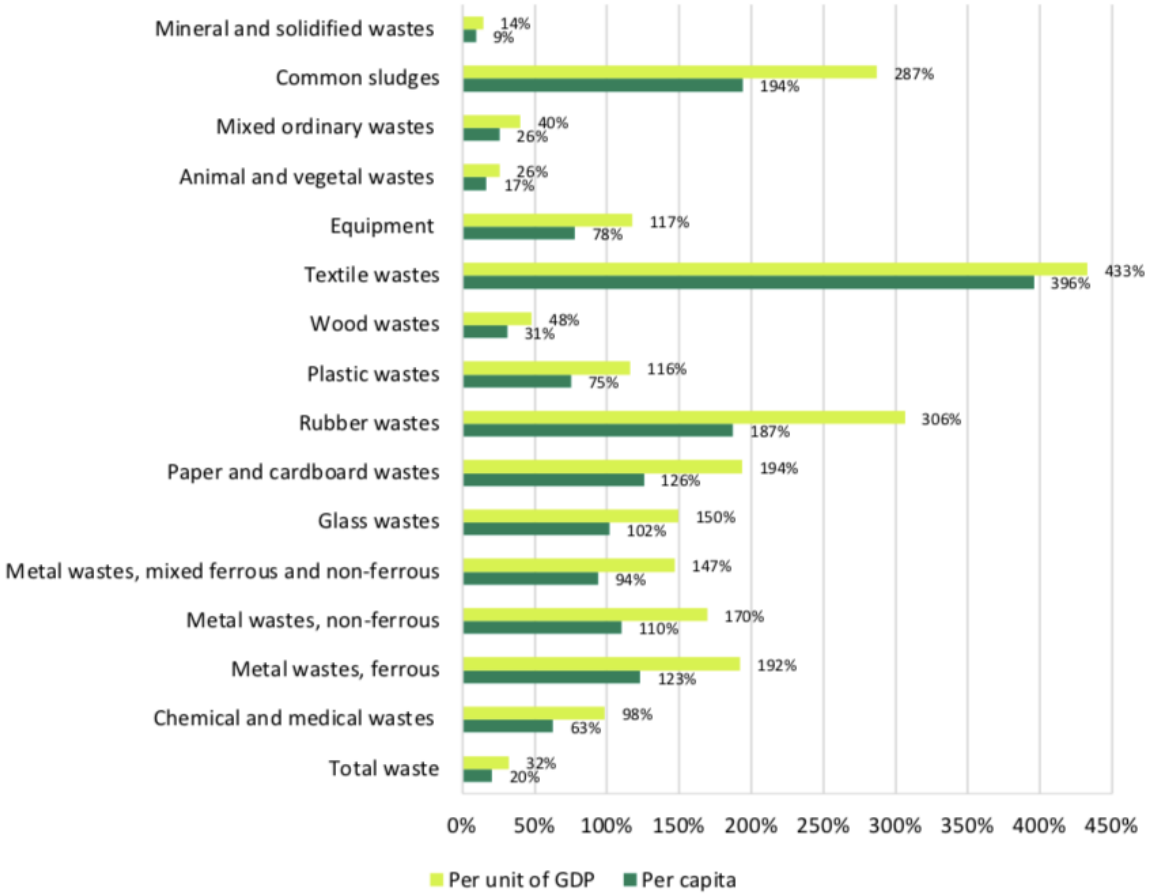


Figure 8 - Ratio of Waste Generated in Portugal compared to the EU27 by waste category in 2016. [Source: EUROSTAT]

For most waste streams, waste generation in Portugal is higher or significantly higher than the EU27 average. Generation of mineral and solidified waste per capita in Portugal is, however, only 9% of the EU27 average. Since mineral and solidified wastes are the most dominant waste fractions in the EU27, representing 79% of all industrial waste, it is likely that total industrial waste generation is significantly underestimated in Portugal. If Portugal had the same mineral and solidified waste generation per capita as the EU27, then total industrial waste generation would be about 42.8 million tonnes, compared to the reported value of 10.5 million tonnes. This justifies further analysis of this waste stream.

Similarly, Portugal reports significantly less waste per capita in Mixed Ordinary Wastes, Animal and Vegetal Waste and Wood Wastes than the EU27 average. Although all MSs work within the same overall regulatory framework defined by the WFD, differences in the way this framework is interpreted, or underestimations of waste quantities may go some way to explain the above anomalies.

Taking EU27 average biowaste generation as reference, Portugal should be generating about 1.2 million tonnes of animal and vegetal waste alone.

4.2.4. WASTE TREATMENT OPERATIONS

The last element to complete the waste statistics analysis is the treatment operations.

Figure shows the ratio of waste treatment operations for each waste category in Portugal for 2018. A total of 9 million tonnes of waste is subjected to recovery operations, or roughly 84% out of total waste treated. In the specific case of mineral and solidified wastes, 49% of the generated quantity is sent to recovery operations, which includes backfilling but excludes energy recovery. However, over half of these 9 million tonnes is being stored temporarily for recycling or energy recovery ('Other recovery operations') making it difficult to identify the actual treatment.

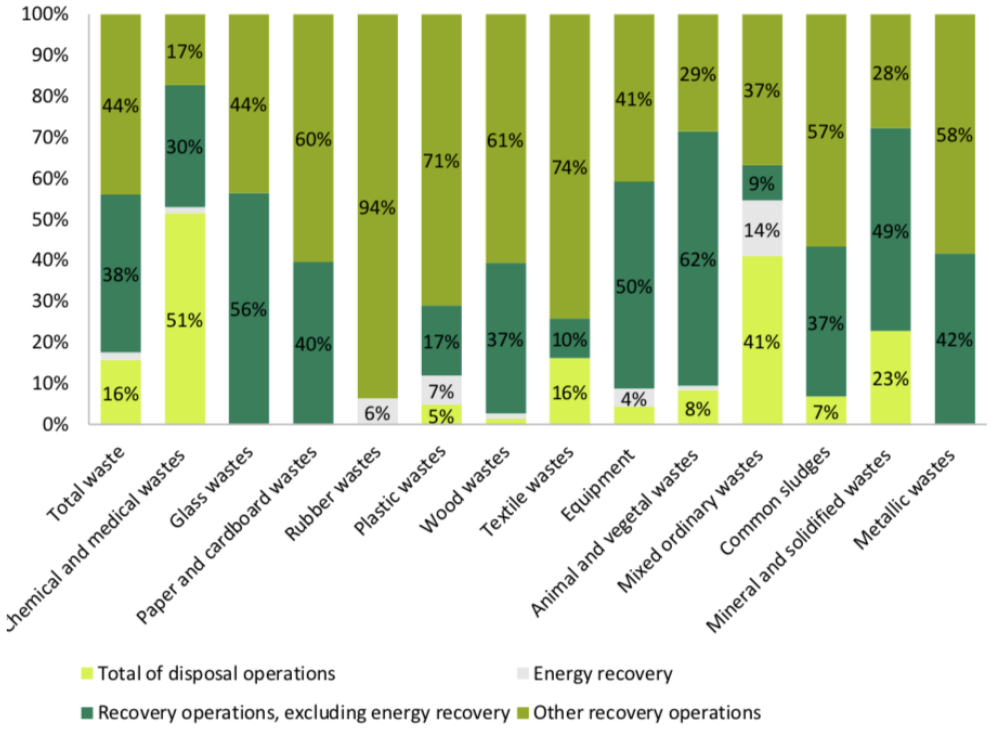


Figure 9 - Share of Waste Treatment Operation by Waste Category in 2018. Source: INE (n.d.)

Chemical and medical waste, mixed ordinary wastes, mineral and solidified wastes, and textile wastes have the highest disposal and energy recovery rates, indicating a potential resource for recycling. However, it is important to highlight the significant share of *other recovery operation* for all waste types. *Other recovery operations* entail storage or exchange before recovery operations and as such are not recovery operations *de facto*[20] but rather intermediary recovery operations. In waste categories such as rubber, textile or plastic wastes, these *other recovery operations* have a much higher share than *recovery operations*, suggesting that either the waste is sold as a product (based on EoW regulation), exported, or it is not sent to recovery operations as expected. These figures suggest that

[20] It is important to highlight the difference between Recovery operations, excluding energy recovery, which refers to all recycling operations (R2 – R10), whereas Other recovery operations refers to two operations that precede a recovery operation: R12 – exchange of waste for submission to any of the operations numbered R1 to R11; R13 – storage of waste pending any of the operations numbered R1 to R12.

it is necessary to improve waste tracking – or at least the transparency of waste tracking - along the waste management system and ensure a transparent relation between intermediary operations (exchange and storage) and eventual recovery.

Energy recovery represents only 200 thousand tonnes of waste, which seems low given the potential use of refuse derived fuels (RDF) and solid recovered fuels (SRF) in industries such as ceramics, paper and pulp, cement, and energy, among others.

In addition, disposal operations represent about 1.7 million tonnes, mostly related to chemical and medical waste, mixed ordinary wastes and mineral and solidified waste. The recycling potential might be low in some of these flows, but it is important to come back to the results of the environmental accounts: Portugal's economy uses a significant amount of non-metallic mineral resources, which could potentially be replaced by mineral and solidified waste.

Figure 10 shows the quantities of each waste category subjected to disposal, energy recovery operations, storage, or exchange of waste for submission, in Portugal in 2018. It is clear that storage and exchange operations are more significant than disposal operations. In the case of rubber waste, for example, these preliminary operations in 2018 represented 94% while disposal only 6% (likely

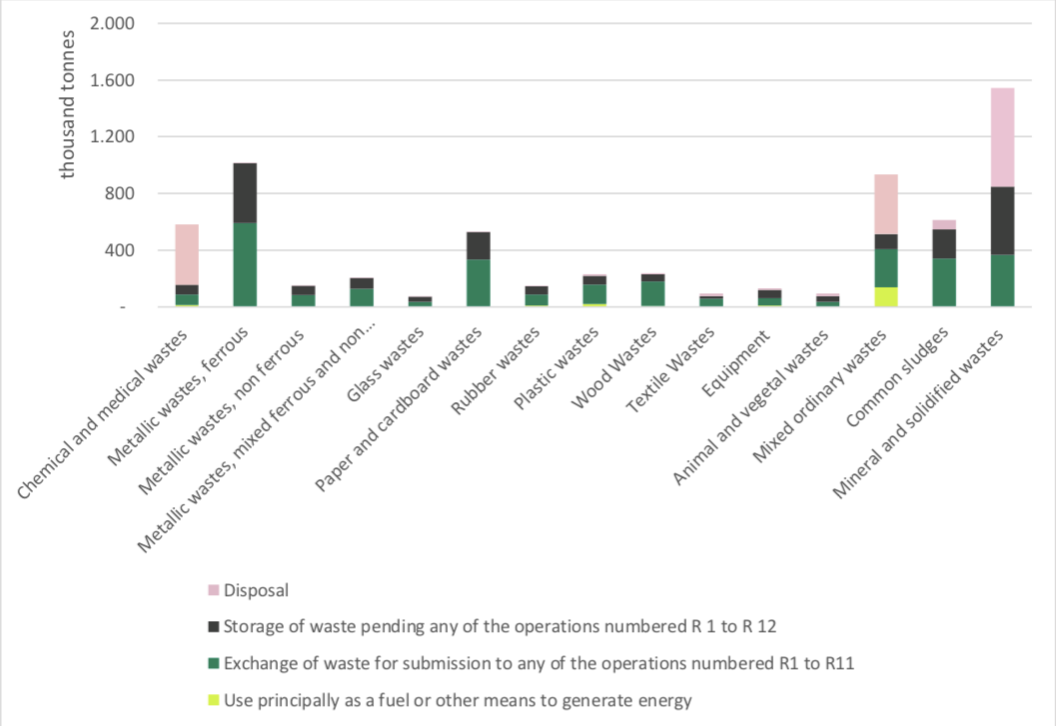


Figure 10 - Waste use potential by waste category for Portugal in 2018 (I) Source: INE (n.d.)

due to the fact that in 2018 waste from tires were pre-treated before being sold as a product: from 2018 an EoW regulation is in place).

Waste treatment operations for economic sectors

Figure 1 presents the distribution of waste treatment operations for each economic sector for Portugal in 2018. As expected, *other recovery operations* represent a significant part of the waste treatment operations for most sectors. Other recovery operations entail waste being exchanged or stored, but this could represent both exports and transfers within or between the country's waste management companies (for example, residual waste from sorting operations). As previously discussed, the reported waste in the waste sector is likely to already have registered within other economic sectors, potentially leading to double counting. However, this is a common issue across European Members States.

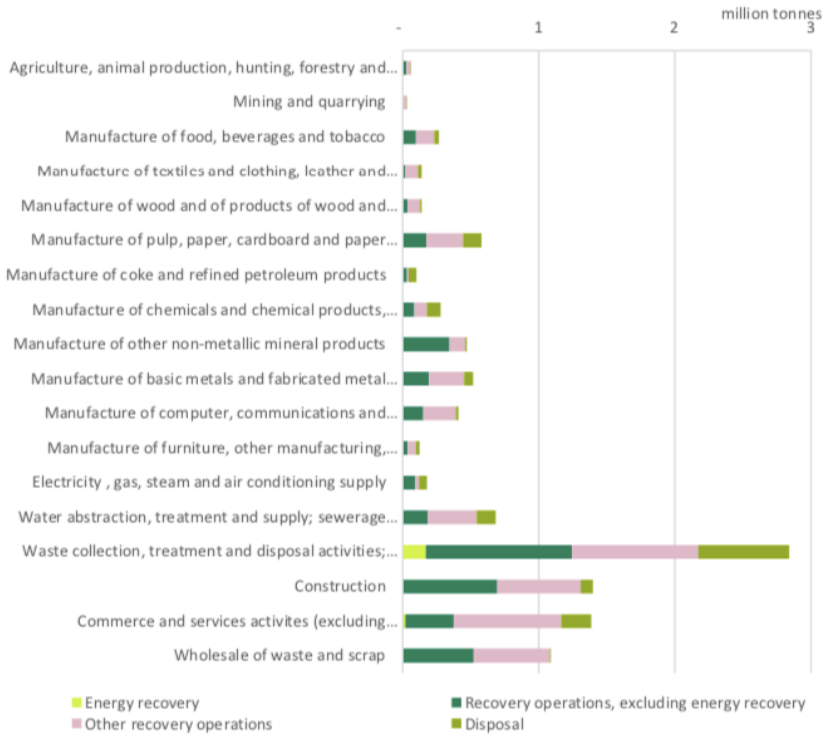


Figure 11 - Treatment of waste by economic sector, 2018. source: Eurostat

The construction sector shows somewhat surprising recovery rates (94%) – among the highest in the EU[21], even though a significant part of that waste should have a low recycling potential. This might be due to a high incidence of backfilling operations or lack of awareness from contractors regarding their legal obligations.

The pulp and paper and chemical sectors may also be relevant for further investigation given that a high share of their waste is currently ends in disposal, but it is necessary to first determine the real potential for waste prevention and recycling, as these are typically resource efficient industries. The service sector also has relatively high disposal rate; in this case there is potential to improve source separation and reduce generation of mixed waste, which has low recycling potential.

4.2.5. KEY MESSAGES

[21] https://ec.europa.eu/environment/topics/waste-and-recycling/construction-and-demolition-waste_en

- Industrial waste generation per capita is only 20% of the EU27 average. However, this is presumably due to underreporting of the waste category *mineral and solidified wastes* generation per capita, which in Portugal is only 9% of the EU27 average. If Portugal had the same mineral and solidified waste generation per capita as EU27, then total industrial waste generation would be about 42.8 million tonnes.
- The relatively large quantities of waste generated by waste management sectors are presumed to largely represent double counting, since most waste generated by these sectors should already have been reported by the first producer.
- A total of 9 million tonnes of waste is subjected to recovery operations, or roughly 84% of total treated waste. However, over half of these 9 million tonnes is being stored or is exchanged for recycling or energy recovery. In some waste streams, these preliminary operations are considerably more prevalent than recovery, suggesting that these wastes are either exported or end up being disposed and not recovered.

4.3. CRITICAL WASTE STREAMS AND HOTSPOT INDUSTRIES

Based on the analysis in 4.1 and 4.2, the following waste streams have been identified that could potentially be used to close material cycles and improve SRM uptake in Portuguese economy. The waste streams are ranked based on an analysis of four criteria: Waste quantities, Recycling Potential, Potential to replace virgin raw materials, and Strategic Value:

1. CDW, as part of Mineral and Solidified wastes
2. Biowaste, including animal and vegetal waste and wood waste
3. Sludges
4. Textiles
5. Mixed Ordinary Waste
6. Rubber

The analysis is presented in Table 2, which assesses where these wastes are generated, their recycling potential, where they can potentially be used as SRM, and their strategic value.

Further, based on this analysis a set of hotspot sectors is proposed:

- Manufacture of textiles and clothing, leather and related products.
- Manufacture of chemicals and chemical products, basic pharmaceutical products and preparations, rubber and plastic products.
- Manufacture of other non-metallic mineral products.
- Water abstraction, treatment and supply.
- Sewerage activities, remediation and other waste management services.
- Construction.

Table 2: Critical waste streams selection criteria

Waste streams	Waste quantities	Recycling Potential	Potential to replace virgin raw materials	Strategic Value
Biowaste, including animal and vegetal waste and wood waste	Biowaste, in this context, can be considered a wide range of waste streams, from animal and vegetal waste to wood waste. Reported quantities are relatively small, but as discussed, that might be the result of *in situ* treatment options which do not get reported as such. Taking EU27 generation as reference and presuming that the exclusions from the WFD and implemented uniformly across the EU, Portugal should be generating about 1.2 million tonnes of animal and vegetal waste alone.	Biowaste has a high recycling potential, potentially being used as fertilizer, as animal feed or as feedstock for biological processes. It is expected that most biowaste is already being recovered, therefore further analysis should focus on identifying strategies to recover the highest possible value from this waste stream.	There are several pathways for the conversion of biowaste into energy, from direct firing to thermochemical processes. Assuming generation of 1 million tonnes of biowaste, conversion potential of 20 m^3 per tonne and lower heating value (LHV) of around 20 MJ/m^3, this waste stream might represent the replacement of 10 million m^3 of natural gas imports, around 0.2% of total[22].	Portugal is currently developing its first bioeconomy strategy, where biowaste should take a key place as feedstock for bioeconomy related activities, namely production of renewable fuels and base chemicals.
CDW, as part of Mineral and Solidified wastes	CDW are mostly comprised of non-metallic mineral waste, which are potentially underestimated (see 4.2). The expected quantities should be higher, around 6 million tonnes if one assumes the EU27 average. This value	Parts of CDW are highly recyclable (e.g., metallic elements), but non-metallic minerals and some plastics have low recycling potential. However, Portugal simultaneously extracts significant amounts of non-	Inputs of non-metallic mineral (NNN) resources in Portugal is around 120 million tonnes per year. Considering that CDW is mostly non-metallic minerals and that these could be potentially used as low-grade	With the expected economic incentives at the European and national levels, it is expected that public investment in civil construction will increase, particularly infrastructures. These can be relevant users of SRM; therefore, it

[22] Nielsen (2002): Heat and power production from pig manure.

	easily justifies CDW as a relevant waste stream, even if the actual value for Portugal lies somewhere between reported values and the EU27 average.	metallic minerals, therefore there should be some potential to replace domestic extraction by recycled CDW.	materials for construction, it is safe to assume that CDW could help reduce 5% of NMM inputs (assuming production of 6 million tonnes per year).	will be necessary to act urgently to ensure that these could foster the SRM market.
Sludges	Sludges comprise both industrial sludges and common sludges, which are mostly generated in wastewater treatment plants. Together these represent around 1.3 million tonnes, a significant part of which should be water content.	The recycling potential for sludges can be limited by the presence of specific contaminants. However, for most sludges, it is possible to reduce water content and use as a renewable energy source or to use it as feedstock for biological processes, as in the case of biowaste.	The most common pathway for the conversion of sludges into energy is through drying and co-firing or through bio digestion. Assuming generation of 1 million tonnes of sludges, conversion potential of 35 m^3 per tonne (5% Volatile Solid) and lower heating value (LHV) of around 20 MJ/m^3, this waste stream might represent the replacement of around 1 million m^3 of natural gas imports, around 0.4% of total.	As in the case of biowaste, Portugal could use sludges as a viable feedstock for biological processes that result in energy and base chemicals. This would help reduce dependence on external energy sources and potentially generate high-value elements for other industries. Simultaneously, it would help reduce use of inadequate sludges in agriculture.
Rubber	Rubber waste generation is relatively low when compared to other waste streams, but its production from post-consumption is relatively stable and should be taken advantage as an SRM.	Rubber waste has significant recycling potential, but the number of outlets is relatively small and has already been tapped. The general trend in Europe for rubber granulate or chip is to replace fossil fuels in energy intensive industries. However, exports to other world regions	Rubber waste, particularly from used tyres, can be used in many applications, from asphalt mixtures to synthetic turf pitches. The replacement potential could therefore be assumed to be one-to-one relationship if the uptake exists,	Portugal, as other EU Member States, have established EPR schemes for tires, which led to the development of a SRM market around rubber waste. However, as outlets decrease, this market is threatened, and many specialised companies struggle to maintain activity.

		have increased in recent years.	which is not guaranteed.	Without action, Portugal (and Europe) may lose capacity to manage this waste stream.
Textiles	Textile waste generation is relatively low when compared to other waste streams, but it is clustered in specific regions, enabling potential regional SRM and new supply chains. Post-consumer textile waste, while outside the scope of this study, can also enable this SRM market.	Textile waste has significant recycling potential, particularly in a cascade system where smaller companies recover waste from larger manufacturing companies. Textile waste could also be used in downcycling applications (e.g., non-woven products for automotive industry, thermal insulation, among others).	Typical applications for textile waste include energy recovery and, in a smaller degree, non-woven products such as thermal insulation. Considering just pre-consumer (around 100 kt), the industry is finding solutions to minimise and to use in other products (niche collections, masks, etc.). However, post-consumer will remain a challenge, and it is difficult to ascertain what the substitution potential is within the textile industry and other non-woven applications.	Textile is one of Portugal's key industrial sectors, occupying a key place in the regional economy of the northern and central interior regions. This alone justifies fostering a SRM market for textile waste with a European scale, potentially encompassing post-consumer textile waste.
Mixed Ordinary Waste	As the name implies, mixed ordinary waste comprises many waste streams, from mingled waste from commercial activities to residuals from waste treatment operations. In 2018, these streams amounted to 1 million tonnes, about 10% of total industrial waste generation.	The recycling potential might be low, particularly in mingled waste, but it could be improved by fostering source separation in services and commercial activities. Regarding residual waste, its recycling potential might be low, but energy recovery is an adequate option for fractions with	Due to the heterogeneous composition of mixed ordinary wastes, it is difficult to ascertain the substitution potential of this waste stream. However, it should be noted that a significant part of this waste stream is residual from other waste treatment activities and could	The strategic value arising from the mixed ordinary waste stream can be related to the intrinsic value of the materials that comprise the waste stream. With the right set of waste policies, it is possible to transfer these materials to cleaner waste streams and ensure that they enter the

		high calorific value, and for mineral waste streams (e.g., ashes) these could be used to replace mineral raw materials mostly used in the construction materials sectors.	be recovered through waste-to-energy (WtE) solutions.	SRM market at their real value. The same reasoning can be applied to residuals, but in these cases, it is necessary to foster the potential outlets and ensure a well-functioning SRM market.

4.4. POTENTIAL TO CLOSE MATERIAL FLOWS

The identification and analysis of industrial sectors already using/capable of using by-products and secondary raw materials has been carried out through literature reviews and interviews with industry organisations within the hotspot industries, with experts from industrial symbiosis experiments in Portugal, including the Relvão Eco Industrial Park, the Chamusca Eco Industrial Park and with the Business Council for Sustainable Development in Portugal, as well as other organisations with similar experience of mapping resource streams and symbiosis potential.

The interviews with branch organisations and representatives of companies (5-10 larger businesses of focus industries) have addressed the following:

Input flows

- Demands for material resources (national and international)
- Whether any of resource inputs could be supplied by SRM
- Whether any of these are already supplied via SRM

Output flows

- Quantities and types of (relatively clean) waste outputs
- Which types are currently landfilled/incinerated?
- Which of these waste types are currently recycled? (How? For which applications?)

Implementation of Waste Framework Directive (WFD), Circular Economy Action Plan (CEAP) and Waste Shipment Regulation (WSR)

- How could the circularity potential be increased?
- What are the obstacles to recycling and use of secondary raw materials?
- What are examples of good practices?

Based on a study conducted by 3Drivers and Instituto Superior Técnico (IST) for the Ministry of the Environment in 2015[23], some relevant results for the present study are presented in the following section. Given the limitations of available statistics on direct material inputs and the unavailability of sectorial data on this topic, and to the best of the team's knowledge, this study is the only account on sectoral resource use for Portugal.

Materials enter the economy through two streams. Through domestic extraction, whereby resources are extracted from nature, namely crop harvest or mineral extraction, and through imports of raw material (e.g., oil) or manufactured goods (e.g. machinery). In the first case, materials essentially

[23] 3drivers & IST (2015): Contributos para uma Estratégia para o Uso Eficiente dos Recursos, report developed for the Ministry of Environment 2015.

enter the economy through agricultural and industrial (extractive) activities. As for the latter, imports can be made by any sector of economic activity.

Materials that enter the economy are then transformed into useful goods and products, resorting to value chains which can be complex, whereby they can flow through various sectors (intermediate consumption) and/or being destined to final uses of the economy, which include exports, final consumption, fixed gross capital formation and/or result in waste and emission and, as such, given back to nature. As an example, consider the value chain of potatoes extracted from nature through agricultural activity, which are sent to the food industry for frying, later sold to other sectors (intermediate consumption, e.g., for corporate canteens in agriculture, services or factories, supporting the production of other goods and services) and/or sold directly to households.

The overall material balance of an economy results from these complex economic interrelations, where materials are consumed and transformed by various economic agents. In order to have a more detailed perspective of the use patterns of resources in a given economy, it is necessary to raise the level of disaggregation of information to the sectoral level, given that these patterns can be understood according to various viewpoints.

The inexistence of statistical information at the sectoral level implied the application of a methodology based on crossing several information sources available, although anchored on the input-output tables of the Portuguese economy, for which the latest version comes from the World Input Output Database (WIOD) and dates of 2011. Therefore, the sectoral results presented have 2011 as the reference year.

4.5. DIRECT MATERIAL INPUT BY SECTOR

Figure 2 presents the direct material inputs estimated for all the activities comprised in each sector of economic activity. The most relevant sectors in terms of direct material input (the material intensive ones), are agriculture, manufacturing, and construction. From a material type perspective, non-metallic minerals represent the largest share of material input in almost all sectors, excluding agriculture where biomass has a larger weight. Fossil fuel has a larger input share in manufacturing but especially in the energy and water and sewerage sector. These entries essentially represent fuels such as natural gas for electric energy generation. It is noteworthy that petroleum inputs are accounted for in the manufacturing sector under “Manufacturing of coke and refined petroleum products.”

Material inputs which enter an activity and are transformed into a new product and sold to another economic activity, end up being accounted as inputs in both activities. As such, the sum of inputs of the various economic sectors is higher than direct material input calculated for the national economy in 2011, which amounted to 233 million tonnes.

Figure 2 also shows the direct material input by type of sector including a more detailed account of the manufacturing activities. In extractive industries, given its nature, is where most inputs of non-metallic minerals take place, which are mainly sold to non-metallic minerals producing activities (e.g., glass and ceramics) and to the construction sector. It is the value chain composed of these sectors which represents the most significant share of material input, whereby it should be targeted for specific efficiency raising initiatives in the future.

It is also worth noting that biomass input essentially takes place through extraction in the agricultural sector (crop and animal production, hunting and related service activities) and in the wood industry (manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials). As for fossil fuels, practically all inputs through imports takes place in

manufacturing of coke and refined petroleum products. As mentioned, there is also a significant input of fossil fuels in the electricity generation activities.

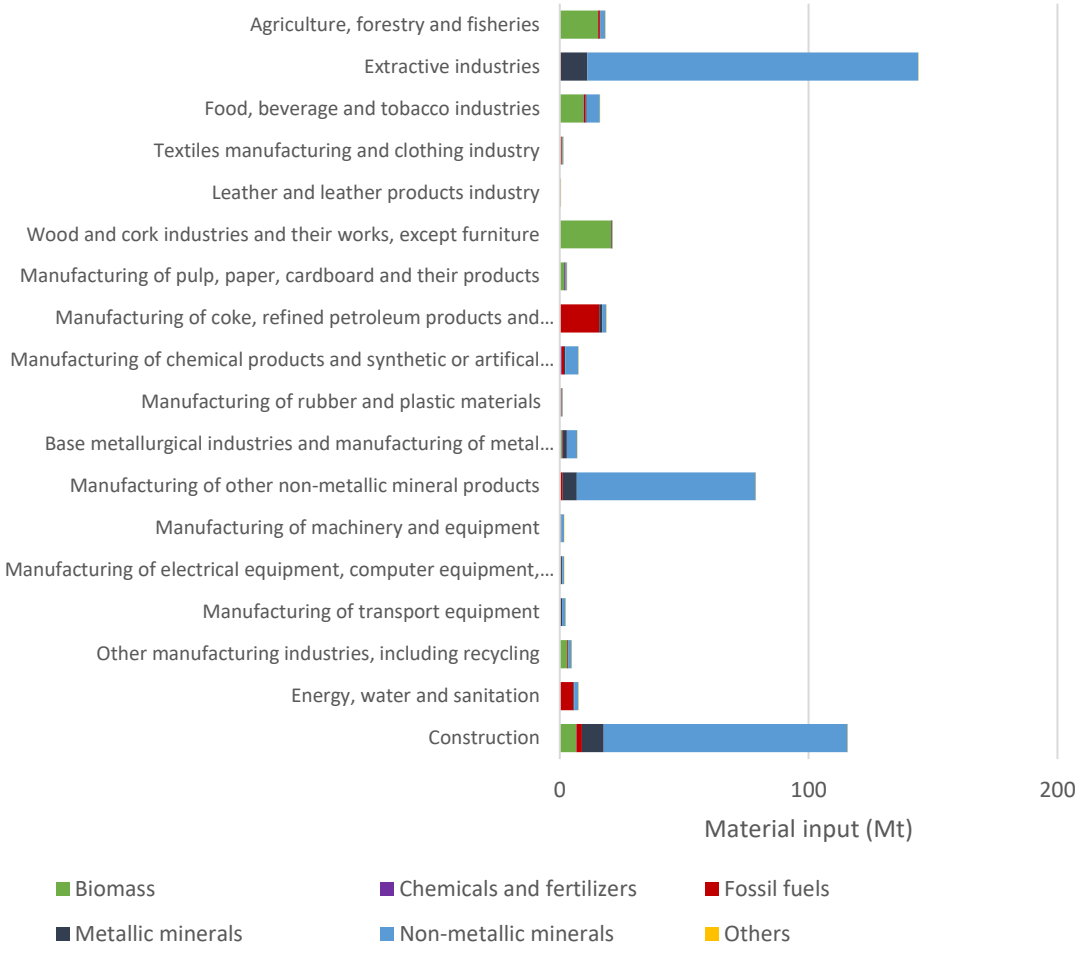


Figure 12 - Direct Material Input (106 t) per industrial activity in 2011. Source: 3drivers and IST (2015)

4.6. CONCLUSION – SELECTION OF WASTE STREAMS

Based on the analysis of waste streams generated and treated in Portugal, statistical analyses and stakeholder interviews have been carried out to identify relevant waste streams and by-products that can potentially be used as secondary raw materials. Four key parameters have been analysed, leading to selection of the four waste streams/sectors in the table:

- The amounts of waste and/or by-products available (presently not used as secondary raw materials), specified on waste streams
- The recycling potential of the identified waste streams
- The potential to replace virgin raw materials in Portuguese industry
- The potential strategic value for Portugal and Portuguese industry.

Selected material flows	Quantity	Recycling potential	Remarks
Construction and demolition waste	Mineral and solidified waste materials constitute around 1.5 MT annually – and may be underestimated according to EU average figures.	Recycling (downcycling) of most materials is possible (for road production) etc. - and presently conducted. Some examples of upcycling or reuse in EU MS, e.g., reuse of bricks at industrial scale and some project specific cases of reuse of windows or metal from one demolition to a new building (however not scalable)	Broad and varying product groups within the sector. Difficult to identify high value solutions with scalability
Textile waste from the textile industry	Four times EU average, around 100,000 tons	Huge recycling potential demonstrated in EU	Key industrial sector, also relevant for project 2
Bio-waste from agroindustry	Reported quantities are relatively small, that might be the result of in situ treatment options which are not reported. Taking EU27 generation as reference, Portugal should be generating about 1.2 million tons of animal and vegetal waste.	Biowaste has a high recycling potential as fertilizer, animal feed or feedstock to biological processes. It is expected that most biowaste is already being recovered – to be investigated. Possibilities to reuse the SRM higher up the waste hierarchy will also be investigated	Portugal is developing its first bioeconomy strategy, where biowaste may take a key place as feedstock for production of renewable fuels and base chemicals
Wood waste from furniture production	According to INE, around 400,000 tons annually (2018) – however, based on EU 27 generation as reference, perhaps the double amount.	Uses for recycled waste wood include traditional feedstock for the panel board industry (most of the recycled wood), animal beddings, equestrian and landscaping surfaces, play areas and filter beds. More recently also biomass fuel production.	Surplus of wood waste in EU will be increased with new post-consumer collection requirements – solutions needed

Chapters 6, 7 8 and 9 of this report present the findings of a thorough analysis of these four sectors respectively as well as strategic suggestions for the future development of circular economy within these sectors.

5. POLICY FRAMEWORK AND REGULATIONS

This chapter analyses the implementation of the EU Waste Framework Directive (WFD), the Circular Economy Action Plan (CEAP) and the Waste Shipment Regulations (WSR) in Portugal, focusing on industrial waste. It provides an overview of the policy framework and regulations that are applicable at a national level to industrial waste as well as the actual practice of waste management and treatment. The review focuses on recycling and recovery of secondary raw materials from the Portuguese industry. The goal is to assess the implementation of EU legislation and to identify the main obstacles and challenges regarding its implementation.

As an introductory note, over the past decade, in line with EU policies, Portugal has improved the policy framework and regulations concerning waste management and treatment to stimulate waste prevention and resource-efficiency while moving towards a circular economy. This has had positive impacts, such as a decrease in landfilling, but there is still ample room for improvement. The policies are ambitious, but the implementation in practice is challenged by several factors including insufficient understanding of waste flows, specifically for waste streams outside the scope of the general regime of waste management, and lack of regulatory enforcement. As a result, some secondary raw material markets (e.g., CDW) are still under-developed, particularly when compared to other Member States.

There are few explicit references to industrial waste[24] in Portuguese waste-related policy documents, which mostly focus on municipal waste. The only policy plan dedicated to industrial waste streams dates from 2002 and is outdated. However, since 2018 a strategic plan for non-municipal waste has been under development, which is expected to be published in 2021 (this plan was already made available for public consultation in 2020). In 2020, the Portuguese Government started the revision of the Circular Economy Action Plan, the National Waste Management Plan, and the Municipal Waste Strategic Plan 2021.

5.1. EU WASTE POLICIES AND REGULATION

Waste management was early recognised as a critical issue for a sustainable development in the EU. The first Waste Framework Directive was established in 1975, followed by a number of additional directives addressing specific waste streams. However, serious gaps persisted in the implementation of the EU waste acquis due to a lack of priority in the Member States, a lack of reliable data and other impeding factors, which led to great differences in the state and quality of implementation between Member States. The widespread use of disposal waste management technologies, such as landfills, which do not help to meet EU targets, illegal waste shipments and other aspects of insufficient implementation create not only environmental damages, but also economic costs and harm to human health[25].

5.1.1. WASTE FRAMEWORK DIRECTIVE

The Waste Framework Directive (WFR) institutes a novel approach to waste management that focuses on limiting impacts on human health and the environment. It sets the overarching legislative framework and defines the main concepts linked to waste management, including the polluter pays

[24] Industrial waste: waste resulting from industrial activities, as well as those resulting from the production and distribution of electricity, gas, and water (Decree-Law no. 102-D/2020, 10 December).

[25] EC (2018a): Communication 2018/656 on the implementation of EU waste legislation, including the early warning report for Member States at risk of missing the 2020 preparation for re-use/recycling target on municipal waste.

principle, the waste hierarchy (Figure 3)[26] and the end-of-waste status (i.e. when waste ceases to be waste after recovery). It lists disposal and recovery operations for waste, and properties rendering waste hazardous.

The Directive set out a range of binding targets to be achieved by the Member States by 2020: Preparing for re-use and recycling of 50% of certain waste materials from households and similar sources, and preparing for re-use, recycling, and other recovery of 70% of construction and demolition waste. It also requires Member States to draw up waste-management plans at national, regional, and local level (if applicable), and to subsequently notify the European Commission.

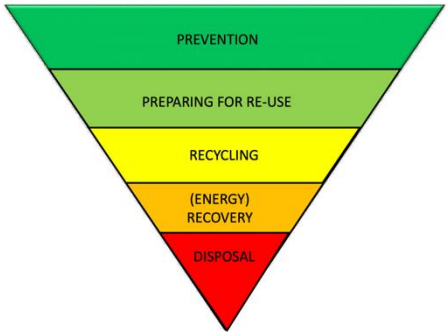


Figure 13 - The waste hierarchy

The Directive was revised in 2018[27] including new and more ambitious targets: preparation for reuse and recovery for municipal solid waste at 55% to be achieved by 2025, 60% by 2030 and 65% by 2035. The Directive also reinforces the need for Member States to take measures to prevent waste generation, including measures to reduce waste generation in processes related to industrial production, extraction of minerals, manufacturing, and construction and demolition.

In addition, it is established that by 31 December 2024, the Commission shall consider the setting of preparing for re-use and recycling targets for construction and demolition waste and its material-specific fractions, textile waste, commercial waste, non-hazardous industrial waste, and other waste streams. This is of significance, since it would be the first time that an EU Directive would set a target for industrial waste.

Waste management plans

Proper legal implementation, application and practical enforcement of EU waste legislation are key priorities of EU environmental policy. In this regard, waste management planning is one of the key tools for authorities to convert the principles of EU waste legislation at national, regional, and local level within their Member State.

In accordance with Article 28 of the WFD, the competent authorities of the Member States shall develop and adopt waste management plans and it is mandatory that the plans identify the measures that need to be taken regarding environmentally sound preparation for re-use, recycling, recovery and disposal of waste as well as an evaluation of how the plan will support the implementation of the objectives and provisions of the Directive[28]. Furthermore, the plan(s) shall:

- Cover the entire geographical territory of the Member State concerned.
- Set out an analysis of the current waste management situation in the geographical entity concerned.
- Set out the measures to be taken with respect to environmentally sound preparation for re-use, recycling, recovery and disposal of waste.

[26] The waste hierarchy, according to which the following hierarchy shall apply as a priority order in waste prevention and management legislation and policy: (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal as last r
resort.[27] EP (2018a): Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.
[28] EP (2018a): Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.

- Evaluate how the plan will support the implementation of the objectives and provisions of the Directive.

Early warnings

On 24 September 2018, the European Commission published the latest review of how well EU waste rules are applied in Europe, presenting challenges and ways forward. The report gives an overview of progress and implementation challenges for several waste streams and suggests areas for improvement for each of them. However, the report focused primarily on municipal solid waste management with little reference to the management of industrial waste. For municipal waste, 14 Member States, including Portugal, have been identified as at risk of missing the 2020 target of 50% preparation for re-use/recycling. For each of these Member States the Commission has presented early warning reports including possible actions to improve their waste management and ensure compliance with EU waste legislation. These actions include more effective separate collection to ensure high quality recycling, efficient extended producer responsibility schemes, economic instruments such as landfill and incineration taxes, and improved data quality[29].

5.1.2. CIRCULAR ECONOMY ACTION PLANS

In 2015, the European Commission adopted an ambitious Circular Economy Action Plan to stimulate Europe's transition towards a circular economy, boost global competitiveness, foster sustainable economic growth, and generate new jobs.

The EU Action Plan for the Circular Economy establishes a concrete and ambitious programme of action, with measures covering the entire cycle from production and consumption to waste management and the market for secondary raw materials. The annex to the action plan sets out the timeline when the actions should be completed[30]. The Action Plan proposes 54 actions contributing to "closing the loop" of product lifecycles through sustainable consumption and production and sound waste management, including greater recycling and re-use, and through the creation of a market for secondary raw materials[31].

Together with the Action Plan, the 2015 Circular Economy package included Revised Legislative Proposals on Waste that include targets for recycling, measures for reducing landfilling, to promote re-use and stimulate industrial symbiosis, as well as economic incentives for producers to put greener products on the market.

In March 2019, the European Commission published a comprehensive report on the implementation of the Action Plan[32] presenting the main results of implementing the action plan and the main challenges going forward towards a circular economy. The report states that the recycling of municipal waste in Europe during the period 2008-2016 has increased and the contribution of recycled materials to the overall materials demand shows continuous improvement. However, on average, recycled materials only meet less than 12 % of the EU demand for materials, which was echoed by a stakeholder report from 2018[33] suggesting that full circularity would apply to only 9% of the world economy, leaving vast areas for improvement.

[29] EC (2018b): Commission Staff Working Document 2018/422.
[30] EC (2015): Closing the loop - An EU action plan for the Circular Economy 2015/614.
[31] EC (2015): Closing the loop - An EU action plan for the Circular Economy 2015/614.
[32] EC (2019a): Report on the implementation of the Circular Economy Action plan 2019/190.
[33] De Wit et al. (2018): The Circularity Gap Report.

The European Green Deal

On 11 December 2019, the European Commission presented a new green growth strategy - the European Green Deal. This describes the EU's climate and environmental policy and contains an action plan for new initiatives to be implemented in the coming years. The goal of climate neutrality in the EU by 2050 governs the content of the strategy. The goal is to ensure sustainable and circular economic development with less pollution and lower greenhouse gas emissions, better health, increased quality of life and new jobs. The Green Deal is an important part of the EU's strategy to implement the UN's 2030 agenda and the UN's sustainability goals.

Circular Economy Action Plan (2020)

The EU's second action plan for the circular economy[34] was presented in March 2020. The new Action Plan announces initiatives along the entire life cycle of products, targeting their design, promoting circular economy processes, fostering sustainable consumption, and aiming to ensure that the resources used are kept in the EU economy for as long as possible. It introduces legislative and non-legislative measures targeting areas where action at the EU level brings real added value.

The European Commission has previously adopted other ambitious initiatives in the context of the Circular Economy Action Plan, including an EU Strategy for Plastics in the Circular Economy[35], a Communication on options to address the interface between chemical, product and waste legislation[36], a Monitoring Framework on progress towards a circular economy at EU and national level[37], and a Report on Critical Raw Materials and the Circular Economy[38].

Examples of measures in the new action plan that may have particular significance for the Portuguese industry are:

- Revision of the Industrial Emissions Directive, as well as continuing the integration of circular economy in BREF documents.
- Revision of the regulation on waste shipments.
- Assess increased harmonisation of criteria for by-products and the end-of-waste status.
- Update the indicators for circular economy and develop new indicators for resource use.
- Mandatory criteria, requirements, and reporting in connection with green public procurement.
- Launch of an industrial symbiosis certification system, led by the industry.

5.1.3. WASTE SHIPMENT REGULATION

The 2006 Waste Shipment Regulation (WSR) transposes the Basel Convention, which governs international exports and imports of waste and transboundary movements of waste into European Law. The WSR defines key terms in waste shipment, sets harmonised rules for the transboundary movements of waste for disposal or recovery, and requires information from Member States on waste shipments.

The WSR applies to shipments of waste:

- Between Member States, within the Community or with transit through third countries.

[34] EC (2020): Communication on A new Circular Economy Action Plan - For a cleaner and more competitive Europe 2020/98.
[35] EC (2018c): Communication on A European Strategy for Plastics in a Circular Economy 2018/28.
[36] EP (2018b) resolution of 13 September 2018 on implementation of the circular economy package: options to address the interface between chemical, product, and waste legislation 2018/2589.
[37] EC (2018d): Communication on a monitoring framework for the circular economy 2018/29.
[38] EC (2018e): Report on Critical Raw Materials in the Circular Economy.

- Imported into the Community from third countries.
- Exported from the Community to third countries.
- In transit through the Community, on the way from or to third countries.

It covers almost all types of waste, with some exceptions, e.g., radioactive waste, waste generated on board vehicles, trains, aeroplanes and ships, shipments subject to the approval requirements other regulations.

The WSR is closely linked with the Waste Framework Directive, which both underline the EU waste hierarchy for waste management options and emphasises environmental protection and self-sufficiency in waste disposal (proximity principle) and focuses on better enforcement and cooperation.

A significant part of waste produced in the EU is moved across national borders to receive adequate treatment. Although the EU waste legislation is based on the principles of self-sufficiency (at EU level) and proximity with waste disposal operations, waste movements across borders might lead to increased environmental benefits if the final treatment is environmentally preferable to alternatives available in the country where the waste is originated. EU Member States are allowed to object to a shipment of waste entering their own territory.

The European Commission is currently reviewing the WSR that governs transboundary shipments of waste both within and outside the EU. The on-going review[39] has found that the WSR has contributed to more harmonised and detailed implementation of international instruments and has resulted in better protection of human health and the environment. However, a range of factors is perceived to have negatively influenced the WSR implementation including:

- Lack of consistent implementation across the EU.
- Administrative burden related to procedures; and
- Lack of harmonisation in enforcement.

The review concludes that there is a strong call to better connect the objectives of the WSR to those of the EU's ongoing transition to a circular economy and to ensure that it facilitates the most "circular" waste treatment option.

5.2. PORTUGUESE WASTE POLICIES AND LEGISLATION

5.2.1. GENERAL REGIME FOR WASTE MANAGEMENT IN PORTUGAL

The European Waste Framework Directive (2008/98/EC) (WFD) was transposed in Portugal establishing the general regime of waste management (Regime Geral de Gestão de Resíduos, RGGR), that has been subject to several amendments. Its objective is to prevent waste generation, promote reuse and recycling of resources as well as improve the functioning of the waste market, providing benefits to economic operators and encouraging the use of secondary raw materials. In line with the definitions in the WFD, the RGGR clarifies some important definitions (e.g., waste and End-of-Waste) and addresses Extended Producer Responsibility, which makes producers accountable for the entire life cycle of products and materials and not just the end-of-life phase, promoting a more efficient use of resources and encouraging eco-design.

[39] EC (2020b): Commission Staff Working Document Evaluation of Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipment of waste 2020/26.

The Decree-Law no. 73/2011 was repealed with the publication of Decree-Law no. 102-D/2020[40], of 10 December, which establishes the revised RGGR, transposing the Directive 2018/851/EC to national law. The Decree-Law no. 102-D/2020 added several legal specifications, most of them going beyond the WFD.

5.2.2. NATIONAL WASTE MANAGEMENT PLAN

In line with the RGGR and WFD, the National Waste Management Plan (*Plano Nacional de Gestão de Residuos*, PNGR) was initially drafted in 2011[41] formulating the strategic orientations and operational principles within a more detailed framework at national level. The goal of the Portuguese national waste management plan, PNGR, is to "promote waste policies integrated in the lifecycle of products, centred around an (increasingly) circular economy and that guarantees a more efficient use of natural resources." The 2011 version of the PNGR was revised and approved in 2014[42] to reflect the newly adopted EU legislation and waste data. The vision, goals, and objectives of the 2011 version, however, were not significantly altered.

The PNGR was the first policy instrument in Portugal that explicitly referred to a life-cycle approach as essential to waste management and resource efficiency. It also encompasses the national waste prevention plan that is required by the WFD. By the time, this report was being drafted, the PNGR 2030, for the 2021-2030 period, was still under revision.

The planning of non-municipal waste management was carried out through two types of instruments: a) strategic plans for industrial waste and hospital waste, and b) specific instruments for specific material flows, typically in the form of legislation or action plans, such as for Construction and Demolition Waste (Decree-Law no. 46/2008, amended by Decree-Law no. 73/2011 and Decree-Law no. 102-D/2020), which will be addressed in more detail later in the report.

5.2.3. PLANO ESTRATÉGICO DOS RESÍDUOS INDUSTRIAIS (PESGRI)

The strategic plan for industrial waste (PESGRI[43]) was approved by Decree-Law no. 89/2002, defining the strategic principles for the management of this type of waste in Portugal. In the context of PESGRI, a national plan for the prevention of industrial waste (PNAPRI[44]) was established covering the period 2000-2015, giving priority to reducing the hazardousness and quantity of industrial waste. Furthermore, a project about prevention of industrial waste (PRERESI) was launched with a collective of business associations, representing sectors with a large potential for waste prevention, as well as scientific/technological institutes. Both PESGRI and PNAPRI are outdated and no longer in use. Since 2018, a strategic plan for non-municipal waste has been under development, expected to be published in 2021 (made available for public consultation in 2020). The new plan will substitute PNGR (the umbrella plan) and include a plan for domestic/municipal waste and a plan for non-municipal waste (three plans in total) - all expected to be published in 2021.

[40] DL 102 contains three decree laws in one document: one for the general waste management (the one that matters for the present project), one for landfill, and one for extended producer responsibility. Reference to DL 102-D in this report refer directly to annex I of DL 102-D.

[41] The PNGR was developed by APA filling the role of *Autoridade Nacional dos Residuos* and approved by the Resolution of the Council of Ministers.

[42] Presidência do Conselho de Ministros (2015): Resolution of the Council of Ministers n.º 11-C/2015.

[43] PESGRI (2002): Plano Estratégico dos Resíduos Industriais (PESGRI 2001).

[44] INETI (2001): Plano Nacional de Prevenção de Resíduos Industriais (PNAPRI).

5.2.4. GREEN GROWTH COMMITMENT

The Green Growth Commitment (Coligação para o Crescimento Verde)[45] was developed in 2014 through a coalition of 100 organisations in Portugal (public entities, business, science, finance sector and NGOs), setting out a comprehensive economic strategy for Portugal after the 2007-08 financial crisis to achieve the following societal objectives:

- Stimulating green sectors, including creating new jobs,
- Promoting efficient use of resources, including increasing water and energy efficiency,
- Increasing renewable energy use and improving biodiversity quality.

The strategy encompasses 14 subgoals, each with quantified targets for 2020 and 2030. To meet the subgoals, the agreement sets out 111 "initiatives" across ten sectors, including the waste sector, where the operational objectives are basically replications of the PNGR objectives, including *increased use of waste in the production of new products, and promoting industrial symbiosis between different industries, involving the trade of waste and by-products.*

Quantitative goals include Increased productivity of materials – from 1.14 EUR of GDP per kilogram (EUR/kg) materials consumed in 2013 to **1.17 EUR/kg by 2020** and 1.72 EUR/kg by 2030; increased incorporation of waste in the economy – from 56% in 2012 to 68% by 2020 and 86% by 2030.

The policy measures foreseen in the GGC range from public procurement, fiscal measures, information dissemination to R&D support.

5.2.5. THE PORTUGUESE CIRCULAR ECONOMY ACTION PLAN

The Portuguese Circular Economy Action Plan (PCEAP) [46] covers the period 2017-2020 and is strongly inspired by the EU CEAP. It does not formulate any specific quantitative goals or targets (that had already been done by the GGC) but expresses general goals and specific strategies related to CE at macro, meso and micro-level. Seven **macro-level "actions**" are defined: 1) Design, Repair, Reuse[47], 2) Incentivising a circular market, 3) Educating for a circular economy, 4) Combating food waste, 5) A new life for waste! 6) Regenerating resources: water and nutrients, 7) Researching and innovating for a circular economy.

Action-line 5 of the PCEAP focuses on waste, by-products, and secondary raw materials. The goal is to increase the introduction of secondary raw materials into the economy, decrease waste production and reduce extraction of natural resources. Key sectors are thermoelectric and refineries, production and transformation, metals, minerals, chemical industry, pulp and paper, wood and pellets, surface treatment with organic solvents and agribusiness industries.

The Portuguese Environment Agency was assigned to accompany and monitoring the waste classification process for by-products. Among the "guidelines" or specific actions by APA that are foreseen in this context are the review of the classification process (fees, deadlines, conditions for classification as a by-product, simplified mechanisms and accountability of operators); the simplification and streamlining of applications for classification of by-products, in line with the single environmental licensing regime; development of an information registration system for monitoring and following up the process of classification; collaboration with international public authorities to

[45] More information on: www.crescimentoverde.gov.pt

[46] Presidência do Conselho de Ministros (2017): Resolution of the Council of Ministers nº. 190-A/2017.

[47] Producers are meant to provide guidelines for products and consumers aiming at reducing the demand for materials and raw materials in production, increasing the reuse of products covered by extended producer responsibility and simultaneously decreasing the production of waste.

establish “circular agreements' for the acceptance of by-products and EoW materials. IAPMEI (the Directorate-General for Energy and Geology) was assigned to support with knowledge on critical raw materials and mapping the needs, in partnership with entities of the Research and Innovation System - SI&I.

To support innovation, the PCEAP aims to promote spaces for experimentation and innovation to test the application of by-products; promote the mapping of needs (critical materials, substitution options) and sharing of good practices. The shipbuilding and shipyard sector is mentioned specifically as repair and dismantling, reducing emissions and material recycling can help make the sector more sustainable.

The Zonas Empresariais Responsáveis (ZER, which can be loosely translated to responsible business areas) can promote industrial symbiosis initiatives between industrial companies in the key sectors and contribute to drawing up Circular Economy Roadmaps for industrial clusters as well as Regional Industrial Symbiosis. Several key entities were identified as well as measures such as awareness-raising actions for companies, a survey of potential industrial symbiosis relationships, identification of barriers to its implementation and its elimination, and training of industrial symbiosis/technicians.

5.2.6. MONITORING

Currently, there is a lack of publicly available monitoring and evaluation reports tracking progress of the above-mentioned policy objectives. The most accessible annual monitoring report is the National State of the Environment Report (REA)[48]. It encompasses **7 factsheets** about waste, parts of which are integrated in this report when relevant for industrial waste (Recycling of specific waste streams, Transboundary movement of waste, Ecovalor - Compliance fees associated to the management of specific waste streams).

According to the PNGR, intermediary evaluations of the implementation of the PNGR should have been conducted in 2016 and 2018. In 2020, a final evaluation with a higher level of detail should be performed to provide input for a revision of the Plan[49]. For the monitoring of the operational objectives, some general, desired trends have been formulated, but no quantitative targets.

5.3. LEGAL STATUS OF SECONDARY RAW MATERIALS

Declassification of waste is a legal mechanism which allows for materials within designated waste streams to be used as products if they comply with certain requirements. This removes the administrative/regulatory burden associated with waste, enabling the materials to be used as secondary raw materials. A Technical Guidance is available for the waste disqualification mechanism, which refers to the following key elements:

a) Application of Article 91 of the General Regime for Waste Management - By-product
b) Application of Article 92 of the General Regime for Waste Management - End of the Waste Status
c) Preparation for reuse
d) Recycling in the manufacturing industry

5.3.1. BY-PRODUCTS’ STATUS

[48] Agência Portuguesa do Ambiente (2019): Relatório do Estado do Ambiente – Portugal.
[49] It is unclear whether this has been done.

In Decree-Law No. 102-D/2020, in line with the WFD, the concept of by-product is defined, as well as the cumulative conditions that must be met for a material or product to be considered as a by-product (and not waste):

- Subsequent use of the material of product can be ensured (the economic application is certain).
- The material is an integral part of a production process but not the main purpose of the process.
- It can be used directly without further processing (other than normal industrial practise).
- It complies with relevant product requirements regarding environmental and health aspects and does not lead to (adverse) impacts.

In Portugal, the producer, either as an individual or through a sectoral association, now declares the substance as a by-product in the Waste Integrated Electronic Registration System (Sistema Integrado de Registo Eletrónico de Resíduos, SIRER). This self-declaration system is established under Decree-Law No. 102-D/2020, which introduces changes in the process. In the previous legal framework, the decision was fully undertaken by the Portuguese Environment Agency.

Since the publication of Decree-Law 73/2011, only 22 by-product classification decisions have been published[50]. The by-product classification decisions after the publication of Decree-Law No. 73/2011 are listed on the website of APA[51]. This illustrates either the lack of interest of companies or the difficulties encountered in the by-product classification and verification of all the required conditions. However, it should be noted that companies tend to experience difficulties in obtaining the by-product approval from public authorities, as confirmed by APA.

5.3.2. END-OF-WASTE

End-of-waste status (EoW) can be applied to a specific waste stream, after being subjected to a recovery (recycling) process through which waste is transformed into a secondary raw material, ready to be incorporated into the manufacture of products. Compliance with the EoW criteria can be proven, based on the following conditions (articles 6 of the Waste Framework Directive and 92 of the new RGGR):

- The substance or object is commonly used for specific purposes.
- There is an existing market or demand for the substance or object.
- The use is lawful (the substance or object meets the technical requirements for the specific application and complies with the legislation and standards applicable to the products); and
- The use will not lead to adverse environmental or human health impacts.

Once these conditions are met, specific criteria can be developed at EU or at Member State level. In Portugal, APA has the competence to establish EoW criteria, based on a number of formal steps. To date, the following EoW criteria have been published:

- At EU level: scrap iron, steel and aluminium (EU Reg.No. 333/2011), glass cullet (EU Reg.No. 1179/2012) and copper scrap (EU Reg. No. 715/2013).
- At national level: recycled plastic (Ordinance No. 245/2017) and for rubber material derived from used tires (Ordinance No. 20/2018).

The EoW (EU or national) criteria determine that the waste management operator must:

[50] As of September 2021

[51] Details on these decisions can be found in: http://apambiente.pt/index.php?ref=16&subref=84&sub2ref=957&sub3ref=958

- Implement a Management System that demonstrates compliance with the requirements established in the respective regulation or EoW Ordinance.
- Issue, for product transport, a Declaration of Conformity according to the model prescribed in the Regulation or Ordinance.
- Subject the Management System to a three-year verification by a conformity assessment body accredited for the purpose by the Portuguese Institute of Accreditation[52].

From the moment that waste is declassified through the EoW procedure, waste legislation is no longer applicable, but the substance/product is covered by product legislation, namely CLP (Classification, Packaging and Labelling - Regulation (EC) No. 1272/2008) and REACH (Regulation (EC) No. 1907/2006).

5.3.3. WASTE TREATMENT LICENSING

Decree-Law no. 102-D/2020 establishes the rules for the licensing of waste management operations[53]. These rules, firstly introduced in Decree-Law no. 178/2006, were intended to reform the prior authorisation mechanism to align it with the models of other EU countries, subjecting waste management operations to a swift administrative procedure of prior control, after which the licensing authority issues a license, and to administrative procedures that ensure effective monitoring of the activity carried out after the said licensing.

The publication of Decree-Law no. 73/2011, which repealed Decree-Law no. 178/2006, established a simplified licensing regime that allows the issuance of a license within a maximum period of 30 days[54]. With the entry into force of Decree-Law no. 75/2015, any license application for waste treatment must be made through the "SILIAmb" electronic platform – the Integrated Environment Licensing System hosted on the APA portal, which aims to enable the electronic processing of all license requests and authorisations.

The Information System for the Licensing of Waste Management Operations (SILOGR) is an online directory of licensed waste treatment operators which is publicly available. In accordance with DL 102-D, article 102, the insertion and updating of licence data in SILOGR is a responsibility of APA, CCDR, IAPMEI (Ministry of Economy) and the waste licensing authorities. The main objective of this platform is to facilitate access by citizens and waste producers to relevant information about the entities that conduct waste management operations.

At a national level, there is a considerable number of licensed entities for the treatment of waste, mainly for licensing operations with an intermediate character, that is, operations of temporary storage and subsequently transfer waste (operations R12 and R13).

5.3.4. TRANSBOUNDARY MOVEMENT OF WASTE

A brief account of the Portuguese implementation of EU regulation is provided in this section.

[52] Or in the case of EU EoW criteria, by any other body national accreditation system, in accordance with paragraph 11 of article 2 of Regulation (EC) No. 765/2018.
[53] APA (n.d.): Atividades de Tratamento de Resíduos.

[54] This Decree-Law does not interfere with the provisions of the other licensing regimes, whenever applicable, namely the licensing of landfilling and waste incineration and co-incineration.

The Decree-Law 102-D ensures the execution and compliance, within the internal legal order, of the obligations arising for the Portuguese State from EU Regulation 1013/2006 on shipments of waste. The objectives are:

- To respect the principle of self-sufficiency and proximity, ensuring that waste treatment operations are carried out with a high level of environmental and public health protection, preferably on national territory, minimising as much as possible the transboundary movement of waste.
- To ensure the establishment of an integrated and adequate network of recovery and disposal facilities for all types of waste, considering the best available technologies with sustainable costs**.**

Until the beginning of the operation of the two Integrated Centres for the Recovery and Disposal of Industrial Waste (CIRVER) in 2009, Portugal lacked industrial hazardous waste management infrastructures, making its export the best alternative, essentially for disposal. With the start of these facilities' operation in 2009, there has been a significant decrease on the exports of hazardous waste.

The total waste exports from the Amber List between 2014 and 2020, are depicted in Figure . One can observe that in 2017 there is a reversal of the reduction trend of waste exports registered between 2014 and 2016, leveraged by the waste sent to recovery operations, with a new reversal of the trend in 2020, also associated with a decrease in waste sent for recovery operations. The figure also presents the trend in waste imports, in which one can observe a reversal of the growth trend seen over the years in 2020, with a 40% decrease compared to 2019. This substantial decrease is related to the beginning of systematic objections to waste shipments to Portugal for disposal operations, with effect from February 1st, 2020. According to APA, in the last few years around half of waste entries are for recovery operations, while the rest is for landfill. The recovery operations are mostly related to the recovery of refuse derived fuels, used as fuel for energy production in cement plants from countries such as Italy, United Kingdom, and the Netherlands.

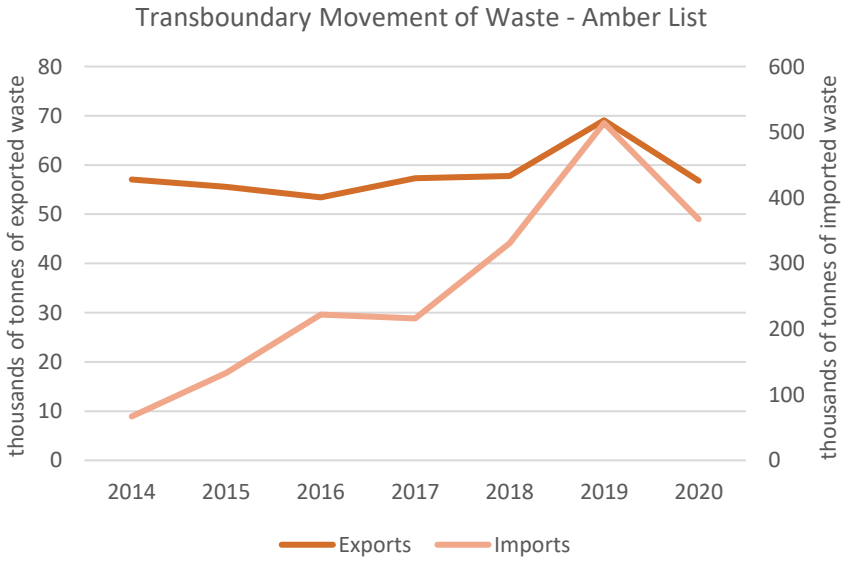


Figure 14 - Transboundary shipment of wastes - amber list, 2014-2019 (Source: APA, 2021)

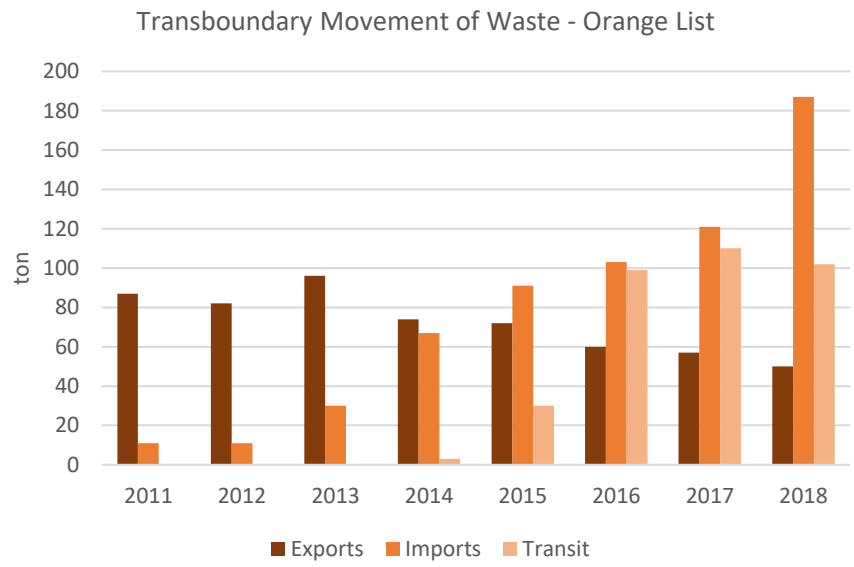


Figure 15 - Transboundary shipment of wastes - orange list, 2011-2018 (Source: APA, 2021)

The green list of transboundary movement of waste (Figure 6) shows a small but continuous increase of both entries and exits (i.e., imports and exports) of waste, with a slight reduction in 2019. As in the amber list waste types, entries are significantly higher than exits. Most of these waste streams are secondary raw materials such as scrap metal, glass cutlet, plastics, and rubber, among others. These are used in specific industries (e.g., steel, glass packaging, cement) for which the domestic output is not sufficient.

The main waste streams that are exported are metals, paper and cardboard, plastic, glass, and textiles. The exit of these materials, particularly metals and textiles, represent a loss in added value to the Portuguese economy, with valuable secondary raw materials not being used in the industry.

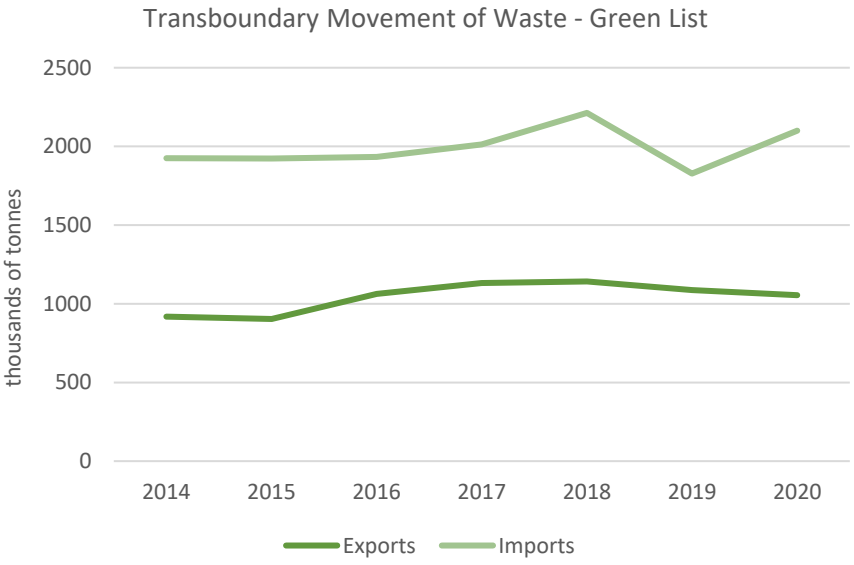


Figure 16 - Transboundary movement of waste – green list (Source: APA, 2021)

5.3.5. MANAGEMENT OF NON-MUNICIPAL WASTE

Non-municipal waste includes all waste other than municipal waste, i.e., industrial, health care, agricultural and other waste which may not be included in these categories because of its specificity, such as construction and demolition waste (CDW). For these types of waste, the producer of the waste is responsible for its management. Companies (waste producers) can conduct the treatment of waste or residual streams on their own premises, which is common in the case of the extractive industry or agricultural activities, or they can contract waste management operators.

As described in the previous sections of the present report, there are currently no operational industrial or non-municipal waste management plans which demonstrates the lack of a sustainable strategy for these waste streams in the past years.

5.4. CONCLUSION AND POLICY RECOMMENDATIONS

The conclusion of this section, related to the Portuguese implementation of EU waste regulation, is that Portugal has been able to implement this legal framework, including the 2018 review of the WFD. Also, Portugal has been able to devise the necessary strategic framework as mandated by the WFD. It is desirable if that Portugal with an upcoming waste plan establishes a clear strategic path towards reducing the amounts of industrial waste and promoting recycling and recovery of secondary raw materials from the Portuguese industry.

Portugal could address some missing elements in the policy framework:

- For the purpose of enabling increased use of residual materials, for which data on quantity and quality of the residual materials is necessary, Portugal could improve data collection and information management systems, beyond the legislative requirements, if necessary, in order to enable knowledge-based discussions and decision making on circular solutions going beyond legislation. This work could be initiated by cross-ministerial working groups and done in close cooperation with the sectors to ensure the needed back up from the industrial community including representatives from the environmental, tax, industry, and domestic authorities.
- Publish the new plan for non-municipal waste, with specific measures to foster eco-innovation for waste prevention and treatment, to promote industrial symbiosis networks, and provide support schemes, from material audit programs to investment in clean production.

While some recommendations require changes in the legal framework, other policy instruments could be implemented quickly using, for instance, instruments such as the Fundo Ambiental. Portugal should move quickly to avoid falling behind other EU Member States that are leading the transition towards the Circular Economy and making the most of the opportunities that Circular Economy presents.

6. CONSTRUCTION AND DEMOLITION WASTE - STRATEGY DRAFT

Construction and demolition are defined as a priority area in the EU in the Circular Economy Action Plan (EC 2015), while the revised Waste Framework Directive (WFD 2008/98/EC, amended 2018/851) has set a mandatory target of 70% (by weight) preparation for reuse, recycling and other material recovery (including backfilling) of non-hazardous C&D by 2020. The Circular Economy Package, launched by the European Commission, explores how circular economy-inspired action in the built environment can directly contribute to increasing the prevention, reuse, and recycling of CDW.

Construction and demolition waste is characterised by its high volume and weight but with probably the lowest environmental burden and the highest inert fraction per tonne of all waste streams. Although the specific environmental impact (per tonne) is low if compared with other waste streams, the associated environmental impacts of such a high amount of CDW is an important concern, mostly derived from its logistics and land occupation. Hence, the management of CDW constitutes a priority for most environmental programmes around the world, especially in Europe[55].

In EU about 850 million tons of CDW is produced every year, representing 31% of the total waste generated within the EU. In a lifetime, an average European citizen generates not less than 160 tons of C&D waste, an amount which is increasing over time. Construction and demolition activities include a wide range of materials such as excavation materials, construction and maintenance materials, concrete, and other stony materials, out of which concrete is the major component after excavated soil[56].

Up to 85% of the CDW is concrete, ceramics and masonry. However, CDW can be very heterogeneous composed of different materials, with different recycling potential, like:

- Concrete, cement and bricks
- Gypsum products (plasterboard, building plaster and gypsum block)
- Ceramic products (tiles and consumer products)
- Glass, Metals and Plastic and Wood
- Asphalt (from roads and roofing shingles)
- Salvaged building components (doors, windows, and plumbing fixtures)
- Trees, stumps, sand, gravel, and rock from clearing sites (materials not – according to APA 2021 – considered as CDW in Portugal).

In the EU List of Waste (LoW)[57] these fractions are not comprised in one CDW category, but instead spread on several categories, such as Mineral waste from construction, Wood waste, Other mineral waste, and Soils.

The European Environmental Agency concludes that while most EU Member States are on track to fulfil 70 % recovery target,[58] the recycling potential of CDW, although high in quantitative terms, is still under-exploited. The massive amount of C&D waste is usually recycled in low-value applications

[55] Gálvez-Martos et al. (2018): Construction and demolition waste best management practice in Europe.
[56] Gebremariam et al. (2020): Innovative technologies for recycling End-of-Life concrete waste in the built environment.
[57] Eurostat (2002): Guidance on classification of waste according to EWC-stat categories - Supplement to the Manual for the Implementation of the Regulation (EC) No 2150/2002 on Waste statistics.

[58] EEA (2021): Contruction and demolition waste: challenges and opportunities in a circular economy.

(down-cycling) such as subbase in road construction[59], for backfilling[60] such as landscaping of old quarries, [61] or sent to landfill[62]. As a result of inexpedient building practices of the past, the lack of generation of high-purity materials during demolition, and the high (technical and safety) requirements placed on materials, the CDW materials streams generated are often not suitable for closed-loop recycling. As such, improving waste management in this sector is crucial for the circular economy. The recovery performances, although in general high, differ significantly between EU Member States, varying in 2016 between 54% and 100%[63], although the data behind these figures is not particularly robust in all instances; for example, Member States have differing understanding and accounting systems for recovery operations of backfilling[64].

Reuse options for CDW include:

- Bricks, windows, doors and gypsum
- Aggregates for frost and load-bearing layers
- Wall and wood panels
- Metals, hardwood timbers

Recycling options for CDW include:

- Brick, concrete, masonry and ceramics as fill, subbase material, or driveway bedding.
- Wood chipped on site and used as mulch or groundcover
- Insulation from exterior walls can be used in interior walls as noise deadening material.
- Metals, lumber, asphalt, pavement

Recycled aggregates from masonry and ceramic wastes, usually mixed with waste concrete, are less usable in bound applications, but their volume is certainly smaller, and their technical viability is proven. Several case studies demonstrate more than 95% CDW recycling, where recycling means any recovery operation by which waste materials are reprocessed into products materials or substances, as defined in the Waste Framework Directive (2008/98/EC)[65] (excluding backfilling). The studies show how market barriers could be overcome in relation to (i) availability, (ii) economics and (iii) acceptability. The profit margin on recycled aggregates depends on the localisation of the resource, which must be situated closer to the user than conventional quarries, and the respective taxes applied to landfill and natural aggregate extraction.[66] Denmark and the Netherlands have been remarkably successful in promoting CDW recycling using high taxes on landfilling and extraction.

There is currently no harmonised application of the definition of backfilling in the Waste Framework Directive, and the dividing line between recycling and backfilling differs among Member States. The differences in recycling rates in the mentioned Member States are likely an effect of this.

[59] Use of materials as subbase for road construction is considered recycling, according to EEA (2021): Contruction and demolition waste: challenges and opportunities in a circular economy.
[60] Almost all countries not reporting backfilling to Eurostat actually have backfilling operations and it is unclear whether these figures are included in recycling figures or not at all. Source: EEA (2021): Contruction and demolition waste: challenges and opportunities in a circular economy.
[61] It is not easy to distinguish between low-value recycling and backfilling. Backfilling is defined as a 'recovery operation where suitable waste is used for reclamation purposes in excavated areas or for engineering purposes in landscaping' – and is not considered recycling as by Eurostat (n.d.b): Guidance on the interpretation of the term backfilling.
[62] Zhao et al. (2020): Use of recycled concrete aggregates from precast block for the production of new building blocks: An industrial scale study.
[63] Eurostat, 2019b
[64] Monier et al. (2017): Resource Efficient Use of Mixed Wastes – Improving management of construction and demolition waste.
[65] Joint Research Centre (2012): Best Environmental Management Practice in the Building and Construction Sector - Final Draft.
[66] EEA (2021): Contruction and demolition waste: challenges and opportunities in a circular economy.

Both construction and demolition activities lead to waste materials that can be recycled as shown in figure 17[67]. They are all highly dependent on the establishment of selective stripping and sorting of waste into separate material streams.

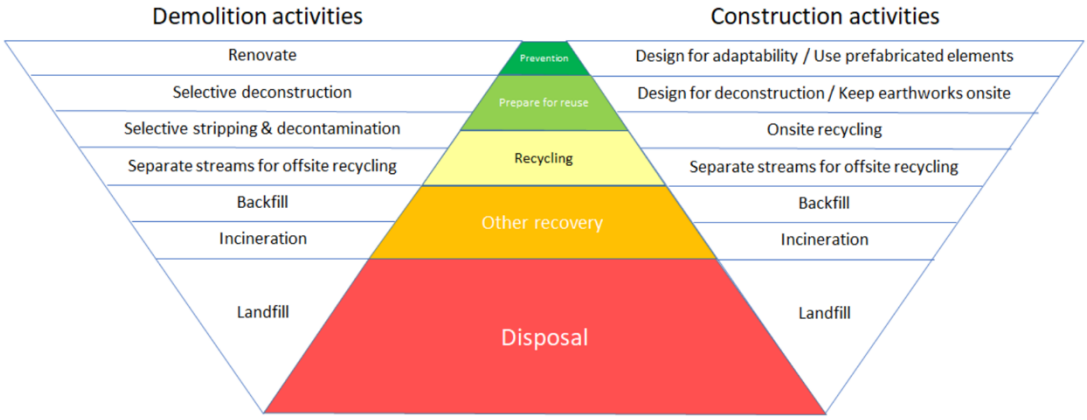


Figure 17: The EU waste hierarchy related to construction and demolition activities. Source: Level(s) indicator 2.2

SRM from construction activities (estimated 10 % of total CDW in Portugal) is less mixed, less contaminated and with higher recycling potential[68].

6.1.C&D WASTE IN PORTUGAL

According to Eurostat, the construction sector in Portugal generated 1.397.749 tonnes of wastes in 2018, equivalent to 136 kilograms per capita[69]. As shown in Figure 8, this is far below EU average of 1,870 kg/capita in 2018[70]

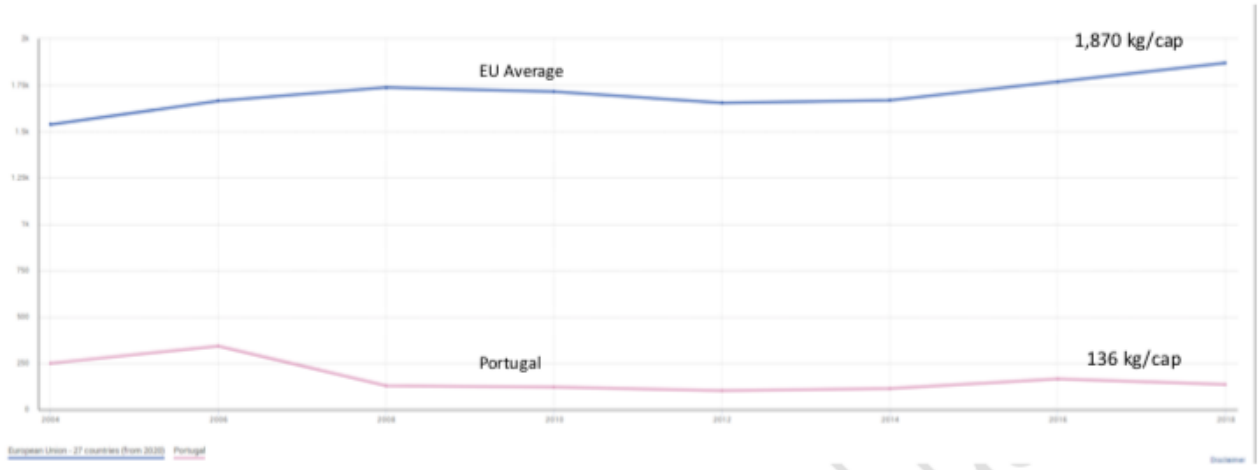


Figure 18 - Total waste from construction and demolition, EU, and Portugal - kilogram per capita [ENV_WASGEN]

[67] JRC (2020): Level(s) indicator 2.2: Construction and Demolition waste and materials.
[68] EC (2011a): Service Contract on Management of Construction and Demolition Waste – SR1.
[69] Eurostat (2021d): Generation of waste-by-waste category, hazardousness and NACE Rev. 2 activity.
[70] Eurostat (2021d): Generation of waste-by-waste category, hazardousness and NACE Rev. 2 activity.

Some of the discrepancy may be due to different approaches to registering generated waste. For example, related to article 2 c of the WFD: *Exclusions from the scope: uncontaminated soil and other naturally occurring material excavated during construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated*[71].

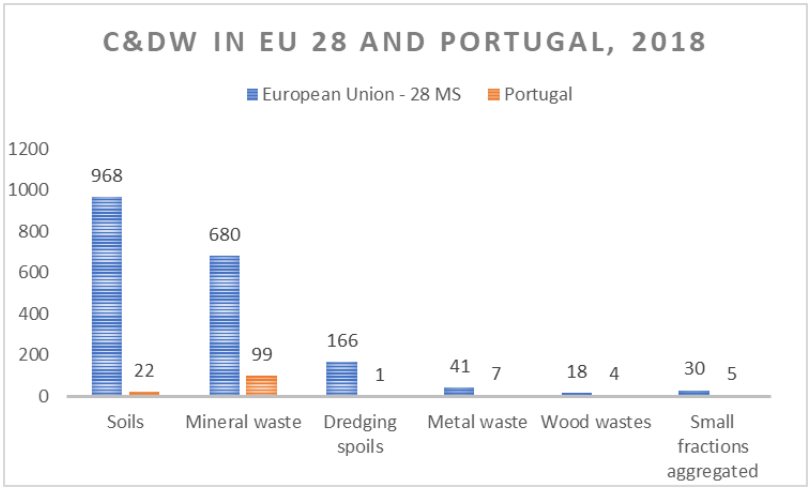


Figure 19 – CDW kg. per capita generation by fraction in EU28 and Portugal (excl. soils), 2018

It has not been possible within the frame of the present project to further investigate the reasons for the significant differences in CDW registration.

19 shows a direct comparison of registered C&D waste amounts in Portugal and EU28 in 2018 excluding soils. Even with the exclusion of soils there is a significant discrepancy for all material types between EU average and registrations[72] in Portugal.

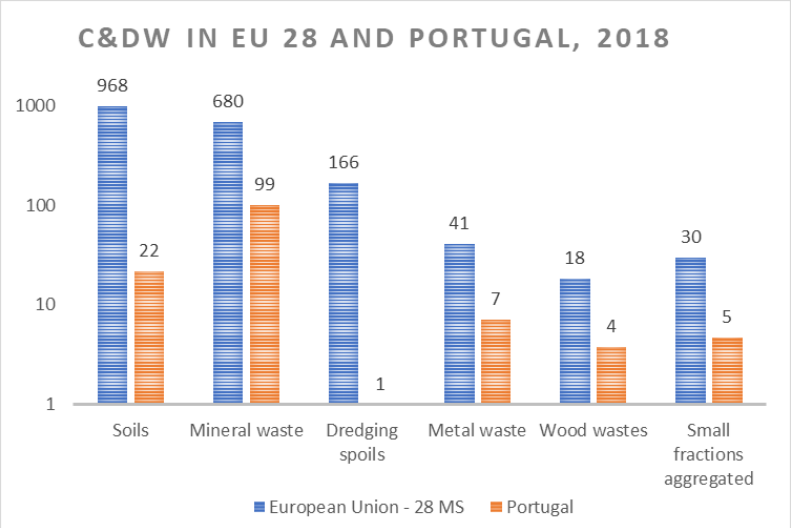


Figure 20 - CDW kg. per capita generation by fraction in EU28 and Portugal (excl. soils), 2018, Logarithmic scale

The same figures are presented in Figure but with *a logarithmic scale* to show differences more clearly. Stakeholder consultations indicate that while some of this discrepancy may be due to lower waste generation in Portugal compared to rest of the EU, there is a high likelihood that a considerable portion of the discrepancy is due to unregistered removal of CDW in Portugal.

[71] https://ens.dk/sites/ens.dk/files/Affald/guidance_on_the_interpretation_of_key_provisions_on_waste.pdf
[72] Eurostat (2021d): Generation of waste-by-waste category, hazardousnwss and NACE Rev. 2 activity.

The recovery rate (defined as the ratio of CDW prepared for re-use, recycled or subject to material recovery, including through backfilling operations) of construction and demolition waste in Portugal was 93 % in 2018 (just above the EU28 average of 90 %)[73], but with a large share of backfilling according to Eurostat (Figure). As mentioned, different approaches to the registration of backfilling and different categorisation of waste treatment options may be a factor of importance.

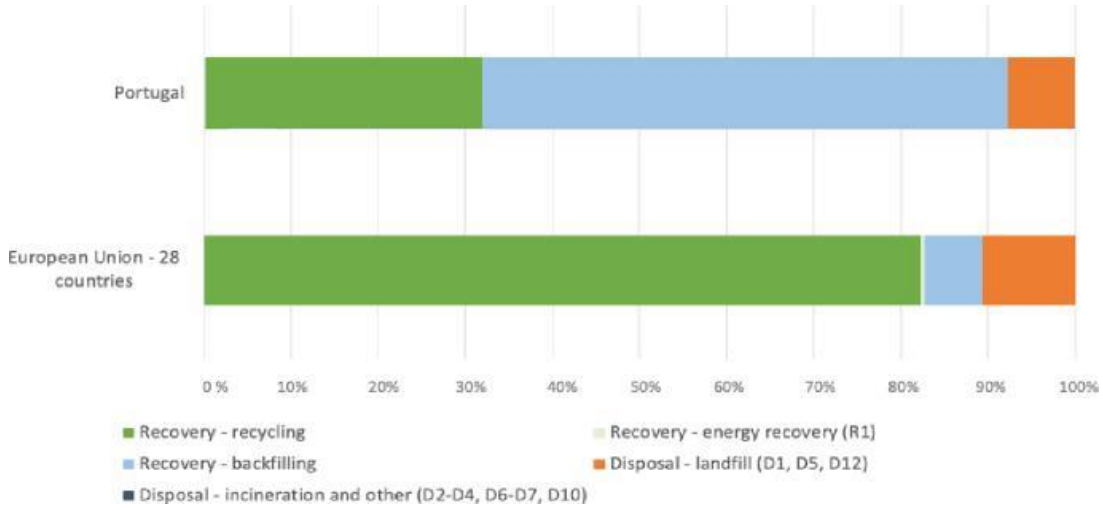


Figure 21: The distribution of the waste treatment of W121 Mineral waste from construction and demolition in Portugal and EU [ENV_WASTRT]

The accuracy of the data varies as stated by the EC and JRC in The Raw Materials Scoreboard:

"Overall, quality of reporting is clearly an issue. In particular, there is a high degree of uncertainty about waste-generation data and the amounts of CDW that are backfilled, whereas data on CDW treated in (for example, recycling) plants are believed to be more reliable. The lack of robust and comparable data on CDW in all Eurostat datasets makes it difficult to gauge actual recovery rates in the EU."[74]

[73] https://ec.europa.eu/eurostat/databrowser/view/ceiwm040/default/bar?lang=en

[74] EC (2021a): EU Science Hub – Raw Materials Information System (RMIS).

Around 73 % of registered CDW in Portugal is mineral waste (Figure 2). The Portuguese economy uses approximately 120 million tonnes of mineral resources annually and presuming that Portugal's C&D waste amounts are equal to EU average amounts – that would mean around 6 MT C&D waste in 2018 – recycling could supply 5% of non-metallic mineral resources inputs in Portugal.

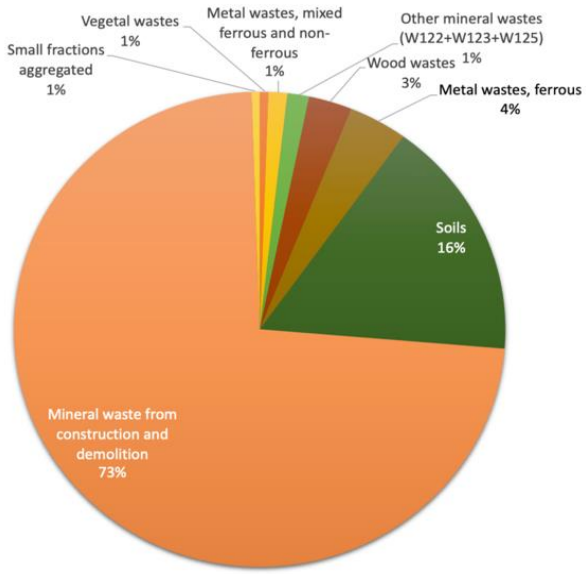


Figure 22 - Composition of construction waste in Portugal (2018) [ENV_WASGEN]

6.2. PRESENT INSTITUTIONAL SETUP

6.2.1. EXISTING VISIONS AND GOALS

Current Portuguese policy includes following targets and visions for improved utilisation of secondary raw materials from construction and demolition:

- Increase the preparation for reuse, recycling, and other forms of material recuperation of construction and demolition waste to 70% by 2020 (PNGR 2020).
- Promote the sustainable use of metal resources, which could reach 1% of GDP and create 25 000 jobs (GGC).

Other targets for the C&D sector include:

- The WFD and RGGR set the target of 70% (material) recovery of non-hazardous CDW to be achieved by 2020[75]. According to the most recent data by APA, this target was achieved in 2016, 2017 and 2018 (79%, 79% and 78%, respectively)[76], [77].
- The Waste Decree Law No 102-D/2020 contains specific targets for CDW, described in section 5.2.4 below.

[75] 70% of preparation for reuse, recycling, and recovery of other materials, including backfilling operations using waste as a substitute for other materials, non-hazardous construction, and demolition waste, excluding natural materials defined in category 17 05 04 of the waste list.

[76] APA (2019): Resíduos de Construção e Demolição. Resultados 2018 e evolução 2016-2018.

[77] In order to estimate the recovery rate, APA followed the guidelines established in the Commission Decision of 18 November 2011 (C (2011) 8165) which establishes the calculation methodology to verify the compliance with WFD targets (EC, 2011b).

- Besides imposing minimum requirements for the number of recycled materials (10%), the Decree-Law no. 102-D/2020 sets targets for reducing the amount of waste in the construction sector per GDP of 5% by 2025 and 10% by 2030, compared to 2018 values (Art. 21).

The National Circular Economy Action Plan, considers the construction sector to be a priority, proposing the transition agenda 'Built environment: more efficiency and material productivity' (Table 3).

Table 3 - Agenda for the construction sector (Source: PAEC, 2017)

Built environment: greater efficiency and material productivity	
Goals	• To increase the introduction of secondary raw materials into the economy; • To reduce waste production, demand for raw materials (primary) and water consumption; • To reduce GHG emissions;
Key Sectors	• Building material producers, developers (e.g. public bodies, municipalities, public enterprises), remodelling, demolition and buildings companies, planners, designers and architects; • Municipalities, built environment users; • Construction and demolition waste (CDW) management operators; • Distribution companies.
Roles or entities to be involved	• Entities designated by the minister for environment (urban rehabilitation, waste, land planning), planning and infrastructure, science and technology, economy: development of policy instruments, investment; • Municipalities and/or municipality associations: collaboration on local actions; • Public institutions focused on real estate, civil engineering: support to define circularity criteria in public works, technical rules for materials made from CDW; • Laboratories, higer education institutions and technology centres in the areas of architecture, design and construction (engineering and materials); • Industrial and technical associations, including competitiveness clusters, waste and real estate and real estate agents; • Companies: material producers, components, engineering and architecture offices.

Guidelines	Design • Rehabilitate and use: protocols to incentivise reuse of components, recovered or recycled materials, development and/or use of material passports, promotion of the use of "empty" built space (public and/or private); • Circular construction: public and private infrastructure such as projects that demonstrate the application of circular solutions (e.g. reuse of components, eco-labels, deconstruction guides, environmental product declarations, cradle-to-cradle design) Manufacture • Promotion of resource efficiency in the value chain: guides on good practices, efficient resource use plans, reverse logistics systems, segregation incentives, incentives for EMAS approach adoption; • Promotion of CDW incorporation into construction materials production: e.g. LNEC protocols; Reuse and recycling • Dissemination of the EU Construction & Demolition Waste Protocol and pilot projects for its implementation; • Reuse of building components: agreements between municipalities, companies and offices to: i) store components removed from demolition/rehabilitation projects; ii) create maintenance criteria; iii) catalogue and reference; iv) disseminate; • Review of legislation: e.g. RGGR, waste management fee for CDW, SILIAmb registration for license renewals, building project plans, quality protocols, etc.; Transversal • Positive discrimination for companies that establish voluntary agreements with the State on this matter.

Strategic Value

CDW constitutes a very substantial part of the waste generated in Portugal, similarly to other EU Member States. Apart from the significant quantity, this waste stream has other characteristics that further complicates its management, like its heterogeneous composition with fractions of varying sizes and the potential presence of hazardous materials. The geographically dispersed and temporary nature of construction works also make it difficult to control and monitor the environmental performance of companies in the sector. The cement industry is one of the main producers of CO_2 in all countries and has significant emissions of sulphur dioxide, nitrogen dioxide and nitric oxide; health risks of locally high concentrations of cement kiln dust; and depletion of drinking water supplies[78]. Thus, increasing the efficient and effective use of secondary construction materials is of high importance.

[78] EC (2012): Science for Environment Policy – From grey to green: Environmental impact of concretes must be fully assessed.

6.2.2. STRUCTURE, LEADERSHIP AND EMPLOYEES

Portuguese politics is structured as a unitary semi-presidential republic with the executive power being shared between the President of Portugal and the Council of Ministers. Among the Council of ministers is the Minister for Environment and Climate Action. At the time of writing, João Pedro Matos Fernandes has the Portuguese Ministry of the Environment and Climate Action (Ministério Ambiente e da Ação Climática/MAAC) as his area of responsibility. Within this Ministry, the public institute 'The Portuguese Environmental Agency' (APA) has been founded with the purpose of proposing, developing, and monitoring environmental policies.

The legislative power is vested in the government and the Portuguese Parliament (the Assembly of the Republic). The government structure is based on the 1976 Constitution which defines the status of the autonomous regions (*regiões autónomas*) Azores and Madeira as well as declaring the three tiers sub-national government being civil parishes (*freguesias*), municipalities (*municípios*) and administrative regions (*regiões administrativas*).

There are also the Regional Coordination Commissions, decentralised services of the ministry responsible for the environment, as Regional Waste Authorities (ARR), which are responsible for ensuring the exercise of their competencies regarding waste management, the exercise of their own competencies in licensing and monitoring the waste management facilities they license, as well as ensuring the uniform application of the technical standards issued by the ANR in accordance with the guidelines of this authority.

Regarding construction and demolition waste, it is also important to mention the importance of the Ministry of Infrastructures and Housing, whose mission is to formulate, conduct, execute and evaluate the infrastructure policies in the areas of construction, real estate, regulation of public contracts, as well as housing and urban rehabilitation policies, among others. In this context, the Institute of Public Markets, Real Estate and Construction (IMPIC) plays a decisive role given its responsibility to regulate and supervise the construction and real estate sector, to stimulate, supervise and regulate the activities developed in this sector and to produce statistical information and sectoral analyses.

The Ministry of Environment and Climate Action (MAAC) has been working to increase circularity in the construction sector since 2017, where the Regional Agenda for Circular Economy was established, supporting SMEs and start-ups innovating with building materials, and funding professional training in circular economy. The Minister for Environment and Climate Action has the potential to provide a clear and sound direction for the C&D sector regarding SRM and inspire and create a sense of coherence. The staff at the Portuguese Environment Protection Agency (APA) must push for and develop effective strategies.

The Portuguese municipalities have the key role to license and supervise constructions and demolitions and are responsible for regulation of a part of the CDW.

European Strategies

Pan-European policies have a huge influence on waste legislation in the Member States and has increasingly been introducing circularity into EU Directives. The concept of circularity seeks to ensure long-term resource efficiency by design while simultaneously having direct benefits on carbon reduction targets. In a regulatory field that has primarily been dominated by energy efficiency targets in the user stage, material efficiency and the use of SRM in the C&D sector has increasingly gained attention the recent years. The European adoption of the European Green Deal, the Circular Economy Action Plan, the Renovation Wave, and the New European Bauhaus initiative are great examples of the constantly increasing focus on increased resource efficiency and circular economy within C&D.

Similarly, the new European framework for sustainable buildings *Level*(s) puts a major focus on circularity within C&D through its macro-objective focusing on resource efficient and circular material life cycles.

Portuguese strategies

Although there are no strategies in Portugal dedicated to increased use of secondary raw materials from the C&D sector, the sector is influenced by a variety of policies and legislation – some of which have goals and requirements for utilisation of secondary raw materials.

The Estratégia Nacional para as Compras Públicas Ecológicas (ENCPE 2020), approved by Council of Ministers Resolution 38/2016, functions as a complementary instrument for environmental policies, contributing to the promotion of pollution reduction, reduction in consumption of natural resources and, inherently, increasing the efficiency of systems. This strategy also intends that the public procurement regime encourages the change of behaviour in society, promoting a new concept of development.

6.2.3. CULTURE

In the C&D sector a number of cultural challenges have been identified from interviews and workshops with industries, associations, and knowledge institutions:

Most construction companies in Portugal are SMEs of which – according to interviews with key sector stakeholders – many are struggled to comply with waste legislation. The operators have limited resources and find little support from the government and associations, and day-to-day operations seize the manpower.

“Micro companies and SME do not have a technical department to sort out the waste and give it the proper destination or invest in research and investigation.” Source: Construction and demolition company.

Since there are few consequences for poor management, it is widespread practice for some SMEs to dump CDW illegally in the environment.

“Many small companies, with works of short duration, and with a small volume of waste, which in the eyes of small builders do not generate a significant impact if dumped incorrectly. In some cases, the waste is also stored until there is enough to be delivered to an operator.” Source: FEPICOP, Portuguese Federation of the Construction Industry and Public Works

There is furthermore a reluctance in registering real volumes and profile of wastes.

“Only the big companies report the waste correctly. The 98% do not report. It is very time consuming for SMEs to deliver the waste correctly. Administrative issues in Portugal are difficult and time consuming. We need simplifications with the regulation and waste classification, and we also need more recycling stations” Source: Construction and demolition company.

During compliance checks, especially the smaller C&D companies can display uncertainty avoidance behaviour instead of consulting with inspectors. For example, if waste operators lack information in order to comply with legislation, they will tend to stay quiet about their doubts, due to a fear that lack of knowledge or capacities on their side may ultimately result in penalties if it is discovered. Today the environmental inspection in Portugal does not facilitate or assist the companies in a transition towards CE but are primarily focused on compliance checking. Stakeholders further highlight that the construction sector lacks the knowledge and experience required to compete on an international

level. There is limited external dissemination of information from working groups on C&D within associations and in general sparse cooperation between industries and within the value chains on the utilisation of SRM. This is partly due to an experienced limited branding value in displaying advanced waste solutions, partly due to lack of trust from entrepreneurs and building owners in the quality and performance of SRM, and partly due to lack of information on the availability of SRM and by-products within the sector. It is also a tendency that EU guidelines are ignored until change is required through mandatory public disclosure. In general, European resources are not optimally utilised, and there is, for instance, no tradition for applying for European Funds for innovative and green projects.

Within the public sector, green public procurement (GPP) has not been fully adopted in public institutions despite new regulation. In the public sector there is limited demand for SRM-products and public procurers seem to be unwilling to deviate from standard procedures, partly because of concerns of being accused of corruption or fraud. It has also been pointed out that there is uncertainty in the contract documents and that the EU standards are perceived to be too complex.

6.2.4. SYSTEMS

One particular system of interest in this context is the monitoring system that has been established in Portugal. Today, statistical information provided by Eurostat informs us that the recovery rate (including recycling) of total construction and demolition waste in Portugal is 93% (compared to 88% in EU 27, 2018). This ensures that Portugal complies with the Waste Framework Directive requiring Member States to take any necessary measures to achieve a minimum target of 70% (by weight) of CDW by 2020 for preparation for re-use, recycling, and other material recovery, including backfilling operations using non-hazardous CDW to substitute other materials. The high recovery rate of CDW in Portugal is mainly achieved by using recovered waste for practices such as backfilling and low-grade recovery applications, reducing the potential to move towards truly circular waste management. But as we have covered, there may be a high discrepancy between the waste quantities produced and the waste that is being registered.

Regulation of Construction and demolition waste in Portugal

In addition to setting targets, the DL 102-D/2020 also defines responsibility for wastes. It states that the management of CDW is the responsibility of the producer of the waste, without prejudice to the co-responsibility of all stakeholders in the life cycle of the products to the extent of their intervention in it. The exception is CDW resulting from minor repairs and DIY works in houses by the owner or tenant, whose collection, transport and / or reception is the responsibility of the municipal system responsible for the collection of municipal solid waste, which must establish specific procedures for the collection of this type of waste.

Regarding the marketing of products, Decree-Law no. 130/2013 ensures compliance with the obligations arising from Regulation (EU) no. 305/2011 of the European Parliament and of the Council, of 9 March 2011, laying down harmonised conditions for the marketing of construction products. The Regulation also defines the conditions necessary for the affixing of the CE marking on construction products in accordance with the general principles described in European Union legislation. The CE marking indicates conformity of the construction product with the performance declared by the manufacturer, corresponding to its essential characteristics[79].

[79] OERCO2 (2013): 1.2.1. Study of Most Used Materials in Construction Sector in Portugal.

The Estratégia Nacional para as Compras Públicas Ecológicas 2020 (ENCPE), which is presently being reviewed, applies the pre-contractual procedures defined in the Public Contracts Code, approved by Decree-Law no. 18/2008, of January 29. In this way, ENCPE 2020 is also covered by the point 7, article 8 of Decree-Law no. 73/2011, which requires "where technically feasible, the use of at least 5% of recycled materials, or incorporating recycled materials, in relation to the total amount of raw materials used on site, accordingly to the contracting of construction and infrastructure maintenance contracts, under the Public Procurement Code "[80].

In 2018, the European Commission published the Protocol for the Management of Construction and Demolition Waste [81] aiming to support the proper management of this CDW. The Protocol contains a set of guidelines aimed at improving the identification, separation and collection at source, logistics, processing and quality management throughout the entire value chain, stimulating recycling and confidence in the quality of recycled materials. In 2018, APA in partnership with the Commissions of Coordination and Regional Development (CCDRs) organised a number of regional events for the dissemination of the EU Protocol for construction and demolition waste. Additionally, a survey was conducted by these entities among municipalities to assess their management and treatment in practice. Based on these activities it was possible for the entities to identify the best practices in CDW management in Portugal as well as the main constraints[82].

In 2016 APA implemented new standards for recycling construction and demolition waste, including a guide for the use of recycled aggregates from recovered bituminous mixtures for uncontaminated layers of road surfaces; a guide for the use of waste materials from construction and demolition on rural and forestry roads; and a guide for the use of waste materials from construction and demolition in ditch filling.

European List of Waste

Data on waste is structured by European List of Waste (ELW) and the following considerations should be taken in account:

- Waste 17 05 04 when sent to an excavation void (quarry) that has an Environmental and Landscape Recovery Plan was considered reuse and, for this reason APA does not have information on these quantities (it is only mandatory to register waste) and there is no historical data on these amounts.
- Regarding 17 04 is possible that this quantity may be inflated, and the waste may not be effectively CDW. Waste producers sometimes make the mistake of identifying metal waste in this subchapter of the ELW, even if it does not come from construction sites (e.g., scrap dealers, service providers). This happens because they do not find in the ELW the description of aluminium, or copper and they fit these EWLs by the description of the metal and not by its origin.

Recommendations in previous studies

A number of policy recommendations have been provided in a previous EEA study of material efficiency and the use of SRM in the C&D sector. The study highlights the main challenges and possible ways to tackle those:

[80] OERCO2 (2013): 1.2.1. Study of Most Used Materials in Construction Sector in Portugal.
[81] EU (2018): EU Construction and Demolition Waste Protocol and Guidelines.
[82] Documents retrieved from https://apambiente.pt/index.php?ref=16&subref=84&sub2ref=197&sub3ref=283

- Increased waste prevention and higher and better-quality recycling can be achieved by overcoming uncompetitive pricing, lack of trust in the quality of secondary materials, lack of information on the composition of materials used in existing buildings and the long delay between implementing actions on new buildings and their effect on waste management several decades later.
- Circular economy-inspired actions, facilitated by measures such as standardising secondary raw materials and sharing information among stakeholders, have a high potential to contribute to increased waste prevention and to higher and better-quality recycling[83].

6.2.5. SUMMARISING THE PRESENT INSTITUTIONAL SETUP

Several vision and strategies are in place, but there are still institutional elements that hinders their implementation. Utilisation of secondary materials requires new forms of cooperation between stakeholders, technological development and involves new kinds of risks. Therefore, capacities must be built, and dialog and cooperation must be established across the value chain and between industry and public authorities. Furthermore, it is important to have properly functioning monitoring systems in place. The challenge of increasing secondary materials is complex and multiple elements in the institutional cycle must be addressed, while maintaining coherence with existing visions, targets and strategies and on the premise of the current sectorial maturity for circular economy.

6.3. EU BEST PRACTISE EXAMPLES

Gentræ

Denmark's largest retailer and distributor of building materials, STARK Group has, in partnership with the waste management company Solum Group and the environmental consultancy Golder, initiated project GENTRÆ (RETREE) in 2019. The main purpose of GENTRÆ was to create a solution for recycling interim wood (wood used in temporary constructions of barriers, railing, etc. at construction sites) by developing a collection and production apparatus that ensures that wood suitable for reuse is sorted from waste streams and prepared for sale in Danish construction centres as an alternative to virgin wood.

STARK delivers the GENTRÆ-containers directly to construction sites and collects them again when full. The wood is then transported to the Solum Group for sorting and cleaning before being resold via STARK's traditional construction markets as a recycled alternative to construction products.

As one of three winners of the Circular Construction Challenge, *Rethink Waste*, launched by Realdania in August 2018, GENTRÆ received a six-month development course and 1 million DKK to develop the first prototype as well as build the business model for their circular solution. While no profits are generated by GENTRÆ at this time, the project partners are optimistic about future perspectives with more focus and regulation on sustainable and recycled building materials and plan to develop several other recycled materials.

As for the construction companies, GENTRÆ offers a relatively cheap solution for collection of waste (600 DKK pr. tonne as opposed to the regular cost of around 720 DKK pr. tonne) that support compliance with the sustainable construction standard DGNB and serves to reduce the overall environmental impact of the construction.

[83] EEA (2021): Construction and demolition waste: challenges and opportunities in a circular economy.

GENTRÆ has collected approx. 100 tonnes of interim wood from construction sites to date. The long-term goal is to be able to collect the 50 000 tonnes of construction site wood waste generated annually, which is estimated to be incinerated.

One of the main challenges has been to develop the right setup to make the sorting of interim wood streamlined, palatable and cost-effective for the construction companies and site employees. Furthermore, the quantity of wood collected is currently too low to benefit from economy of scale and testing is prohibitively expensive.

Similar projects can have significant potential to further circularity of often-overlooked materials in the Portuguese construction sector. Financial support and standards on a certain degree of recycled materials in new constructions would support this development.

Madaster

Madaster is a publicly accessible Dutch online platform for registering materials and products used in buildings. It functions as an online material passport for registered buildings, so the buildings can be considered long-term material bank.

The purpose of the material passport is to preserve a record of the identify, quality, value, and life expectancy of the materials present in the building. This information makes it easier to recycle and reuse the materials in the buildings at end of life or during renovation.

Madaster also includes a 'circularity index' by which each material pass is scored. With the circularity index, it is possible to see what percentage of the materials in a building can be recycled.

Madaster is an independent platform offering free access to private individuals, as well as companies, governments, and scientific organisations, and is widely used by the construction industry. Building owners use the register to demonstrate the sustainability of a building and manage demolition costs; architects and the contractor plan and adjust proposed materials, products and construction methods already in the design phase, while property managers can plan more accurately for maintenance schedules and costs.

Most of the buildings registered in Madaster are new constructions. However, in 2018 Madaster started a partnership with the engineering company Re Use Materials, which carries out inventory lists of buildings. This makes it easier to register existing buildings in the Madaster platform. Madaster is also working towards collaborating with several online marketing platforms with recycled materials to further promote the sale of recycled materials.

Incentive for material passport

TAX BENEFITS: In early 2019, the government of the Netherlands decided to promote the use of the material passport through tax incentives. Through a tax reduction, contractors can save up to 75% on environmental investments. The prerequisites for the reduction are a material passport registered in an online platform such as Madaster.

GREEN BUILDING COUNCIL: From 2020, the Dutch Green Building Council will award points in BREEAM for registration of materials in a material passpost. In practice, this means that

registration of materials in a material passport gives a building a higher score, and that registration becomes a prerequisite for achieving the highest score.

OPALIS

Online inventory of salvaged building materials around Brussels[84]

The Opalis project is a website provides an online inventory of the professional sector in salvaged building materials in Belgium. It helps builds a bridge between second-hand dealers and commissioning agents such architects and building contractors and by so doing increases the potential, both in terms of collecting salvaged materials and in offering these materials for sale. The goal has been to organize and create better connections between actors across the value chain.

The OPALIS site was created by Rotor asbl. Rotor is an association that has been working since 2005 on the issue of reuse, through research work, interior fittings from reuse materials and collaborations with architects, companies, and project owners.

The site offers a directory of professional operators who sell second hand construction materials from dismantling of old installations or buildings. In addition to the supply of construction products, these operators often offer other services including deconstruction, cleaning, resizing and advice.

Opalis also provides technical documentation on the most common construction products on the re-use market covering main characteristics, availability, frequency, and indicative prices.

The materials listed on Opalis come from demolition and renovation projects. The site contains detailed information and photos from all dealers within a one-hour drive radius around Brussels (but also provides some names of companies in France and the Netherlands), as well as information about distinct types of materials.

The project was developed in several phases through support from Bruxelles Environment, the Duurzaam Materialen en Energiebeheer Fund, the Brussels-Capital Region within the framework of the Regional Circular Economy Program (PREC, measure RD15), the OVAM within the framework of Vlaanderen Circulair, and ADEME (France) as well as the Île de France region.

It started with regional funding and funding from the Ministry of Environment for Brussels. The Ministry was interested in encouraging reuse in constriction and started to investigate the recycling and reuse industry in Brussels. It was initially difficult to find reclaim dealers in Brussels, but this did not mean that there was no reuse at all. Many companies were already working with reuse and recycling on a smaller scale and then the Rotor Deconstruction cooperative was established to organise the reuse and recycling of construction materials and demonstrate the active use of the materials.

The objective of the Opalis site is to facilitate the use of re-used materials in construction and renovation projects. Around 250 tons of used material is sold on the platform each year. When a

[84] Opalis (n.d.): Construire et rénover en réemploi.

product is sold, the buyer who assesses and examines the suitability of the materials. Ceramic tiles, claddings, stone, wood, and doors are the most common products sold on the site.

The platform also hosts a collection of cases for the use of the recycled materials. These examples vary in size, from the use of reclaimed tiles in a commercial store to the use of almost 100 tons of steel structures. One issue with the platform is that there is currently no clear way to distinguish between professional dealers and smaller ones selling material on the side – Opalis are searching for a way to indicate this in the future.

A level of verification is conducted on the companies one the platform: around 80% of the companies currently on the site has been visited. Site visits account for a substantial part of the operating budget of the platform: the development of the website was a relatively small part. This means that funding is needed to keep the platform running. To date, the project has received four rounds of funding, which means that it has not been necessary to establish a participation fee. Companies have been approached directly about their potential inclusion on the Opalis platform – a process that has been repeated with every new funding round. Most of the approached companies have been happy to join. Only around 5% of the companies/dealers currently on the platform have themselves initiated contact with Opalis, the remaining 95% have been encouraged to join by the project team.

Gamle Mursten (old bricks)

Reuse of old bricks in building facades creates an architectural value and has raised interest in Denmark. Bricks are carefully dismantled from old buildings, sorted, and cleaned – the mortar is removed. The dismantling and the cleaning processes are labour intensive and increase the cost of the bricks compared to new ones. Technically the renovated bricks fulfil the requirements for reuse and are marketed and patented by Gamle Mursten. With the support of the Danish Environmental Protection Agency, a circular economy concept for marketing reusable bricks has been developed.[85] The reuse of bricks saves significant amounts of CO_2, the estimated savings in greenhouse gas emissions is on average about 0.5 kg CO_2-eq per brick[86]. The bricks are used for new construction as well as renovation of existing buildings. For almost 20 years Gamle Mursten has continuously developed the brick cleaning technology while supplying reused bricks to all over Northern Europe.

Reusing newer bricks

It has not been possible to recycle individual bricks since the 1960's because the mortar today is stronger than the actual brick. In The Resource Rows – a new urban residential development in Copenhagen – The Lendager Group in collaboration with Carlsberg Byen cut out brick modules from Carlsberg's historical breweries in Copenhagen and installed them in steel frames so they could be used as new facade elements. Bricks from old schools and industrial buildings in Denmark were also used. In addition, around 300 tons upcycled wood from the construction of Copenhagen Metro was used in the facades and interior of The Resource Rows. By using recycled materials, a lot of virgin materials can be saved construction emissions could be reduced by up to 70 % compared to building with virgin materials[87],[88].

[85] Danish EPA (2018a): *Genbrug af mursten*. Miljøprojekt nr. 2002.
[86] EACI (2014): Project Information Sheet - Market uptake of an automated technology for reusing old bricks (REBRICK).
[87] Lendager (n.d.): The Resource Rows.
[88] VCØ (n.d.): Ressourcerækkerne.

Combineering

Combineering A/S is a privately owned Danish company with more than 25 years of experience in the recovery of industrial residual products. Combineering's core business concept is to develop or further recovery solutions for industrial residues and then to mediate these between producer(s) and end user(s). Combineering's services can include development of a solution, securing the necessary environmental approvals, logistics (administration of all daily transports including paperwork with cross-border transports) and financial management, etc.

Combineering usually works with a no solution, no pay model when developing solutions for a company's residual products. Combineering will in turn also gain the right to trade in the given residual product for a set number of years. Their clients (Novo Nordisk, Rockwool, Leca among others) receive a more environmentally friendly business profile at a low or unaltered expense compared to their current alternative (often landfill or incineration).

Because of their wide-ranging industrial networks in Europe and many years of experience in recovery of residual products, Combineering can sustain their no soluiton, no pay business model.

The experience and knowledge of a company like Combineering could be invaluable when developing environmentally sound solutions for the large Portuguese industries. Combineering explicitly disassociates themselves from material markets or hubs because of a precieved lack of quality control and proper declaration of substances within the traded materials, which too often leads to increased environmental and health risks. Instead Combineering identifies specific solutions to specific and thoroughly analysed residual products. Several producers and end users can, however, be involved in a single solution for a (relatively homogenous) residual product. Combineering highlights the importance of regulation on the variety of virgin materials that are permitted: having fewer permitted materials promotes circularity without impacting competitiveness. Combineering would be interested in a meeting with APA and the larger companies in the relevant Portuguese industries.

One of the main barriers is the necessity for a large quantity of residual products when developing a cost-effective solution. An annual flow of approx. 100 tonnes of a given residual product is required. The residual product does not have to come from a single producer but must least be relatively homogenous.

Recycling of concrete

Recycled concrete is a waste material mainly obtained from construction and demolition (C&D) activities. The massive amount of C&D waste produced each year is usually used for low-value applications such as road construction or is land-filled instead of being recycled. Depending on the nature of the construction project, concrete waste ranges from 32% to 75% of the total waste generated on site. Some specific elements such as concrete beams or blocks can be dismantled from a building and reused, but "clean" crushed concrete waste is barely reusable, and when recycled usually results in a downgraded product Recycled Concrete Aggregates (RCA). However, when C&D waste is properly separated, crushed, screened, and treated, the produced RCA can be used to fully replace natural aggregate to produce concrete blocks.

There are few technical barriers for recycling of the main constituents of CDW, concrete and ceramic wastes, but there are barriers related to their commercialisation, the market of virgin materials and their logistics. However, virgin natural aggregates are inexpensive to the point of being economically competitive with RCA, which limits the market for RCA. In some Member States (for example Spain) natural virgin aggregates are inexpensive, so the total cost of aggregates in the final product are

insignificant. In addition, the environmental benefits of using RCA rather than virgin aggregates in terms of greenhouse gases emissions is highly dependent on their transport and therefor distance from the final construction. [89,90]

Sydhavn recycling centre – recycled concrete

Sydhavn recycling centre, which opened in 2019, is a project that has moved the boundaries for sustainable recycle concrete. The new recycling centre is built with recycled concrete, where 40 % of the concrete consists of RCA. This is five times than the previous standard for recycled concrete. It is also the first time in Denmark that recycled concrete has been used for outdoor surfaces. The project was led by The Municipality of Copenhagen and the concept was developed by Bjarke Ingels Group and designed and planned by COWI and Krilov[91]. The RCA came from a demolished chimney from an incineration plant in Copenhagen. The project shows great potential both environmentally and economically for the expansion of recycled concrete at a larger scale[92].

Analysis of hardened concrete properties made with recycled concrete aggregates[93]

The use of RCA as a replacement in new concrete has gained popularity worldwide as a method of reducing natural aggregate consumption. However, many engineers, owners, and agencies are reticent to use RCA due to a lack of understanding on how the material will impact the physical and mechanical properties of the final concrete. An analysis of a database of mechanical properties of concrete containing coarse RCA generated from 115 peer-reviewed journal articles, show that, on average, the compressive strengths of concrete systems with 20% or less RCA replacement were 2% lower than that of the natural aggregate systems. Increased levels of RCA decreased the average concrete compressive strengths; at the extreme end, replacing 100% of aggregates results in a reduction in compressive strength of 10%. Results indicate that, in general, adequate concrete strengths for a variety of applications can be achieved at all replacement ratios of coarse RCA.

Advanced Dry Recovery (ADR) and Heating Air classification system (HAS)[94]

ADR and HAS been industrial-scale technologies that recycle End-of-Life (EoL) concrete into coarse, fine, and ultrafine particles. While ADR is used to sort out clean coarse aggregates, HAS is used to produce clean fine aggregates by heating and separating the ultrafine hydrated cement components. Concrete made of recycled coarse and fine aggregates displays comparable mechanical properties as the reference concrete using virgin aggregates. Both technologies are designed to be mobile so that EoL concrete wastes can be processed at the demolition site or close to ready-mix concrete plants, reducing the heavy traffic related to construction activities.

Use of new concrete products made from recovered demolition waste for an industrial building in the Port of Antwerp, Belgium [95]

CDW from the selective demolition of an office building was used for the construction of a new waste collection centre. Recovery focused on the mineral fraction of CDW. This selectively collected

[89] Zhao et al. (2020): Use of recycled concrete aggregates from precast block for the production of new building blocks: An industrial scale study.
[90] Gálvez-Martos et al. (2018): Construction and Demolition Waste Best Management Practices in Europe.
[91] Dansk Beton (n.d.a): Bæredygtig Beton Prisen 2019.
[92] Strabag (n.d.): Recycling concrete during the construction of Sydhavn Recycling Centre.
[93] Jayasuriya et al. (2021): Development and statistical database analysis of hardened concrete properties made with recycled concrete aggregates.
[94] Gebremariam et al. (2020): Innovative technologies for recycling End-of-Life concrete waste in the built environment.
[95] Bergmans et al. (2015). Recycling of construction and demolition waste: case study in the Port of Antwerp.

mineral fraction was crushed to produce mixed recycled aggregates (MRA). Currently, MRA are used almost exclusively in low-grade unbound applications like (sub)foundations. However, this market is getting increasingly saturated. The development of high-grade applications is needed to assure a market for the stony fraction of CDW. The use in these high-grade applications requires recycled aggregates with a higher purity to guarantee optimal technical and environmental performance.

To obtain this higher purity, the MRA was treated by advanced automated sorting technologies. Near Infrared (NIR) sorting was used to reduce the content of problematic fractions (e.g., organics, gypsum). These materials can lead to expansive compounds, delays in hardening and a lack of bonding strength in cement-based materials. The NIR sorting significantly improved the technical and environmental quality of the MRA. Subsequently, the purified MRA was colour (UV-VIS) sorted. This sorting technique allows the separation of a grey (concrete) fraction and a red (ceramic) fraction. The concrete fraction was then reprocessed into new concrete products that were used to produce foundation concrete and polished concrete floors, both inside and outside the building. The latter application can be considered as very high level, demonstrating the technical possibilities of pure recycled concrete aggregates.

During the case study, a high-grade recycling option for autoclaved aerated concrete (AAC) was also demonstrated. The major challenge for AAC recycling is sulphate leaching, causing both environmental and technical problems. A strong reduction in sulphate leaching from AAC recycling products was obtained via immobilisation. Recycled AAC was used in the case study as a sand replacement in an insulating flooring screed.

The Njals Tower scandal

Problems discovered during the construction Njals Tower, a new tower block in Copenhagen, has led to concerns about the use of recycled concrete in buildings[96]. The project began in 2017 and was led by construction contractor Bach Gruppen A/S. In February 2020, the Municipal of Copenhagen received information from a whistle-blower about fraud and major problems with the quality of concrete used in the project. Examination conducted by Danish Technological Institute and later by COWI, an engineering consultancy, showed that compressive strength of the concrete foundation under the 86-meter-tall tower was too low for the purpose. The concrete contained recycled concrete and other materials. The problems were so serious the that municipal of Copenhagen in September stopped the construction[97],[98].

The industry association for the concrete sector, Dansk Beton, indicates that the scandal has created concern within the construction industry about the use of recycled concrete. However, Dansk Beton stresses that the issues that have plagued the construction of Njals tower should not lead to concerns about recycled concrete, rather, this is a case where standards and rules has not been followed. In addition, the primary parameter for the compressive strength of a concrete is the ratio of water to cement – and therefor the low strength of the concrete indicates poor concrete composition, and that use of recovered materials is unlikely to be the primary cause of the low strength[99].

[96] Dansk Beton (n.d.b): Njals Tårn har skabt nervøsitet om genavnelse af beton.
[97] Chor et al. (2020): Højhuset, der gemte på em grim historie: "Det skulle aldrig være sket" – Højhus bygget på tvivlsom beton – svindelsag og lyssky forretninger spøger.
[98] Andersen (2020): Cowi: Stoppet højhusbyggeri bør tjekkes til tops.
[99] Dansk Beton (n.d.b): Njals Tårn har skabt nervøsitet om genanvendelse af beton.

Upcycling into new insulation

With over 30% of Denmark's waste coming from construction, up- cycling of used building materials has become an area of increased focus. As a result, traditional disposal methods that send waste insulation to landfill sites and crushed porcelain and sanitaryware to make road fill are being replaced by a new, greener alternative jointly developed by three Danish companies. Construction waste from Danish recycling centres is delivered to RGS90, a company specialising in the processing, sorting, removing, and recycling of waste products. All unwanted materials are removed and then recyclable ROCKWOOL insulation and ROCKFON acoustic panels are separated from the unrecyclable insulation before being granulated. Porcelain and sanitary- ware are crushed before being sent to the ROCKWOOL production facility, where they are used to manufacture new recyclable insulation[100].

6.3.1. SUMMING UP ON BEST PRACTICES IN THE EU

The review of best practices shows a multitude of individual innovative circular C&D waste solutions implemented across the EU. The analysis shows that a series of institutional factors are key to creating a conducive framework for innovative circular transformation, including[101]:

- A strong national vision having CE solutions or a CE model as a goal
- National support structures and systems for innovative CE solutions
- Proximity of physical flows and assets
- Maturation and diversity of market and networks
- Inherited values and established culture and patterns of cooperation.

There is no o*ne size fits all*: solutions need to be developed in a national or local context, based on the conditions created by the institutional and market frameworks. Industrial transformation processes necessitate an understanding of how institutions shape common visions of a desirable pathway, form consumption patterns and production modes, and define investment and policy decisions. Due to the variety of materials used in construction sector, there is not one single approach to increase recycling and reuse in the sector. The examples highlight sustainable initiatives covering the most relevant initiatives, such as:

· Take-back schemes, recycling CDW.

· Alternatives to virgin materials, by making good quality and cheap SRM accessible.

· Mapping of the reuse and recycling of CDW.

· Innovative technologies for sorting and cleaning CDW.

· Promoting and facilitating cheaper CDW collection.

· Networks & platforms for tracking and treading for recycling and reuse of CDW.

· Increasing traceability and transparency by implement product passports for SRM.

· Facilitation of better connections between actor across the C&D value chain.

· Knowledge sharing & facilitation of registration, organisation, storage and exchange of data.

· Promotion of consumer awareness in regard to the circular and economic value of SRM.

[100] State of Green (2018): Circular Economy – Denmark as a circular economy solution hub.
[101] Inspired by the organisational model presented in section … and Henrysson & Nuur (2021): The Role of Institutions in Creating Circular Economy Pathways for Regional Development.

The examples illustrate how the CE approaches are being implemented within the C&D sector across Europe. The initiatives minimise the environmental impact of construction, through reductions in landfill, use of virgin raw materials and transport of construction materials. Furthermore, the initiative results in better access to trustworthy and clear information for consumers, making environmentally responsible behaviour more likely.

The existence of well-functioning circular solutions across the EU can inspire Portuguese companies and institutions to pursue circular transition. However, only the interplay between institutions, companies, researchers, and market forces will reveal which practical solutions will be sustainable in a Portuguese context.

6.4. DRAFT STRATEGY OBJECTIVES AND OUTPUTS

The following section proposes a new vision for the improved utilisation of SRM in the Portuguese C&D sector, and the means to achieve that vision. It contains three strategy objectives and a number of associated strategy outputs and activities. This approach to strategy development is associated with the methodology of LFA; the logical framework approach, developed in 1969 and widely adopted and promoted by the European Commission and UNDP.

Objective and long-term goal

The overall objective and long-term goal are strongly related to the long-term goals in existing targets, visions and strategies described in the previous sections, including the Circular Economy Action Plan.

> By 2030, based on reliable data, Portugal produces less CDW, while CDW is recognised and valued as secondary raw materials

Strategy objectives

The strategy objectives are the concrete desired conditions that the strategy seeks to achieve though its implementation – all relating to the overall goal. Within each strategy objective, measurable strategy outputs and associated activities are defined.

1. By 2030, there is a well-functioning regulatory cycle in the C&D sector
2. By 2030, companies conduct waste management and registration according to regulation

These will be elaborated in the following sections.

6.4.1. STRATEGY OBJECTIVE 1: BY 2030, THERE IS A WELL-FUNCTIONING REGULATORY CYCLE IN THE C&D SECTOR

The regulatory cycle is the stepwise process of developing, implementing, and evaluating legislation. The adaptation of a new strategy or policy can be expected to be successful only when each of these elements is included and fully developed. All elemets play a critical role in the eventual success of the policy.

The implementation of a policy often takes place as compliance checking and monitoring, but this is only effective if inspection systems are in place and if non-compliance can be adequately addressed.

In some cases, compliance promotion is more effective. This entails make compliance more attactrive than violation and subsequent legal action. This saves time and effort for the authorities and the potential violator and, once compliance is assured a first time, the violation rarely reoccurs. Feedback mechanisms should enable information derived from enforcement response, compliance promotion efforts and compliance checking to be assessed and brought to the other segments of the regulatory cycle for consideration and improvements[102].

The regulatory cycle in the Portuguese inspection schemes is not fully functional. Although the decree law sets targets on both minimisation of waste and the use of recycled materials the implementation of new policies, it is not always sufficiently enforced. Stakeholders experience that while the previous decree law demanding 5 % recycling in public constructions was easy met by industry, registration was too resource demanding for small companies. Furthermore, insufficient feedback is collected to allow for the adjustment of the legal framework, and as such it is difficult to adjust the framework to make these policies enforceable.

As the new amended legislation regarding SRW and CDW has recently been introduced in Portugal, Strategy Objective 1 does not focus on developing new legislation, but on the implementation and enforcement of the existing legislation and ensuring that evaluation mechanisms are in place to provide feedback to support the improvements of these policies. The background section in this paper describes the barriers on the regulatory cycle and possibilities for improvement.

Five necessary outputs have been identified as having a potential to improve the regulatory cycle in the C&D sector in Portugal:

Strategy output 1.1 - National working groups on CDW are streamlined and expanded.

This includes working groups within associations. Several regional working groups already exist and have developed strategies and action plans for the use of secondary resources in C&D. However, contrary to many other European countries and as described in the background section in this paper, there is no culture for sharing and disseminating the work resulting from these working groups.

This means that potentially valuable feedback on the implementation of new regulation does not reach the authorities, which limits their ability to make the necessary adjustments to enable better implementation.

There is an opportunity to establish better feedback mechanisms that allow industry professionals to have bigger influence on the regulatory cycle. A number of policy actions could be used to enable this:

Activities to achieve the strategy output:

- Map existing working groups on CDW: for instance, within waste operators, waste managers, coordination and regional development commissions, builders, contractors, professional associations (of engineers, architects etc.), and even other industries such as prefabrication, cement and ceramic, and design offices.
- Define a common approach and arrange common meetings for all relevant and interested working groups (network management). Agree on value creation in relation to specific objectives.
- Establish and fund systems for exchange of knowledge and perspectives.

[102] IMPEL (n.d.): Doing the right things.

Strategy output 1.2 - Regulation pursuing increased CDW recycling adopted

The vast majority of CDW is inert and with good planning the valuable SRM can be directed back into the construction material loop instead of becoming waste in landfill or backfilling. In some Member States, requirements for selective demolition and sorting have been put in place. This has created the foundation for maintaining the value of SRM which in turn influences the quantities going to backfilling.

Several policy requirements may create a better foundation for successful selective demolition, including requirements for pre-demolition waste audits that identify hazardous waste and valuable resources, selective demolition, and waste management plans. Waste management plans are described in the 2016 EU Construction and Demolition Waste Management Protocol as detailed plans containing information about how the different steps of the demolition/renovation/construction will be performed, by whom they will be performed, which materials will be collected seperatly at source, where and how they will be transported, what will be recycled, re-used or disposed of, and how to follow up.

Today waste management plans and pre-demolition audits are not mandatory by law in Portugal, although they are recommended in the new decree law.

Activities to achieve the strategy output:

- Investigate viable options for new law requirements and/or assisting voluntary agreements for the adaptation of waste management plans in each construction strategy and pre-demolition waste audits. To be undertaken together with working groups, associations, and ongoing projects (Like the recently initiated CLOSER project).
- Investigate options for law requirements on selective demolition as defined in the EU Construction and Demolition Waste Management Protocol. This should be integrated into existing requirements for the sorting of waste fractions such as wood, mineral fraction (including concrete, bricks, tiles, tiles, ceramic materials, and stone), metal, glass, plastic, and plaster. Consider initially introducing requirements on a voluntary basis.
- Establish criteria and requirements for decontamination prior to demolition.
- Provide a clear vision for and future expectations of regulation, so that companies can make the best long-term decisions. For instance, a plan with gradual implementation of requirements and criteria allows companies to make cost-benefit assessments that consider also the future regulative context.
- Investigate additional instruments with potential positive impact on the recycling rate, for example Extended Producer Responsibility which could potentially be used for specific building materials as mentioned in the revised WFD[103],[104].

The only EPR scheme for CDW with take-back targets identified is imposed in Flanders. Producers of several smaller material streams have initiated pilot projects, set up logistic schemes or invested in infrastructure to collect post-consumer materials as input for new materials: gypsum, autoclaved aerated concrete, bituminous roofing, PVC, and mineral wool. Selective collection of the concerned

[103] EP (2018a): Directive (EU) 2018/851 of the European Parliament and the Council of 30 May 2018 amending Directive 2008/98/EC on waste.
[104] Guggemos & Horvath (2003): Strategies of Extended Producer Responsibility for Buildings.

Strategy output 1.3 – Regulation better understood by the businesses

Different stakeholders have emphasised that some waste operators struggle with the process of registering waste. Most waste producers and operators in Portugal are SMEs and they tend to lack the resources to integrate new regulation and to keep up with the rules for waste registration and classification. This hinders data collection on the waste amounts that are potentially available for utilisation, and the options of de-classifying material as waste to use it as SRM. Some organisations have addressed this[105] through the development of technical specifications with recommendations and minimum requirements for the use of SRM from C&D, but there is still a need for more guidelines and technical specifications that reflect the market demand.

Activities to achieve the strategy output:

- Investigate barriers for waste registration in C&D industries, e.g., surveys, interviews, and analysis on questions from users of the waste platform for registration and classification.
- Investigate product groups with high recycling content and possibilities for use as SRM together with the sectoral associations and investigate options for mandatory requirements of recycling of certain materials and product groups.
- Develop targeted information, e.g., guidance to industry for CDW specifically suitable for recycling - in light of market demands and possibilities.
- Promote the usage of end-of-waste criteria inspired by, for example, the Nordic End-of-Waste Criteria for Construction & Demolition Waste[106].

Strategy output 1.4 - Improved and increased inspection at demolition sites and C&D companies

Compliance checking can be done in several ways, both systematically and ad hoc. What is important is that it adheres to a strict protocol for preparation, on-site visit, and reporting. A code of conduct needs to be followed by all inspectors and investigators to maintain consistency in reporting. This requires coherence and coordination across vertical levels of governance: the national, regional, and local level. Today there are some issues with coordination and communication between entities working with the regulatory cycle in Portugal, where information is not always efficiently shared between entities. Better communication between distinct levels of governance, but also between governance bodies and industry should be pursued.

Activities to achieve the strategy output:

- Improve multilevel governance by coordinating the local, regional, and national authorities ensuring an integrated approach to inspection policies.
- Support with systems for the exchange of information between entities and departments.
- Involve and motivate municipal authorities to achieve the objectives described in this strategy.
- Define inspection rate targets and priorities and provide necessary technical and financial support to inspectorates to reach inspection rate targets. A risk-based approach should be applied, setting focus on the construction and demolition sites that represent the greatest environmental risk[107].

[105] For instance, see LNEC: http://www.lnec.pt/en/

[106] Hjelmar et al. (2016): End-of-Waste Criteria for Construction & Demolition Waste.

[107] The European Network for the Implementation and Enforcement of Environmental Law, IMPEL, recommends a risk-based approach. https://www.impel.eu/about-impel/strategy/.

Strategy output 1.5 - Improved success rate in enforcement related to CDW

A well-functioning regulatory cycle requires that compliance checks enable inspectors to act promptly and consistently and according to an enforcement strategy when legislation is violated. In Portugal there is potential for improving the legal enforcement measures, since the authorities seldomly successfully prosecute violators, often due to difficulties in acquiring sufficient evidence. In particular, the potential environmental damage – the cause and effect – is difficult to establish and demonstrate for enforcement purposes, hindering effective court decisions in the present legal regime.

Activities to achieve the strategy output:

- Identify and analyse insufficiencies in enforcement (cases) of violations of CDW regulation.
- Prepare enforcement guideline with a strategy for handling of non-compliance situations and procedures for gathering evidence and proceeding with court cases where necessary.
- Enforce requirements of 10 % SRM in new public constructions (green public procurement): This could involve engagement with e.g., Comissão de Coordenação e Desenvolvimento Regional (CCDR).

6.4.2. STRATEGY OBJECTIVE 2: BY 2030, COMPANIES CONDUCT WASTE MANAGEMENT AND REGISTRATION ACCORDING TO REGULATION

Whereas Strategy Objective 1 is mostly concerned with the systems, structure and involvement of stakeholders, Strategy Objective 2 is concerned with the issues associated with the culture within the sector, as well as the development of competencies and dissemination of information. As such, this objective addresses the social aspects of the overall objective through soft regulation such as voluntary instruments, campaigns, knowledge disseminations, and capacity building activities.

Competent, committed, and responsible professionals across the value chain in C&D are necessary to achieve Strategy Objective 2. The utilisation of secondary raw materials is a system innovation that requires professionals to undertake many new practices, use new technology, and engage in new forms of cooperation across the value chain. Professionals keen to use secondary raw materials will also engage with new areas of legislation and it is crucial that they find the necessary support from the legislative systems instead of facing legislation as a barrier. It is important to make sure that the industry has the competencies to comply with new legislation and requirements, and that essential information is disseminated and communicated effectively.

In this context, culture is defined as the physical arrangements, ways of communication, traditions, implemented values, assumptions, and paradigms that are common for a given group; it helps the social body stick together: The culture in a sector can be guided in a desirable direction by deliberate development of, among other, values and managerial style.

Strategy output 2.1 - Companies are offered support for registration and classification of CDW

There is already legislation in place in Portugal regarding registration and classification of CDW, but statistics show a discrepancy between registered waste and the estimated amounts of CDW. One reason is that current definitions are considered confusing by many stakeholders, hindering the correct and effective registration of waste.

Today, the primary contact surface between private companies and public authorities is the environmental inspectors' compliance-check visits, during which a company may not reveal a lack of capacity for CDW registration because of concerns for punitive consequences. Therefore, some

SMV's express uncertainty avoidance rather than eagerness to consult with the authorities if they struggle with aspects of registration or waste management. In other Member States, this issue has partly been addressed through the introduction of catalyst inspections, where inspectors focus on opportunities for improving the situation rather than (but not instead of) focus on non-compliance incidents. This approach emphasises compliance promotion in cases of non-compliance and requires a mentality shift both from inspectors and industries, as it is founded on more trust between public authorities and the private sector.

Activities to achieve the strategy output:

- Prepare regime for catalyst inspections[108], conduct capacity building of inspectors and inspectorates (IMPIC) (in cooperation with FEFAL, CCDR and IGAMAOT).
- Prepare easily understandable information and guidance on waste registration and classification and disseminate to the target groups.
- Investigate options for using the sustainability indicators from the new European Framework for sustainable buildings - *Level(s)* - in the sector. This could be through promotion and information campaigns. Level(s) presents good practices to construction companies and introduces a whole life perspective on buildings, which may lead to constructors being more aware of the end-of-life stages of their buildings, as well as the embodied environmental impact of their applied building materials.
- Support the establishment of a Green Building Council in Portugal (in cooperation with World Green Building Council) to enable increased use and promotion of certification schemes and capacity building activities.

The new decree law simplifies the procedure for de-classifying waste to become SRM. There is a need for communicating the changes and the associated processes to support the companies in a more circular approach. This includes dissemination of guidelines and best practice cases, training courses and strengthened dialogue with networks of waste operators. It is suggested to:

- Communicate rules for segregated demolition and declassification of waste and disseminate guidelines and best practice cases, inspired by Member State experience (included under output 1.3) and
- Run training courses to waste operators.

Strategy output 2.2 - Improved infrastructure for collection and storage of SRM from C&D

The Portuguese systems for registering, collecting, and storing SRM from CDW can be improved to cascade utilisations within the sector. More valid and robust data on the quantities and availability of SRM from C&D can facilitate new investments in waste management and recycling solutions from the private sector. In many Member States, high waste fees on unsorted industrial CDW reward correct collection and treatment of recyclable waste fractions – assuming that waste is correctly registered in the first place (as otherwise fees cannot be imposed correctly and waste fees risk disincentivising waste registration and increasing illegal dumping practices). Communication of the potential economic benefits from preserving the value of waste materials and from preparing the materials for recycling or reuse can be done through demonstration projects with best available technology and practices.

[108] Catalyst inspection is an inspection approach aiming at supporting businesses in complying with the regulation (as opposed to non-compliance inspection focusing on detection of non-compliance incidents).

Activities to achieve the strategy output:

- Investigate barriers for correct data management on recyclable CDW.
- Establish system for compiling data on recyclable CDW.
- Support pilot projects demonstrating cost effective solutions for segregated waste collection and recycling to change the mindset of operators and
- Communicate potential benefits of increased recycling to the industry.

6.4.3. STRATEGY OBJECTIVE 3: THE QUALITY AND COST OF SRM CAN COMPETE WITH VIRGIN MATERIALS

Strategy objective 3 is mainly focused on the fiscal incentive structures within C&D that influence the quality and cost of SRM. This relates to the issue surrounding the lack of functioning markets for CDW. Virgin materials are often cheaper than SRM because negative environmental externalities (the extraction of virgin materials and carbon emissions etc. associated with material production etc.) are seldomly captured and priced by the market – especially with the lack of a well-functioning regulatory cycle. Furthermore, in developed countries like Portugal, manual labour is often more expensive than raw materials, causing high prices for preparation for reuse and refurbishment. The main idea behind the implementation of circular economic strategies worldwide is thus to promote life cycle thinking and the markets for SRM.

Today, several concepts (new and old) promise to improve the basis for circularity in construction, including design for deconstruction, life cycle thinking, total cost assessment. These concepts are supported by new technology and methods such as BIM. The concepts and technologies have the potential to improve the quality of SRM but are often not commonly used.

Strategy output 3.1 - CDW is carefully managed on construction, renovation, and demolition sites

The first strategy output seeks to improve the quality of SRM from C&D, including introducing and promoting best practices, with reference to the 2016 EU Construction and Demolition Waste Management Protocol. The qualitative value of recycled construction materials is based on their environmental features and on their technical performance. Appropriate quality management procedures and protocols allow suppliers to control and secure their processes and the quality of products. Quality management is vital throughout every stage of the process, but good quality management is particularly important when the recycled construction materials are used in 1) high-end applications and 2) in large volumes (high recycled content)[109].

Activities to achieve the strategy output:

- Promote the usage of practises that improve the quality of SRM from C&D through information campaigns and
- Promote waste audits before demolition and renovation works of buildings according to recommendations from the EU Construction and Demolition Waste Protocol[110]).

[109] EC (2018f): Construction and Demolition Waste Protocol and Guidelines.

[110] The project CLOSER, initiated in 2020 and with APA as active partner, aims to increase the reuse and recycling of materials from demolition or rehabilitation of buildings, including establishing a system of pre-audit which is not at present applied in Portugal. The project is expected to lead to a Portuguese guide for pre-demolition or rehabilitation of buildings audits. https://www.eeagrants.gov.pt/media/3444/closer_en-27out2020.pdf

Strategy output 3.2 - Public procurement favours SRM products and recycling

Public procurement of buildings account for a significant share of the overall market: within the non-residential building segment, public investments represented 38% of the total production in 2019[111]. As such, there are major environmental benefits to be achieved with the introduction of stronger criteria for green public procurement.

As described in the background section, Portugal legislation already requires the use of a minimum of 10% SRM in public buildings. However, there are indications that these requirements have not yet been fully implemented. Therefore, activities targeting managerial stakeholders within public institutions need to be introduced to promote compliance with the requirements.

Activities to achieve the strategy output:

- Strengthen the leadership within public institutions with clear visions for GPP[112];
- Support of the GPP strategy by action plans and dedicated pursue of the 2020 GPP targets[113];
- Establish GPP criteria for demolition that support reuse and recycling.
- Promote and support a culture for procuring green constructions.

Strategy output 3.3 - Technological solutions for reuse and recycling are implemented

The recovery of SRM from C&D requires technical processing of the waste material. Such processing requires waste operators to engage in the adaptation and sometimes development of new technological solutions to minimise manual labour and optimise the quality of the SRM. In some cases, authorities in other Member States have successfully supported such R&D activities, resulting in new business opportunities. There are many promising opportunities in Portugal for similar policy support for innovation:

Activities to achieve the strategy output:

- Facilitate and support initiatives for 'cascading demonstration projects' in Portugal.
- Disseminate information of best practice and BAT.
- Encourage research and demonstration projects by promoting symbiosis actions between actors: for example, private companies, organisations, governmental and municipal actors and knowledge and science institutions.
- Establish national support programmes for innovative solutions within reuse and recycling of SRM.
- Establish support funds for the application of Environmental Product Declarations (EPDs) for recycled materials and the support of technological niches.

[111] FIEC (2021): Portugal.

[112] A renewed GPP strategy is expected in 2022 and the LNEG is conducting GPP training all over the country. https://ec.europa.eu/environment/gpp/pdf/news_alert/Issue_105_Interview.pdf. Increased national leadership, as expressed in the 2021 UN Guideline on Sustainable Public Procurement, can be expressed through clear policies and binding targets, better budgets, supportive structures with a national GPP support unit, or improved systems not favouring the cheapest product but the best value for money etc.

[113] The Portuguese GPP strategy already contains ambitious targets for GPP (https://encpe.apambiente.pt/content/objetivos-e-metas?language=pt-pt) and a guideline for green procurement of office buildings (following the EU GPP guideline), recommending recovery of materials for reuse and recycling, but not providing any detailed requirements on this. https://encpe.apambiente.pt/sites/default/files/documentos/Criterios%20Final%20GT1_ENCPE_AMS.pdf In addition to the previous foot-note, support could be provided from national level in the shape of action plans with allocated budgets, broad capacity building, dissemination of good case stories in public media etc.

- Provide public support for private companies for the application of EU programmes.

Strategy output 3.4 - Platform for SRM transition introduced

The business-to-business market within SRM from C&D is decentralised and project based, meaning that there is no continuous flow of materials with security of supply. Instead, SRM arise as diverse resource flows from multiple sources. The establishment of a market platform, digital or non-digital, centralised, or non-centralised, would provide a both sellers and buyers of secondary resources with a common marketplace. Similar platforms exist in several Member States, and in some instances are funded and maintained by the national EPA.

Activities to achieve the strategy output:

- Establish a platform for the dissemination of information regarding SRM and
- Establish or incite a platform for the registration and trading of SRM for the construction sector and other sectors as found relevant, with technical solutions for companies.

6.5. MONITORING FRAMEWORK

A strategic plan is only as effective as its implementation, and successful implementation requires proactive strategic monitoring. While the potential benefits of strategic planning are vast, many strategic plans fail to achieve desired outcomes in the implementation phase.

The following draft monitoring framework illustrates how APA can monitor the implementation of the CDW strategy.

Overall objective: By 2030, Portugal produces less CDW, while CDW is recognised and valued as a secondary raw material	- CDW amounts reduced xx %as compared to 2020 - Use of C&D waste and materials as secondary raw materials increased (… %?) - A market for C&D waste and materials as secondary raw materials is functioning	- National waste inventories - Survey covering selected representatives from the C&D sector - Data from the waste transition platform

Strategy element	Indicators	Means of verification
Objective 1: By 2030, there is a well-functioning regulatory cycle in the C&D sector, promoting recycling and use of SRM	- Companies are increasingly motivated to recycle and use SRM through the regulatory cycle	- Survey among companies - Survey among inspection units
Output 1.1: National working groups on CDW are streamlined and expanded	- Working groups covering the value chain exists and are supported by GoP	- Survey on CDW working groups
Output 1.2: Regulation pursuing increased CDW recycling adopted	- Regulation to pursue selective demolition, sorting and recycling – and reduce backfilling - has been adopted	- The existence of the adopted regulation
Output 1.3: Waste registration and classification simplified	- Stakeholders find new regulation understandable and effective	- Bi-annual survey of stakeholder opinions

Strategy element	Indicators	Means of verification
Output 1.4: Improved and increased waste inspection at demolition sites and C&D companies	- Risk-based model for coordinated waste inspection of building sites implemented - Frequency of waste inspections of building sites increased	- Inspection guidelines - Inspectorate reports
Output 1.5: Improved success rate in enforcement related to CDW	- Guidelines for effective inspection, data gathering, and enforcement disseminated to all relevant authorities	- National inventory of enforcement actions in the C&D
Objective 2: By 2030, companies conduct waste management and registration according to regulation	- Percentage of breaches of CDW regulation are minimised - Portuguese CDW figures are coordinated with EU average figures	- National inventory of enforcement actions in the C&D sector and the related outcome - National waste statistics
Output 2.1: Companies are offered support for registration and classification	- Systems established for catalyst inspection and support to companies - Information disseminated on de-classification - Companies express that support is being offered	- New inspection guidelines - Account of information disseminated - Company survey
Output 2.2: Improved infrastructure for collection and storage of SRM from C&D	- Sufficient collection and storing infrastructure	- Company survey
Objective 3: The quality and cost of SRM can compete with virgin materials	- Increased use of SRM	- Company survey - SRM platform data
Output 3.1: CDW is carefully managed on construction, renovation, and demolition sites	- Increasing amounts of secondary raw materials made available for industry	- SRM platform data
Output 3.2: Increased public procurement of segregated demolition and constructions with SRM products	- Number of C&D public procurements with green requirements	- Information provided by central and decentral procurement entities
Output 3.3: Technological solutions for reuse and recycling are innovated	- Number of C&D companies having received financial innovative support	- Data from national support programs
Output 3.4: Platform for SRM transition has been introduced	- Portuguese SRM platform established and supported covering all relevant waste materials (not only CDW)	- Number of users of the platform and amount / value of materials traded

7. TEXTILE WASTE FROM THE TEXTILE INDUSTRY - STRATEGY DRAFT

Textile waste from the textile industry can be used in manufacturing of new textiles together with virgin raw materials[114]. Textile waste is most used in downcycling applications such as non-woven products for automotive industry or thermal insulation, protective floor coverings, filtration, furniture, and packaging. Recycling of textiles may involve the mixture of textiles for isolation of buildings or car seats, using whole textile cut-off pieces for new purposes or fibre-to-fibre recycling[115].

The composition of industrial textile waste is typically well-known and uniform, which means that industrial textile waste has several advantages over post-consumer waste in a recycling perspective.

Recycling processes for major fibres/textiles[116]

Material	Mechanical recycling	Chemical recycling
Polyester	Sorting by type and colour, washing, and chopping. Extrusion into yarn	Depolymerisation, repolymerisation and extrusion into chips
Nylon /polyamide	Cleaning and palletisation (for homogenous flows only)	Depolymerisation and repolymerisation to make new yarn
Cotton	Separation by colour, shredding and re-spinning	Promising innovative development
Wool	Separation by colour, pulling the garment back into a fibrous state	Not available
Polycotton	Small scale processes for producing insulation materials and other lower grade applications	Requires pre-separation into cotton and polyester. Still in pilot phase

The wide range of natural and manufactured fibres, recycled fibres, several types of threads and varied treatment possibilities, together with the variety of textile manufacturing processes inclding weaving, knitting, felting, and tufting, give rise to an almost unlimited range of textile fabrics.

The textile and apparel industry are one of the world's most polluting industries[117]. The process of turning raw materials into finished garments has significant negative environmental and social implications, including air and water pollution and exploitation of human resources, especially where production is outsourced to lower labour cost countries[118]. Material recycling of industrial textile waste back into new textile products is environmentally advantageous compared to incineration or landfill but is currently limited[119].

[114] Fibre-to-fibre recycling of textiles is still fairly niche and can happen as either as mechanical or chemical recycling – each with their limitations and possibilities. EC (n.d.a): Raw Materials.
[115] Wrap (2019): Fibre to Fibre Recycling: An economic and financial sustainability assessment – Identification of and recommendations to overcome barriers to the Development of post-consumer closed loop clothing recycling in the UK.
[116] EEA (2019a): Textiles and environment in a circular economy.
[117] Boström & Micheletti (2016): Introducing the Sustainability Challenge of Textiles and Clothing.
[118] Shen et al. (2017): Sustainability Issues in Textile and Apparel Supply Chains.
[119] Watson et al. (2017): Stimulating Textile-to-Textile Recycling, Nordic Council of Ministers.

In 2018, the textile and clothing industry in the EU-28 represented a turnover of €178 billion and investments of €5 billion, and the 171 000 companies in the sector employed over 1.7 million workers in the EU. The competitiveness within the sector is often linked to innovation and technology development, but sustainability and environmentally friendly production are becoming important competitive factors[120], [121]. Textile production still uses vast amounts of raw materials, water, energy, and chemicals and generate air, water and soil pollution through untreated effluent and waste, with a big impact on the environment. Recycling and reuse of industrial textile waste is crucial for achieving a more sustainable sector.

Textile waste has significant recycling potential, particularly in a cascade system where smaller companies recover waste from larger manufacturing companies. Post-consumer textile waste, while outside the scope of this study, can also enable this SRM market.

7.1. TEXTILE WASTE FROM THE PORTUGUESE TEXTILE SECTOR

According to Eurostat, the generation of textile waste from the Portuguese textile industry in Portugal increased from 40 940 tonnes in 2012 to 68 149 tonnes in 2018, which is a little over 10% of the total textile waste generation from the European textile industry, and around 400% higher per capita than the EU27average[122]. On top of this, according to stakeholders, not all textile waste is registered as waste since some high-quality waste/excess materials from the textile production are sold directly to other sectors.

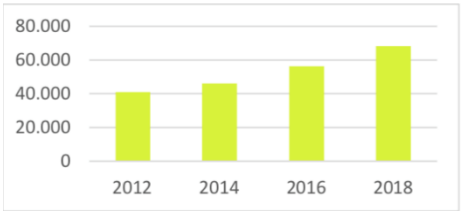


Figure 23 - Textile waste production in Portugal (tonnes)Eurostat [ENV_WASGEN]

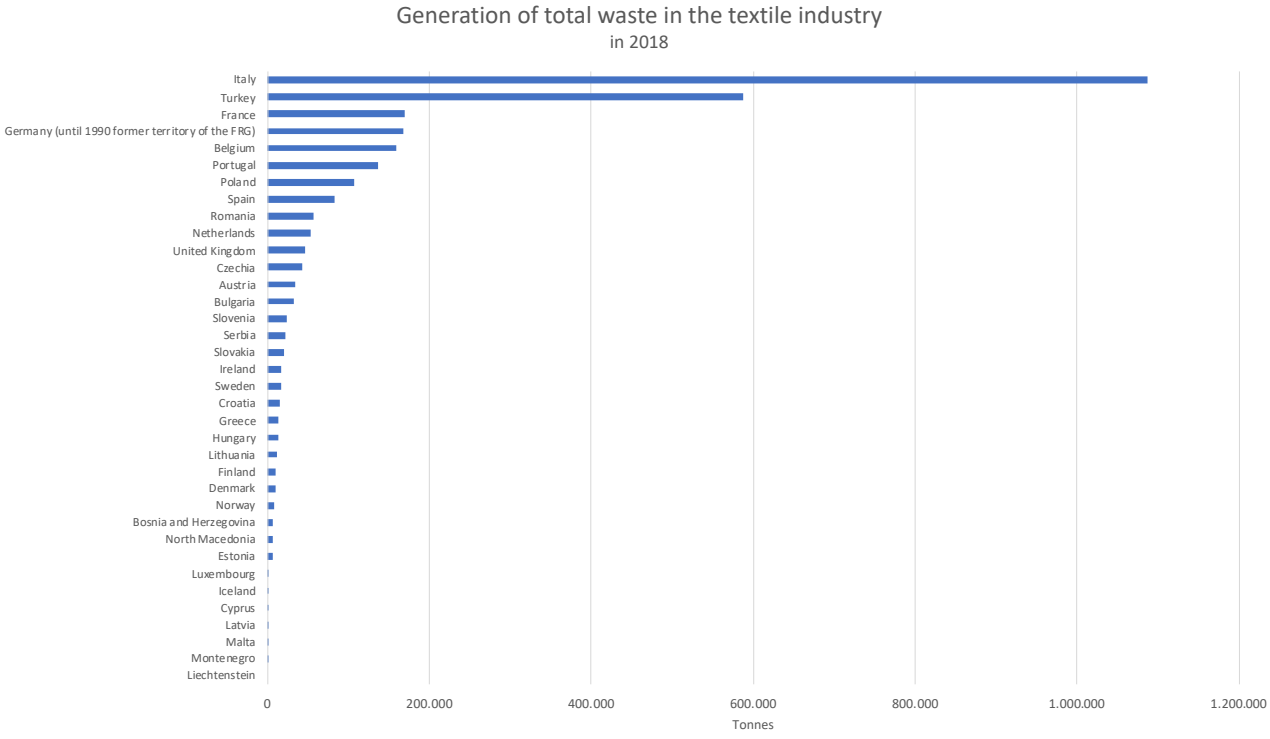


Figure 24 - Generation of total waste in tonnes in the textile industry (2018). Source: Eurostat [env_wasgen]

[120] EURATEX (2018): Annual Report – Activities of the year.
[121] Shen et al. (2012): The impact of ethical fashion on consumer purchase behaviour.
[122] Eurostat (2021d): Generation of waste-by-waste category, hazardousness and NACE Rev. 2 activity.

The available data cannot be disaggregated into types of product or fibre categories.

Of the industrial textile waste generated in Portugal, 40% is recycled (excluding intermediate operations that are not considered recycling) according to Eurostat data[123] (up from 36% in 2016) and, according to interviews, some of the main textile recyclers import textile waste for fibre production. There is no clear consensus from the sector stakeholders whether these figures are dependable. Some stakeholders indicate that the main types of SRM used are leftovers from cut fabrics, and that most of the waste from production is used today. Almost all cotton waste is recycled, PP (Polypropylene) garments also easily recycled, but multifibre and polyester are technically more difficult to work with and more likely to be downcycled. However, many companies are still looking for ways of using the generated textile waste and some companies will use low-value recycling processes. Textile waste is often fed into other sub-sectors, which may not use the materials properly. For example, cutting waste used in car workshops to clean oils, after which there is no way to recover or reuse the material which ends in landfill or incineration. In the past, textile waste was often used in the automotive sector or for production of stools and thick yarn, however, this use is decreasing.

Around 50% of the potential SRM is currently used in high-value recycling processes. One of the main barriers is that it can be very time consuming to pre -elect and sort material for recycling.

The focus in the strategy will be to determine the amount of downcycling in recovery operations and the opportunities to maintain or add value in the process. More robust information on the composition of the waste materials is essential for increasing the efficient recycling of the textile waste.

7.2. PRESENT INSTITUTIONAL SETUP

7.2.1. EXISTING VISIONS AND GOALS

The Portuguese Circular Economy Action Plan[124] identifies textiles as a key sector., where material efficiency in the value chain should be increased through design, product manufacturing and services, although no specific goals related to the textile sector are set. Proposals for activities include yarn recycling, designing for remanufacturing, digitisation, and zero waste production.

7.2.2. STRUCTURE AND EMPLOYEES

As of 2018, the textiles sector in Portugal (defined by NACE Rev. 2 code C13) consists of 3 542 enterprises, employing 47 738 persons. The textile sector in Portugal is the fifth largest in EU28 (including UK) in terms of people employed and number seven in terms of number of enterprises[125].

7.2.3. EXISTING STRATEGIES

123 Eurostat (2021d): Generation of waste-by-waste category, hazardousness and NACE Rev. 2 activity, September 2021. Available at: https://ec.europa.eu/eurostat/databrowser/view/ENV_WASGEN__custom_680694/default/line?lang=en

124 República Portuguesa (2017): Leading the transition – Actionplan for circular economy in Portugal: 2017-2020.

125 Eurostat (2021d): Annual detailed enterprise statistics for indutry (NACE Rev. 2, B-E).

European Strategies

The European Green Deal the Circular Economy Action Plan[126] and the Industrial Strategy[127] all identify textiles as a priority sector in the EU development towards circularity and carbon neutrality[128],
The EU strategy for textiles[129], to be adopted in 2022, considers the use of targets to increase recycling efforts. This initiative is expected to boost markets for sustainable and circular textiles through the facilitation and encouragement of sustainable investment in production processes, design, new materials, new business models, infrastructure, and capacity. It considers and prepares for the implementation of the Sustainable Products Initiative[130] by underlining possible approaches for improving design for sustainability, among other things by focusing on the uptake of secondary raw materials and tackling the presence of hazardous chemicals.

Portuguese strategies

An inter-ministerial group has conducted an analysis of the Portuguese economic context to identify key sectors that are material intensive, export-oriented and have a significant consumer impact – for speeding up the circular economy[131]. The textile sector is suggested to be one of the important ones.

The new Portuguese Bio-Economy Action Plan (presumed to be adopted in 2021[132]) contains specific targets for the textile sector's transition to a sustainable and circular bioeconomy. Of specific (potential) relevance to increased use of SRM are the following goals:

2025

- Increase by 20% the integration and recovery of bio-based waste.

2030

- Replace 40% of fossil fibres used in textile production with biologically based fibres produced in Portugal.
- Increase by 50% the use of artificial fibres and bio-based alternatives in the production of textiles and
- Increase the circularity of post-consumer textiles by 40%.

Many producers and brands in the textile sector have their own strategy for sustainability and sustainable products in their portfolio or they use the benchmarks and criteria that are set in certification systems such as OEKO-tex[133], Global Recycled Standard[134], etc.

Strategic Value

Textile is one of Portugal's key industrial sectors, occupying a prominent place in the economy of the northern and central interior regions. This alone justifies fostering a SRM market for textile waste

[126] EC (2020): Communication from the Commission to the European Parliament, the Council, the European economic and Social Committee and the Commettee of Regions – A new Circular Economy Action Plan – For a cleaner and more competitive Europe.
[127] EC (2020c): Communication from the Commission – A new Industrial Strategy for Europe.
[128] EC (2019b): Communication from the Commission – The European Green Deal.
[129] EC (2021b): Roadmap – EU strategy for textiles.
[130] EC (2020d): Inception Impact Assesment – Sustainable Products Initiative.
[131] República Portuguesa (2017): Leading the transition – Actionplan for circular economy in Portugal: 2017-2020.
[132] Text made available by Ana Vaz, APA, September 2021.
[133] OEKO-TEX (n.d.): More transparency for a more sustainable future.
[134] ControlUnion (n.d.) Cerification Programs – GRS – Global Recycle Standard.

with a European scale, potentially encompassing post-consumer textile waste. The textile and clothing industry is one of Portugal's most important, representing[135]:

- 10% of the Portuguese Total Exports.
- 20% of the manufacturing Industry's Employment.
- 9% of the Manufacturing Industry's Turnover.
- 9% of the Manufacturing Industry's Production.

Portugal has around 5 000 companies working in all sub sectors of textile and clothing industry – mostly SMEs (a higher number than included in NACE code C13 in section 7.2.2). The textile and clothing companies are mainly placed in the north of Portugal, potentially enabling regional initiatives and new supply chains. There are some companies located in East Portugal working with wool products.

EEA Recommendations

The EEA in 2019 provided policy recommendations for circular development of the EU textile sector[136], including recommendations specifically targeting increased utilisation of SRM:

- Phase out chemicals of concern;
- Binding minimum standards and complementary voluntary targets;
- Sustainable sourcing labelling;
- Resource taxes on new fibres;
- Sustainable production & product policies. Tax on resource use and environmental impact;
- R&D support investment support for SMEs;
- Extended producer responsibility;
- Recycling and recycled content targets;
- Quality requirements for recycled fibres;
- Clear end-of-waste criteria and
- Investment funding and support.

7.2.4. CULTURE

A series of interviews with key stakeholders has provided understanding of the key cultural challenges.

Overall, stakeholders experience a socio-technical lock-in, where it is hard to break from status quo regarding both habits, preferences, competencies, contracts etc. There are already functioning low-grade solutions in place for the management of textile waste, and approximately 82% of the textile waste is channelled to valorisation in some production – and landfill/incineration serves as an easy option for the remaining minor quantities. Significant quantities of surplus materials are also donated to companies that may not provide clear information about the final destination of the materials. One business representative explains: "*Often what happens is that waste goes to other sub-sectors, which often do not use the materials properly. For example, cutting waste often goes to workshops to clean the oils, but what happens is that after they are used, there is no way to recover them, and they end up going to incineration. In the past, textile waste was used a lot in the automotive sector, but this is less and less the case, it was also used a lot for stools and thick yarn.*"[137]

[135] ATP (n.d.): Statistics.
[136] EEA (2019b): Textiles in Europe's circular economy.
[137] Interview, José Ferreira, Valérius, 2020

There is a potential for high-grade cascade applications, but several stakeholders express a concern about the quality of the SRM. Companies need information on the exact content of the side streams, (not just composition, but also the presence of chemicals), but companies are also hesitant when it comes to sharing production information, as this may also be misused. Such information is regarded as business-sensitive since it informs about overall production quantities and textile design. The lack of knowledge of the availability and quality of the SRM is a significant barrier to its utilisation.

Furthermore, pressure from consumers to improve environmental performance of the products targets brands and does not necessarily reach the producers. Some companies, however, are becoming more engaged in the use of by-products, because their clients (international brands, mostly from Spain) express concerns for the environmental performance of the products. Overall, this pressure is not successfully translated along the value chain.

The social barriers are combined with several technical barriers and a lack of mature technological solutions. Even though there are possibilities to apply for EU funding, very few companies use this opportunity. There is overall a lack of investment in solutions for the utilisation of SRM.

7.2.5. SYSTEMS

Currently, there are no systems for sharing information of the content of side-streams with waste operators or potential buyers of SRM, even though the producers may hold such information. This includes information such as the chemical content and composition of mixed textiles.

Sector stakeholders highlight through interviews and workshops that most textile SRM and virgin raw materials used in Portugal are imported from abroad. The SRM mainly consists of yarns and are used in, for example, construction and automotive applications.

Some weaving and knitting companies would like to use recycled yarns. The national availability of mechanically recycled yarn is estimated to be insufficient by stakeholders, while the recycled yarns are considered more expensive than virgin raw materials. UN COMTRADE data (import/export) and Eurostat PRODCOM data (production) does not clearly differentiate between virgin raw materials and SRM, and as the traded SRM is not categorised as waste it is not registered in Portuguese waste registers.

7.2.6. SUMMARY ON THE PRESENT INSTITUTIONAL SETUP

Assessing the institutional elements in the Portuguese textile industry illustrates a weak foundation for the utilisation of textile SRM, which may be part of the reason textile SRM are being exported out of the country instead of being used locally. The new bio-economy strategy directly targets the SRM from the textile industry, but it is yet to be translated into concrete action plans and ambitious policy incentives. The cultural maturity for industrial symbioses is somewhat low, partly due to lack of trust between industries: a prerequisite for such constellations. The sector demands more transparency since quantities and content of the textile SRM are not recorded or shared systematically.

7.3. BEST PRACTISE EXAMPLES

Pure Waste

The Finnish company Pure Waste have been working with responsible fashion for more than a decade and uses pre-consumer textile waste to produce new high-quality textile for clothing. Together with

their partner, Pure Waste collects and recycles waste from the textile industry in India and, since 2020, Pure Waste have collected their own products from consumers, collecting a total of 935 kg the first year. Pure Waste collects to types of materials: cotton, primarily from sewing factories or discarded clothes, and polyester made from recycled PET bottles. Although the company mainly works with a single material composition, they have been able to ensure a fibre of high quality that can be turned to various purposes. The fabric and fibre waste made of cotton is sorted by colour and quality. The colour of the product is determent by the colour of the recycled fibres, and therefore it is not necessary to dye the fibres[138]. Thereafter the sorted fabrics and scraps are mechanically processed into fibres and mixed with the chemically recycled polyester. The mixed fibre is re-spun into new yarn. Pure Waste produces several grades of yarns which are used for knitting and weaving. Avoiding dyeing reduces wastewater and use of chemicals: the process uses 99% less water and generate 50% fewer CO_2 emissions compared to virgin materials[139].

Pure Waste also addresses social sustainability in production. First, most of the production takes place in India, a country known for its unsustainable textile production. By keeping the production in India, Pure Waste does not take jobs out of the area, while ensuring a sustainable and circular production method. Secondly Pure Waste ensures fair and equal salaries above minimum wage, serves food on-site and provides transport, accommodation and healthcare to its workers if needed[140].

Reverse Resources

Reverse Resources (RR) is an Estonian company and a software platform enabling a large global network of stakeholders to track and trade textiles waste from garment factories. The RR network and platform currently includes 40 recyclers, seven waste handlers and 945 manufacturers[141].

Today textile recycling can be hindered by incomplete waste data and lack of access to waste streams. Digitally mapping pre-consumer textiles waste from garments factories creates stronger incentives for recycling the textiles waste getter higher value and ensuring greater, more stable, and cost-efficient recycling. The RR platform remove barriers by matching factories, traders and recyclers and providing full transparency of waste flows. The platform ensures that garment factories get higher value for their leftovers, traders get access to greater market volumes and recyclers get control with feedstock and cost savings.[142] RR have already mapped out over 15 000 tonnes of demand for clean textile waste that cannot find enough trustworthy supply. The primary demand is for cotton with 98+% purity. RR reports quarterly to factories on the amount of waste traced to recycling and where it ends, and similar report are provided to brands that received the waste[143].

The platform has been described as an effective and a user-friendly tool that can be used by textile and garment production to develop and implement a shift toward a zero-waste production[144]. RR won the Global Change Award given by H&M in 2016 and has been recognised for their efforts toward circular economy on a global scale[145].

[138] Pure Waste (2020): Sustainability Report.
[139] Pure Waste (n.d.): The Process.
[140] Pure Waste (2020): Sustainability Report.
[141] Reverse Resources (n.d.a): Be part of the most extensive textile waste network.
[142] Reverse Resources (n.d.b): Full circularity in textile industry by 2030.
[143] Reverse Ressources (2020): Platform for tracing & trading of textile waste.
[144] Oyetunde (2021): Reverse Resources: the uber of textile and garment waste.
[145] Reverse Resources (n.d.c): Our partners.

Pactex Project (AEI TÈXTILS)

Since 2015, AEI TÈXTILS, a Catalan cluster of technical textiles, has been developing several sustainability projects. Four projects related to circular economy are currently ongoing: MIDWOR-LIFE, LIFE-FLAREX, PACTEX and ECODITEX[146].

PACTEX is a national project developed in cooperation by AEI TÈXTILS and the Catalan Packing Cluster. The project aims to establish synergies between the companies of both clusters and foster the effective use of material resources by reducing industrial waste at source, reuse of products, improving recyclability and recovery of waste. first, the project identified the type of material resources and residues generated by companies in both sectors. Then a series of improvements and innovative measures (technological and or non-technological) were proposed to help companies achieve better reuse of material resources and reduce the generation of industrial waste. An assessment of the technical, economic, and environmental impacts of each proposal and measure has also been performed. Finally, there were a selection of the most appropriate measures, which could be assessed to prove that they are technically, economically, and environmentally viable. The results of the project and all suggestions for improvement and innovative measures proposed have been gathered in a sector guide[147].

Lenzing

The Austrian Viscose, Modal and Lyocell fibre manufacturer Lenzing has developed the fibre series TENCEL™, derived from sustainable wood sources. All Lenzing's standard Lyocell and Modal fibres are biodegradable and compostable under industrial, home, soil, and marine conditions.[148].

Lyocell fibres are produced in a closed-loop production, which transforms wood pulp into cellulose fibres with a low ecological impact. There are two ways in which Lyocell fibres differ from other fabrics made from wood: First by using N-Methylmorpholine N-oxide instead of using the harmful sodium hydroxide. NMMO is organic and dissolve the pulp directly without any chemical change. Secondly, they only use wood from PEFC or FSC certified tree plantations[149]. Lenzing's solvent-spinning process recycles water and reuses solvent at a recovery rate of more than 99%[150]. To contribute to the circular economy in textile, the Lenzing Group developed the REFIBA™ technology, which made it possible to upcycle post-consumer cotton waste from garment production by making it a part of the Lyocell fibre production. The cotton scraps are transformed into pulp, which can be mixed with the virgin wood-based pulp from the lyocell production[151]. TENCEL™ Lyocell and Modal fibres have been given the STANDARD 100 by OEKO-TEX® certification and are free from regulated and non-regulated harmful substances[152].

Sandermann

The Danish firm Sandermann believe that their product should have the smallest effect on the planet as possible. Sandermann started in 2012, with the discovery that many sheep breeders discarded the coarse wool, because of the difference in quality from wool normally used in the fashion industry.

[146] CircE (2021): AEI TÈXTILS, the Catalan cluster of technical textiles.
[147] AEI TÈXTILS (2017): PACTEX.
[148] Tencel (n.d.a): Our sustainable process.
[149] Benton-Collins, K. (2021): Material Guide: What is Tencel? And Is It Sustainable?
[150] Tencel (n.d.a): Our sustainable process.
[151] Tencel (n.d.b): TENCEL™ x REFIBRA™ technology.
[152] Tencel (n.d.a): Our sustainable process.

The vision for the firm sprouted from that revelation: they wanted to stop the burning of wool in Denmark and use the by-product for yarn[153].

Sandermanns production and design processes use by-products and minimise waste in their production lines, with the purpose of moving towards circular economy. Sheep in Denmark are often bred for other purposes than wool production. The wool is therefore considered a by-product. The products made from Sandermann consist primarily of by-products from local, Danish sheep breeders[154]. The coarse wool fibres from sheep-production are mixed with the wool-waste with finer wool types, such as wool from merino sheep and alpacas, to make the yarns soft and comfortable to wear on the body. The wool from merino sheep and alpacas are not considered by-product, because the breeders are able to sell wool-waste from these animals[155]. In 2018, Sandermann won the Audience Award at Fashion Makes Sense in Amsterdam[156].

Worn Again

Worn Again Technologies, a polymer recycling technology firm, launched its first pilot plant in January 2020[157]. Current textile recycling methods turn less than 1% of non-reusable materials back into new textiles, and current recycling methods for plastics are unable to meet the demand for high-quality products. Worn Again Technologies will be able recapture raw materials from non-reusable products. The recycling technology can separate, decontaminate, and extract polyester and cellulose from non-reusable textiles and polyester bottles and packaging to produce dual PET and cellulose outputs, and thereby meeting demand for high-quality materials. In this way Worn Again Technologies can put sustainable resources back into production supply chains as secondary raw materials.

Worn Again Technologies investors include H&M Group, Sulzer Chemtech, Himes Corporation and Directex, and are supported by influential brands and partners, such as H&M, Kering, ASICS Europe, Sympatex, Dibella and Dhana. Worn Again have an ambition to scale and licence their technology to global plant operators as quickly as possible, with help from some of their strategic partners to accelerate the movement toward a circular economy[158].

Infinited Fiber

The Finnish company Infinited Fibre has developed technology that can take cellulose-rich waste that would otherwise be landfilled or burned – old textiles, crop residues like rice or wheat straw, used cardboard and more – and transforms them into premium-quality fibres for the textile industry. The technology consists of seven steps. First the textile waste is collected and sorted by type. Buttons and zippers are then removed, and the textile are disintegrated into fine shreds. The cellulose-based fibres are then separated from fibres like polyester, then they are activated with urea, making a stable dissolvable cellulose carbamate powder. During wet spinning, the powder crystallizes, making fibre filament. From there the fibre filament is cut, washed, and dried, making a high-quality, cellulose

[153] Sandermann (n.d.a): ”Vi tror på, at der sagtens kan laves et smukt og holdbart garn af et råmateriale, der ellers ville have været gået op i røg”.
[154] Sandermann (n.d.b): Sandermann x bæredygtighed.
[155] Sandermann (n.d.c): Produktion.
[156] FashionUnited (2018): Paolo Carzana and Sandermann winners of Fashion Makes Sense Award 2018.
[157] Worn Again (2020): About us – News.
[158] Worn Again (n.d.): A world where resources are kept in constant circulation, driving economic, social, and environmental benefits.

carbamate staple fibres. In the last phase the stable fibres are delivered to yarn spinners or non-woven manufactures[159].

With the technology cotton, viscose and other cellulose-based materials can be turned back into new natural fibres. The feeling of the fibres is equal to cotton and as versatile. The production line used animal feed grade urea, making it possible to conform to the Manufacturing Resticed Substances List (MRSL) and the zero Discharge of Hazardous Chemicals (ZDHC) standards. The technology can be retrofitted cost-effectively to any pulp and viscose fibre lines in existing factories, and thereby making it possible for other to benefit from the circular product line[160].

Touchpoint

Touchpoint design and manufacture sustainable workwear. The Finnish company uses eco-materials such as fabrics made from recycled raw materials, cutting waste or regenerated fibres made by Spinnova, as well as utilizing surplus materials. Workwear must be durable, and although Touchpoint use sustainable materials, their workwear has a lifetime of up to 60 months[161]. In 2021 Touchpoint will begin to collect all cutting waste from their nearby production partners, reducing by-products from the nearby production lines[162]. Touchpoint also uses recycled plastic bottles and recycled metal in the production of fabrics and products, for example in belt buckles. Hesburger, a Finnish fast-food chain has workwear collection made by Touchpoint that it was the first product line to be made from 100% recycled materials[163].

At the end of Touchpoints products lifecycle workwear are recycled and turned into composite material, which can be used to manufacture outdoor furniture and serving trays for the fast-food industry[164].

Touchpoint's daughter company 'Rester Oy'is building a plant able to recycle 12 000 tonnes of textile at the end-of-life phase. This textile will be used for various industrial applications, including yarn and fabric, insulation materials for construction and shipping industries acoustic panels, composites, non-woven and filter materials, and geotextiles[165].

Spinnova

Spinnova is a Finnish fibre technology company developing textile fibre directly out of biomaterials without any use of harmful chemical processes or dissolving. Spinnova's technology can use almost all types of cellulose-based waste streams[166]. The primary fibres processed into pulp is made from either FSC (Forest Stewardship Council) certified wood and/or PEFC certified wood or cellulosic waste streams e.g., agricultural waste and cotton waste[167].

When the pulp comes into the production line it is mechanically refined into Micro Fibrillated Cellouse MFC) a fine paste-like material, which is extruded to create the fibre network[168] Spinnova

[159] Infinited Fibre (n.d.) Ready to change the world? Our technology is too.
[160] Infinited Fibre (n.d.) Ready to change the world? Our technology is too.
[161] Touchpoint (n.d.): Workwear as service never wears out.
[162] Touchpoint (n.d.b) : Responsible Touchpoint.
[163] Issuu (2021): Touchpoint Responsibility Report 2020.
[164] Touchpoint (n.d.): Workwear as service never wears out.
[165] Touchpoint (n.d.c): Rester.
[166] Spinnova (n.d.a): Technology.
[167] Spinnova (n.d.b): Sustainability.
[168] CFDA (n.d.) Spinnova.

textiles are 100% biodegradable with no added plastic or harmful chemicals. Because of the technology used to spin the biobased yarn and the utilisation of tree-based celloluse, Spinnova textiles used 99.5% less water than cotton-based textiles[169]. The last 0.5% of the (evaporated) water used in production is the only waste stream, otherwise the production is a closed loop process.

Spinnova describes their technology as an opportunity for real circularity170, because their textiles not only can be recycled, but upcycled right back into the production line without use of any chemicals or dissolvents. Because of the nature of the material, the quality of recycled fibre will be just as good as the first time around. At the moment Spinnova are testing the number of times the fibres can be recycled without losing quality171. The company is currently developing fibre products with several retail brands for clothing, shoes, and non-woven materials172. It is also planning to develop a take-back system, where consumers can bring back products to retail outlets at end of life which will be then sent to recycling at a Spinnova173.

Dafecor Ldt.

Dafecor is one of the few companies using textile waste on an industrial scale in Finland. Dafecor takes leftover materials from the Finnish textile production[174] and waste textiles from clothing stores, laundries, hotels[175] and clean waste textile from consumers. Using a mechanical recycling process, the company transforms the textile materials back into fibres and uses these to manufacture new materials and products for various uses. During the processing of SRM and by products Dafecor strive to add few or no additives with linseed oil as an exception, leading to a line of products only containing textile waste for the most part. [176] Dafecor's products are mainly used in industrial maintenance to prevent or rectify environmental damage. Dafecor are specially known for their special carpets used to absorb water, fuel, light oils, and chemicals.[177] In addition, the company manufactures insulation products for construction, as well as products suitable for the furniture industry and gardening[178]. Test have shown, that Dafecor's utilisation of recycled textile did not affect the product performance, making the products useful both in a waste reduction perspective and as a prevention of hazardous liquid spills[179].

Furthermore, Dafecor is a part of an industrial symbiosis with hotels own by the Lindström Group. Dafecor receive disposed bedding, terry cloth products and roll towels. These products are grinded into the textile pulp, which feeds into the manufacturing of new textiles for Lindströms hotels such as roll towels, absorption mats and oil absorbent brooms[180].

[169] Spinnova (n.d.b): Sustainability.
[170] Spinnova (n.d.b): Sustainability.
[171] Spinnova (n.d.a): Technology.
[172] CFDA (n.d.): Spinnova.
[173] Spinnova (n.d.a): Technology.
[174] CircHubs (2018a): Textile Waste - Material description and quantity estimations.
[175] Lindström (n.d.): New products from used textiles – Dafecor makes new products from used textiles.
[176] Dafecor (n.d.a): Tuotantoprosessi.
[177] This is Finland (2016): Finnish Fashion gives new life to old fabric.
[178] Dafecor (n.d.b): Suomalainen perheyritys.
[179] Finnish Fashion (n.d.): Dafecor.
[180] Lindström (n.d.): New products from used textiles – Dafecor makes new products from used textiles.

Reda S.p.A.

The Reda Group was founded in 1865 and have been producing versatile fabrics and Italian tailoring for more than 150 years[181]. Reda is committed to minimize waste to apply the circular economy mindset, not only by reducing the waste produced, but also by making use of the unavoidable waste. They are committed to ensuring that materials used to create fabrics are recycled and reused. Reda recycles 99,1% of all waste and only 0,9% goes to landfill. Furthermore, the company obtains 220 tonnes by-products such as sample leftovers and coloured and raw blouse from the production of fabric. To minimise the amount of chemical used for the production of fabric and textile Reda has adopted and implemented the 4sustainability Chemical Management Protocol: concretely, adopting the Manufacturing Restricted Substances List (MRSL) and the zero Discharge of Hazardous Chemicals (ZDHC) and complies with REACH regulation. Reda is the first textile manufacture in Italy to be awarded the B-Corp certification. This was achieved through B Impact Assessment (BIA), which measures company performance in five different areas: environment, community, customers, governance and workers[182].

Nuova Fratelli Boretti and Re. Verso

Since 1960, Nouva Fratelli Boretti has worked with regenerated textile. Nuova Fratelli Boretti has created an engineering process to regenerate waste from pre-consumer textile processes based on wool, camel hair, and cashmere. Based on long standing cultural traditions rooted in the Prato territory, the company has been able to implement an innovate manufacturing process, where SRM can be reintroduced to the market. From the initial processing and trade of post-consumer garments to the re-engineering of scraps pre-consumer of wool, cashmere and camel hair knitwear and apparel, Nuova Fratelli Boretti developed a traceable and transparent process. Nuova Fratelli Boretti is a founding partner of Re. Verso and the exclusive licensee for the engineering of the raw material of the ReVerso supply chain. The company especially focus on quality and that the SRM shall be chemically safe. The textile scraps are sorted by type and shade to determine the material composition and to avoid adding chemical colorant. The company ensures that no waste is generated during production by enabling the use of SRM for apparel, home furnishing, fashion accessories and padding for cars[183]. The cashmere, wool and camel hair reintroduced by Re. Verso are used in major clothing brands and featured in numerous haute couture collections[184].

Products are certified GRS (Global Recycle Standard), APEOFREE, and comply with chemical safety certifications in line with PRSL and MRSL.[185]. Life Cycle Assessment analysis (LCA) have been performed by on Re. Verso products, which found that by using 1 000 Kg of Re. Verso wool instead of virgin wool saves 76% in energy, 89% in water, 96% in CO_2, 99% in SO_2 and 76% in chemicals and dyeing. Similar results were shown for cashmere, with saving of 82% in energy, 92% in water, 97% in CO_2, 96% in chemicals and 97% in dyeing[186].

[181] Reda (n.d.): Cosmopolitan.
[182] Reda (2020): Sustainability report – 2019.
[183] NFB (n.d.a): Renewed Noble Fibres.
[184] BusninessEurope (2018): Nuova Fratelli Boretti textile processes from regenerated waste.
[185] NFB (n.d.b) : Certifications.
[186] NFB (n.d.a): Renewed Noble Fibres.

Orange Fiber

Orange Fiber, a company based in Italy, have developed a method of using the 700 000 tonnes of by-product, produced by the local citrus processing industry. Following a collaboration with Politecnico di Milano University the company was founded in 2014, and the manufacturing of the first citrus based sustainable fabrics for fashion was put into production[187].

Orange Fiber uses an innovative process to extract cellulose fibres from by-products from the production of citrus juice. The citrus peels would otherwise have been disposed of at cost to the citrus processing industry and environment. The new collaboration is an example of industrial symbiosis leading to the first pilot plant for extraction of the citrus-based pulp in 2015[188]. The citrus cellulose is spun to biodegradable yarn by partners in Spain, then send back to Italy to produce soft, lightweight, and silk-like fabric. The result is a high-quality fabric that can be both dyed, coloured and printed on.[189], and can be mixed with other materials to make them opaque or shiny[190].

Orange Fibre are currently working scaling up the technology to restart the production, with long-term goals of optimising the cost of production. Eventually, they want to replicate the technology in Italy and abroad[191]. In 2021, a partnership between Orange Fibre and the Lezing Group, a leading global producer of wood-based speciality fibres, have led to the production of TENCEL™, a branded lyocell fibre made of orange and wood pulp[192].

Renewcell

Renewcell is a Swedish sustaintech company founded in 2012 by a group of scientists from the Royal Institute of Technology in Stockholm, using a new technique to decompose cellulose and with that a unique textile recycling technology. Following growing interest for from the fashion industry, the first industrial scale Renewcell plant opened in 2018. In 2020 garments made from Circulose® recycled in Sweden became available[193].

The textile industry is already using dissolved pulp cellulose from wood in the production of viscose, lyocell, modal, acetate, and other types of cellulosic fibres. Instead of wood, Renewcell use recycled cotton or viscose for their Circulose® products. Cotton has the purest cellulose found in nature, and therefore it is possible to sell Circulose® branded products as a sustainable virgin-quality fashion pieces in compliance with the principles of circular economy[194].

The process behind Circulose® starts with receiving used garments and textile production waste with high cellulosic content, like cotton or viscose. The textiles are shredded, buttons and zippers removed, and colours drawn out of the textile. Hereafter, the shredded textiles are turned into a slurry, making it possible to sperate contaminants and other non-cellulosic content. The slurry is then dried to produce a pure, natural Circulose® branded dissolving pulp made from 100% recycled textiles. The sheets of Circulose® are finally packaged into bales and fed back into the textile production value

[187] Reset (2019): Orange Fiber: Sustainable Fashion Made of Orange Peel.
[188] H&M Group (2019): Orange Fiber.
[189] Amberoot (2018): Future of Fashion: Innovative Fabric – Orange Fibre.
[190] Reset (2019): Orange Fiber: Sustainable Fashion Made of Orange Peel.
[191] H&M Group (2019): Orange Fiber.
[192] Tencel (2021): Lenzing collaborates with Orange Fibre as a part of new TENCEL™ Limited Edition initiative.
[193] Renewcell (n.d.a): About Renewcell.
[194] Renewcell (n.d.b): Circulose®.

chain as a replacement for virgin materials like cotton, oil and wood[195], minimising water use, land use, waste and pollution, and chemicals[196].

Södra

Södra is a forest industry group that processes the forest products, delivered by its 53 000 owners in the southern parts of Sweden, into renewable, climate-smart products for international export[197].

Södra has created OnceMore®, a process for industrial-scale recycling of textile waste of blended fibres. OnceMore® combines textile waste with cellulose from renewable wood to create pure, high-quality dissolving pulp for the textile industry. This makes it possible to recycle large volumes of used cotton and blended fabrics into pulp that can be used to make new clothing and textiles[198]. OnceMore® are currently looking for cooperative partnerships with different stakeholders from all levels of the value chain[199].

The technique used for OnceMore® pulp can separate the cotton and polyester in polycotton blends, which are one of the most widely used textiles on the market. The pure cotton fibres are then added to our wood-derived textile pulp, which can then be used to make new textiles. When the OnceMore® technology was first used in 2019, the pulp contained 3% recycled textile. By 2021, they reached a share of 20% recycled textile in the pulp striving to reach 50% by 2025. The amount of recycled textile used for the pulp, has made it possible for Södra to receive a Recycled Claim Standard certification (RCS). The wood used for the pulp is also certified though Chain of Custody certificates from PEFC and FSC[200].

Houdini Sportswear

Houdini Sportswear AB is an international outdoor clothing company based in Stockholm, Sweden, striving to make 100% of their value chains in compliance with circular economy[201]. All the fabrics used by Houdini Sportswear in 2019 were recycled, recyclable, renewable, biodegradable or Bluesign certified. This have been standard since 2019, and in the 2021 fall and winter collection, 77% of all Houdini Sportswear products comply with the principles of circular economy[202].

As a partner in Eco-Circle, knowledge-sharing about closed-loop systems for polyester became accessible for Houdini, providing opportunity to recycle fibre, that are suitable to be recycled again at the end of its lifecycle. Houdini provides a take-back system for all products and treat worn-out garments as a resource to recycle, rather than as waste. Even Houdini's older garments that are not considered suited for recycling can still be returned and use. This approach makes significant cuts in emissions: the mechanically recycled polyester emits 32% less CO_2 and uses 94% less water[203]. Besides the reduced emissions from productions, an end-user survey showed that products such as

[195] Renewcell (n.d.c): Technology.
[196] Renewcell (n.d.d): Market.
[197] Södra (n.d.a): Med verden som marked.
[198] Södra (n.d.b): The Oncemore® pulp – wood and textiles in pure harmony.
[199] Södra (n.d.c): Sustainable will never be out of fashion.
[200] Södra (n.d.b): The Oncemore® pulp – wood and textiles in pure harmony.
[201] Houdini (2019): Planetary Boundaries Assesment 2018 – This is Houdini – Our reasons to exist, methodology and promise to the future.
[202] Houdini (n.d.): Sustainability status: 100%.
[203] Houdini (n.d.b): Recycling: The quest to eliminate waste.

Houdinis 'Power Houdi' was used at least 1200 times, compared to an average garment commonly used 7 to 10 times in the western world[204].

Furthermore, the company strive to innovate the clothing industry though their open-source platform, which is used to share and exchange knowledge on sustainable methodologies, technologies and solutions[205]. The platform has also helped Houdini to connect with other companies, universities, and suppliers with the purpose of interdisciplinary collaborations across sectors[206].

7.3.1. SUMMARY ON GOOD PRACTICES

The review of EU best practices within textiles illustrates that the sector is highly driven by private initiatives, most likely responding to market demands. The highlighted examples cover a variety of sustainability initiatives such as:

- take-back schemes utilising post-consumer wastes.
- innovative recycling technologies.
- certificated products, production processes, and sources.
- social responsibility initiatives.
- networks for tracking and trading SRM.
- industrial symbioses and matchmaking activities.
- increased durability of end-products.
- waste reduction activities.
- biodegradable products with no chemicals.
- closed loop productions.
- regenerative materials.
- knowledge sharing and open source.
- alternative raw materials such as wood, PET bottles, metals, biowaste etc.

The examples illustrate that niches within the sector are undergoing a fast transition towards more sustainable production methods, with highly measurable sustainability benefits such as 99,5% reductions in water usage, reductions in carbon emissions, environmental pollution, reduced land use and waste generation. The examples illustrate that these benefits do not necessarily compromise the quality of the quality and that companies are benefiting from taking leading position in the SRM market in terms of both export potential and brand value.

7.4. DRAFT STRATEGY OBJECTIVES AND OUTPUTS

The following section proposes a new vision, and the means to achieve such vision, for the improved utilisation of SRM in the Portuguese textile sector. It contains three strategy objectives and a number of associated strategy outputs and activities. This approach to strategy development is associated with the methodology of LFA; the logical framework approach, developed in 1969 and widely adopted and promoted by the European Commission and UNDP.

[204] Adventure Journal (2020): Houdini Sportwear Has a Blueprint for Escaping the Gear Pollution Treadmill.
[205] Houdini (n.d.c): How we want to change the world.
[206] Houdini (2019): Planetary Boundaries Assesment 2018 – This is Houdini – Our reasons to exist, methodology and promise to the future.

7.4.1. OBJECTIVE, PURPOSE & EXPECTED RESULTS FROM THIS STRATEGY

Overall objective and long-term goal

The overall objective and long-term goal are strongly related to the Circular Economy Action Plan.

> Resource usage, textile waste and environmental degradation associated with the textile sector is decoupled from its economic value and growth.

7.4.2. STRATEGY OBJECTIVES, OUTPUTS AND RELATED ACTIVITIES

The concrete desired situation that the strategy aims to achieve is:

> The management of industrial textile waste is improved in accordance with the waste hierarchy

The European waste hierarchy is defined in the Waste Framework Directive[207], establishing the hierarchy of preferred waste management and disposing options in the following order:

- Prevention
- Preparing for reuse
- Recycling
- Recovery
- Disposal

Improving the waste management according to the waste hierarchy implies moving the fractions up in the hierarchy - moving from linear towards circular economic management.

The objective will be achieved through delivery of four strategy outputs as elaborated in the following sections:

Strategy output 1.1 Data on industrial textile waste is robust and valid

There are uncertainties and lack of statistical data regarding the quantities and flows of industrial textile wastes, partly because some excess or waste materials are sold as products. These uncertainties make it harder to regulate the sector through fiscal policies whilst obscuring the possibilities for the establishment of new partnerships and industrial symbioses. SRM from the textile industry is currently being both imported to and exported from Portugal, but this flow and the utilisation of the SRM are not well registered. As such, there is uncertainty around how much textile SRM is being used and how it is being utilised. Activities to address this problem are:

- Viable solutions for registering the different compositions of industrial textile waste are investigated.
- A system for more precise registration of industrial textile waste is developed and implemented in close cooperation with the stakeholders.
- Existing quantities and types of textiles SRM produced, imported and exported are mapped in order to estimate whether these resources are utilised optimally and whether there are further recycling potentials.

[207] EC (n.d.b): Waste Framework Diretive.

Strategy output 1.2 Industries are aware of potential benefits of symbiosis and cooperation

Existing examples of industrial symbioses in the Member States serve as a reminder that much value of textile secondary raw materials is lost when the materials are disposed as waste. Companies that manage to find applications for their SRM either through the establishment of subsidiaries or through close cooperation with external partnering companies can minimise costs and increase benefit from additional revenue streams, while the recipients can achieve savings compared to virgin raw materials, and all involved companies improve their environmental performance.

Industrial symbioses within the textile sector are not limited to the recycling of textiles but may just as well include the cascading of chemicals, heat, water etc. related to the manufacturing of textiles. Industrial symbioses are often regarded a win-win-win, as it benefits both the companies involved, the society as a whole, and improving resource efficiency and waste management. However, symbiosis requires innovative, trusting, and patient entrepreneurs as new business models, technologies, logistics, contracts and forms of cooperation need to be established. It requires strong dialog between companies (and sometimes public authorities) and openness to share business related data. To improve the maturity at sectorial level towards industrial symbioses, it is important to communicate the associated environmental and economic potential. Several European initiatives already have set this on their agenda, and it may be beneficial to investigate the possibilities of joining such initiatives, e.g., the Interreg project SYMBI[208]. Activities could include:

- Industrial symbiosis is promoted for the textile sector through the dissemination of best practice examples and involvement in supranational projects such as existing EU Interreg projects.
- Potential linkages to the collection and recycling of post-consumer textile waste are investigated.
- Industrial symbioses between textile producers and (potential) users of waste are supported (see section with policy recommendations for supporting industrial symbiosis).

Strategy output 1.3 Relevant actors are informed and have knowledge about material flows and available SRM

The availability of SRM is often limited since companies may not want to share such information. There are examples of successful European trading platforms that are either voluntary or mandatory for the related industries to use[209]. Such platforms dedicated to SRM provide the opportunity for companies to identify useful sources of materials that fit with their needs and criteria.

Public authorities may serve the function of matching companies when they have the overview of existing flows of side-streams. As a continuation of strategy output 1.1, municipalities or public/local chamber of commerce can be key intermediaries between regulation and companies and may be equipped to assist companies by serving as a mediator and matchmaker, as well as by guiding companies through intersectional legislative grey zones. Companies can find legislation ambiguous because utilisation of SRM crosses several public sectors that often work in silos[210]. Other Member States have successfully established interdisciplinary and independent public bodies to specialise in supporting industrial symbiosis. Compliance checks may also be used to support companies in carrying out screenings of potential side-streams. Actions include:

[208] SYMBI (n.d.): Industrial Symbiosis for Regional Sustainable Growth and Ressource Efficient Circular Economy.
[209] See for instance the platform Materiaalitori, provided by the Finnish Ministry of Environment and maintained by Motiva.
[210] Svendsen et al. (2020): Guide: How can Municipalities Support the Development of Industrial Symbiosis.

- A national network and working group on industrial symbiosis is established, with the purpose of identifying and removing regulatory barriers for industrial symbioses (without compromising on environmental protection), improving intersectional communication, communicate benefits of industrial symbiosis to the industry, participate in European Interreg projects, operate a national trading platform, conduct matchmaking etc. This could be established with industry experts, researchers, and public authorities as a triple helix cluster.
- Guidelines and information disseminated on toxic-free textile production and source separation of textile waste in industrial facilities.
- A trading platform dedicated to SRM from the textile industry is established. This could include industry stakeholders. The initiative requires digital tools, transportation and logistics companies, investment, and IT technologies etc.

Strategy output 1.4 New methods and technologies are applied for more efficient use of textile by-products

High-grade textile recycling is still niche, and existing technologies have several limitations[211]. R&D could be improved with necessary and well-targeted fiscal support. Few companies apply for European funding, which could be incentivised through communication and support from APA.

Textile side-streams are significantly more uniform than post-consumer textile waste, and it is easier to obtain information on technical details and information of traceability. However, such transparency is often lacking when the SRM pass from one actor to another. Since trade of SRM is highly trust-based, a product declaration would create a common ground that can serve to hold producers of SRM accountable for the content in the SRM, while making it easier to obtain the necessary information for buyers. The introduction of a national product passport/technical product declaration that is approved and produced by public authorities has the potential to support the market.

- Provide support to technological development aiming at high value recycling at industrial scale.
- Support provided to application process for EU funding.
- Introduce a product passport or tag with technical details and information on traceability. This could be in cooperation with certification advisors, technological centres, brands, retailers, producers, recyclers, industry associations, APA, EU institutions, and other public entities. CITEVE can run preliminary tests and define who should be involved.
- R&D investment support for SMEs that can display innovative ideas.

7.5. MONITORING FRAMEWORK

A strategic plan is only as effective as its implementation, and successful implementation requires proactive strategic monitoring. While the potential benefits of strategic planning are vast, many strategic plans fail to achieve desired outcomes in the implementation phase.

The following draft monitoring framework illustrates how APA can monitor the implementation of the textile strategy.

[211] Wrap (2019): Fibre to Fibre Recycling: An economic and fincial sustainability assessment – Identification of and recommendations to overcome barriers to the Development of post-consumer closed loop clothing recycling in the UK.

Overall objective and long-term goal:
Resource usage, textile waste and environmental degradation associated with the textile sector is decoupled from its economic value and growth

Strategy element	Indicator	Means of verification
Objective: The management of industrial textile waste is improved in accordance with the waste hierarchy	• At least 90 % of industrial textile waste is used in Portugal as secondary raw material for new production	• Data from waste registration system combined with data from industry
Output 1.1: Data on industrial textile waste is robust and valid	• The system for collection of data on industrial textile waste improved • Industry provides valid and robust data on textile waste amounts	• Data from the registration system • Survey among textile industries
Output 1.2: Industries are aware of potential benefits of symbiosis and cooperation	• Best practice examples are distributed to the industry	• Account of APA communication efforts • Survey among textile industries
Output 1.3: Relevant actors are informed and have knowledge about material flows and available SRM	• Public actors play an active role in informing and supporting industries in SRM endeavours	• Account from the relevant public actors • Survey among textile industries
Output 1.4: New methods and technologies are applied for more efficient use of textile by-products	• Pilot projects are conducted supported by public funding (Portugal, EU)	• Number of SRM pilot projects in the textile sector

8. BIO WASTE FROM THE AGRO-, FISHING, AND FOOD PROCESSING INDUSTRY - STRATEGY DRAFT

Bio-waste is a key waste stream with a high potential for contributing to a more circular economy, potentially delivering valuable soil-improving material and fertiliser as well as biogas, a source of renewable energy. This project focuses specifically on the biowaste produced from the agriculture industry, fishery industry and food processing industry.

The EU Platform on Food Losses and Food Waste and the EU Joint Research Centre (JRC) highlight the lack of an appropriate evidence base and insufficient data on food loss and waste levels from the food processing industry [212],[213]. Statistics on the production of biowaste across the Member States are not comprehensive, reliable or comparable – due, among others, to the many differences in the way the statistics are recorded and reported. The most recent estimates of European food waste levels (FUSION, 2016) reveal that 70% of EU food waste arises in the household, food service and retail sectors, while the remaining 30% is generated in the food production and processing sectors[214]. The collection and analysis of data from across Europe for this study show an estimate of annual food waste in the EU-28 of 88 million tonnes in 2012, of which the *primary production sector constitutes 10 % (9 million tonnes ± 1,5 million tonnes*)[215]. Studies indicate that the waste amounts from the primary production sector are the most difficult to analyse and quantify, one major reason being the diversity of the sector and the lack of in-depth studies[216] [217].

International research on the economy-wide options and effects of reducing bio-waste from the food industry shows that waste amounts are minimised by saving food inputs, using additional labour, or investing in better storage facilities. Reducing bio-waste may lead to decreased food prices, encouraging increased use of agricultural products[218].

Residues from the food industry can represent a major disposal problem for the industry. At present, up to one third of waste/residues from fruit and vegetables – typically peels, pips, kernels, and skins – are discarded during preparation and processing, hereby creating a ‘waste’ while also decreasing the maximum nutritional potential of the fruit or vegetable[219].

Biowaste is a subject often debated in relation to post-consumer, municipal waste, but the treatment techniques used for municipal bio-waste are often also applicable to bio-wastes from the food processing industry[220]. Based on life-cycle analyses, the JRC has identified a 'hierarchy' of treatment options for bio-waste: Waste prevention and reuse (e.g., redistribution or use as animal feed) is clearly environmentally most preferable, followed by anaerobic digestion (recovering both materials and energy) and composting[221].

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[212] EC (n.d.c): EU Platform on Food Losses and Food Waste.
[213] EC (n.d.d): European platform on Life Cycle Assessment – Food System Analysis.
[214] EU Fusions (n.d.): Establishing reliable data on food waste and harmonizing quanification methods.
[215] EU Fusions (n.d.): Establishing reliable data on food waste and harmonizing quanification methods.
[216] EC (n.d.e): Food Safety – Animals. Iriondo-DeHond et al 2018: Food By-productss as Sustainable Ingredients for Innovative and Healthy Dairy Foods
[217] Iriondo-DeHond et al. (2018): Food Byproducts as Sustainable Ingredients for Innovative and Healthy Dairy Foods.
[218] Britz et al. (2019): Economy-wide analysis of food waste reductions and related costs.
[219] Babic (2014): Food industry by-products as raw materials in functional food production.
[220] EEA (2020): Bio-waste in Europe — turning challenges into opportunities.
[221] Manifredi & Pant (2011): Supporting Environmentally Sound Decisions for Bio-Waste Management — A practical guide to Life Cycle Thinking (LCT) and Life Cycle Assessment (LCA).

8.1. BIOWASTE FROM THE AGRO-, FISHING AND FOOD PROCESSING INDUSTRY

Bio waste produced in the primary sector and the food and beverages manufacturing sector can be identified as waste categories 'Animal and mixed food waste' and 'Vegetal waste,' from the 'Agriculture, forestry and fishing' and 'Manufacture of food products' sectors. The database shows that Portugal has generated **53 047 tons o**f biowaste in 2019[222], or 32 kg per capita – considerably below the EU average of 120 kg per capita.

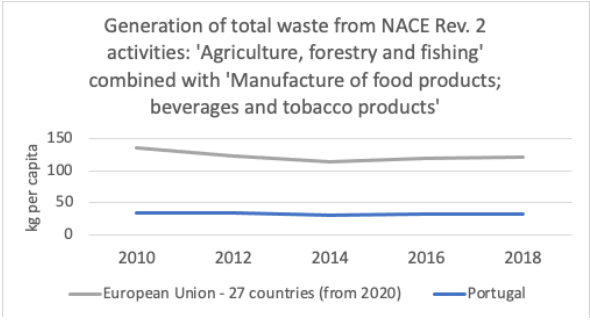

Figure 24

The majority of the biowaste registered from these sectors in Portugal is recycled (95%) with only a small amount incinerated or landfilled.

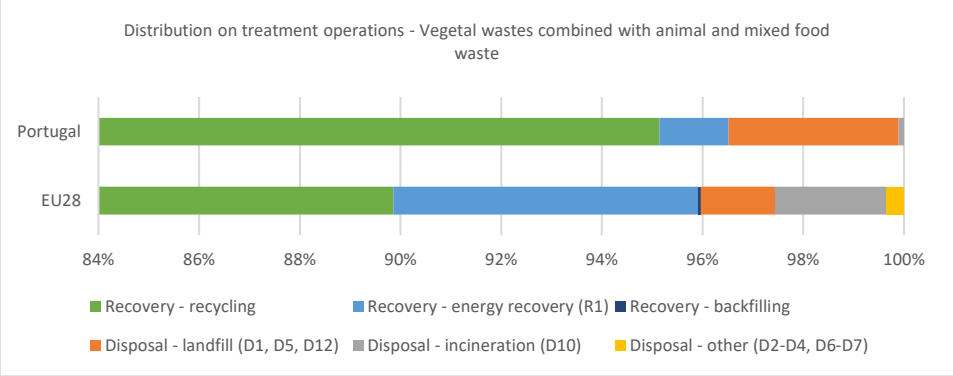

Figure 25

As in other EU Member States[223], vast amounts of non-utilised crops, residues, and surplus materials from the agricultural sector in Portugal are handled in situ (ploughed down, left on the ground etc.)[224]. According to EU regulation, surplus biomaterials from the agricultural sector used for soil improvement or in other ways treated in-situ are not categorised as bio-waste – and therefore not registered. However, as circular economy strategies typically follow a more ambitious path than regulation, it might still be relevant in Portugal to investigate the amounts of residue organic waste.

Providing a picture of the volume of such surplus materials from the agricultural sector in Portugal, a recent study by the Portuguese National Energy and Geology Laboratory (LNEG) totals the annual non-utilised biomaterials production in Portugal from agriculture and food processing to about 3.396.427 tonnes and 318.991 tonnes, respectively[225].

[222] Eurostat (2021a): Material flow accounts in raw material equivalents – modelling estimates.
[223] Franke et al (2016): Food losses and waste in primary production - Data collection in the Nordic countries
[224] LNEG, 2017
[225] The LNEG report states that about 50% of the biowaste generated and treated in situ play an important role in the biological balance of the ecosystem providing the soil with nutrients and water retention. LNEG, 2017

Biowaste	corn by-products	rice straw/husk	vine trimmings	olive tree trimmings	fruit tree trimming	nut tree trimmings
Production	1 416 727	200 786	974 738	273 225	512 163	18 788
Total	3 396 427					

Biowaste	carob pulp	citrus pulp	olive residue	grap marc	nuts/dried fruit shells	beer by-products
Production	45 000	12 317	88 379	69 840	15 000	88 455
Total	318 991					

Thus, there may be a substantially larger potential for biomaterial recovery than Eurostat shows, why these materials are included in the further deliberations in this section.

Conclusions on the consultations with the food processing industry suggest that most of the waste in this sector is already being used, primarily as animal feed. The food processing industry, however, wishes to become more self-sufficient and minimise the import of soy products, among others, and the sector representatives have shown great interest in expanding or improving the use of by-products and waste materials. Some initiatives have been tested in small scale, for example drying of fruits, manufacturing protein bars of fruit waste, and using broken cookies from production in yogurt products, etc. The challenge is achieving better use of the waste and surplus materials and providing more value to the Portuguese society.

8.1.1. EXISTING VISIONS AND GOALS

The following sections of waste regulation DL 102-D / 2020 directly target bio-waste from the food manufacturing value chain:

- Reduce by 25%, by 2025, the amount of food waste in all the food production and supply chains, including the agri-food industries, catering companies and supermarkets. And by 2030 reduce it by 50%. (Art. 21 DL 102-D/2020).
- Companies in the agri-food industry with more than 10 staff must adopt, by the end of 2023, measures to fight food waste and should deliver information for measuring this food waste (Art. 23 DL 102-D/2020).
- From 2024 onward, all companies associated with food production and distribution are prohibited from disposing food that can still be consumed, with the possibility of establishing food donation agreements (Art. 23 DL 102-D/2020).
- Biowaste from restaurant and industrial activity must be separated without mixing it with other residues (Art. 30 DL 102-D/2020).
- The declassification process is changed to be self-declarative, as opposed to the previous process involving the ANR (Nacional Agency of Waste) and lasting 90 days. Compliance with the criteria is ensured by Collaborative Laboratories, or technological centres and declared in SIRER (Art. 91 DL 102-D/2020).

Portugal is currently (Sept. 2021) developing its first bioeconomy strategy in which biowaste, and surplus biomaterials are expected to have an important role as feedstock for bioeconomy related activities, including production of renewable fuels and base chemicals.

8.1.2. STRUCTURE, LEADERSHIP AND EMPLOYEES

The Portuguese structure for policies on biowaste does not deviate significantly from the structure on CDW or textile waste – refer to section 5.2).

8.1.3. EXISTING STRATEGIES

European Strategies

Bio-residues from the specific sectors agriculture, fishing and food processing industry are not explicitly targeted in any of the major EU waste related strategies and policies, and a significant part of these residue materials are excluded from the scope of the waste directive.

The 2020 EU strategy: 'A Farm to Fork Strategy for a Fair, Healthy and Environmentally-friendly Food System' states that: "Tackling food loss and waste is key to achieving sustainability. Reducing food waste brings savings for consumers and operators, and the recovery and redistribution of surplus food that would otherwise be wasted has an important social dimension. It also ties in with policies on the recovery of nutrients and secondary raw materials, the production of feed, food safety, biodiversity, bioeconomy, waste management and renewable energy[226]." The strategy, however, does not entail specific waste related targets, actions, or indicators for the sectors in focus.

Portuguese strategies

No strategies targeting the specific sectors have been identified in the Portuguese policy framework. The Portuguese Circular Economy Action Plan mentions: "Potential to apply biomaterials, symbioses with other by-products (e.g. rubber, textiles), yarn recycling"[227] but does not include more specific goals, targets or actions.

The current version of the RGRR focuses on biowaste from municipal waste. The legislation states however that biowaste from catering and the industry needs to be separated at source by producers by the end of 2022 in the case of entities who produce more than 25 tonnes per year: otherwise by the end of 2023.

The national Bio-economy Action Plan is fully aligned with the European Bio-Economy Strategy of 2018 and with European Green Deal and will promote structural changes that enable the shift to high value-added products produced with sustainable principles and innovative biobased resources.

Key interventions in the plan are:

- Promote sustainable production and intelligent use of local resources.
- Promote Research & Innovation;
- Develop the circular and sustainable bio-industry.
- Act on Society through communication, training, and education and
- Monitor the sustainable Bioeconomy – to further understand ecosystem boundaries.

Under the Bioeconomy initiatives in the Portuguese Recovery and Resilience Plan, and fully align with the action plan, three sectors that will set the stage for future Bioeconomy opportunities across the Portuguese economy: textile, footwear, and natural resin.

The Bio-economy Action Plan it is now in legislative procedure, where it will be subjected to public consultation and after that approved by the Council of Ministers.

8.1.4. CULTURE

[226] EC (n.d.f): Food Safety – Farm to Fork strategy for a fair, healthy and environmentally-friendly food system.
[227] República Portuguesa (2017): Leading the transition – Actionplan for circular economy in Portugal: 2017-2020.

According to stakeholders, the currently dominant solutions for biowaste – as animal feed or leaving it on ground for soil improvement – are cheap and simple, and as such are hard to substitute with more circular solutions.

The material flow – including side streams, and residues – in the primary production is driven by biological processes which are not standardised. There are several external factors, such as weather and soil conditions that hamper production, and because of this, the output does not always meet all the buyer's quality demands – for example for aesthetic or size requirements – even though the product could still be consumed[228]. Although some residue material left in situ from farming can improve the soil, it is not always the best use of the material and can in some instances be harmful, for example, as with the high potassium content in oranges[229].

The cost of scaling solutions up from pilot to industrial scale is high and the industry is generally not convinced that there are alternative solutions that could be economically viable for the primary production actors.

Barriers for the uptake of the surplus and waste materials from the primary production mentioned by stakeholders are:

Retail specifications

Strict specifications from retail on size and looks of fruit and vegetables mean that a significant amount of the primary materials ends up not being used.

Socio-economic lock in

Long distances between the actors in the relevant sectors create logistical challenges for increased uptake of the materials, exacerbated by the lack of mapping of possible value chains that could support creation of synergies between producers and secondary material customers. There is a need for more cooperation between companies and R&D institutions, as well as financial support to pilot activities and to scale up from pilot to demonstration phase. Food safety studies can be particularly costly, making it more difficult to use by-products in other food materials, for example in dehydrated nutrition bars or canned products.

Seasonal production

Agricultural production varies with growing seasons and enormous quantities of crops – and related surplus materials – are produced only at certain times of the year. A thorough study of surplus bio-materials available as secondary raw materials for new production in Portugal could facilitate increased use of these materials.

Lack of resources in companies

Most companies in the sectors are SMEs and do not have the required resources to pursue transition projects. Stakeholders indicate that many of these SMEs may have few research competences and lack a support network that could enabling them to seek solutions to their residues and by-products. Few industries have knowledge on regional alternatives of waste management and, since there is no communication between companies with waste and companies that could potentially use such materials, solutions are seldomly pursued.

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[228] Franke, Ulrika et al (2016): Food losses and waste in primary production - Data collection in the Nordic countries

[229] Calabro, P.s., Folino, A., Tamburino, V., Sappia, G., Zema, D. A. & Zimbone, S. M. (2017): Valorisation of citrus processing waste: A review

8.1.5. SYSTEMS

Overall, there are few systems in place in Portugal to support the utilisation of SRM. There is no system for communication between the value chain actors with surplus materials and the potential users of secondary raw materials, there is a relatively high fee for changing the status of the materials from waste to by-product (in the perception of some stakeholders), the food safety regulation is by some stakeholders considered a barrier for using waste material as animal feed. Furthermore, stakeholders argue that there is a lack of support systems for testing and up-scaling pilot technologies for new products based on secondary raw materials.

8.2. EU BEST PRACTISE EXAMPLES

EatGRIM

EatGRIM is a Danish start up business from 2018. They source class II and "ugly" vegetables straight from organic farmers primarily in Denmark and a few other places in Europe for distribution to private consumers and professional kitchens in Denmark. In that sense, they have become a platform for selling and buying ugly fruits and vegetables and thereby minimizing waste of food in the primary production.

EatGRIM has cut out the middle agents between farm and customer and shorten the supply chain. This makes it possible for farmers to be paid a fair price for the produce even though the vegetables are 'ugly' and therefore hard to sell at a full price on the conventional market. The same amount of work goes into growing, harvesting, packaging, and transporting an ugly carrot, therefore price has been an issue in this class II market; an issue EatGRIM is working to overcome. An added benefit of the solution is that the produce sold by EatGRIM is fresher when it reaches the customers due to the short supply chain.

EatGRIM operates with two markets - private consumers and professional kitchens - and provides two different 'products' that are designed to meet the needs of the costumers and at the same time be flexible to the uncertainty of supply from class II veggies which changes every week.

GRIM boxes are a consumer product. A weekly box of seasonal fruits and vegetables. The boxes come in three sizes. The specific content of the box is not known beforehand – but the consumers are guaranteed a certain variation and amount each week.

Weekly order sheets are designed for professional kitchens. Each week, suppliers provide information on the quantity and quality of the produce available (e.g., size, deformity, colour, marks or scratches) and an order sheet created. Once the orders are finalised, the farmers will harvest their produce on Mondays, EatGRIM will pack it on Tuesdays and send it out to the professional kitchens on Tuesday afternoons or Wednesdays. EatGRIM only accepts orders once per week and since most professional kitchens need to order daily, they will primarily use EatGRIM as a weekly supplement and not as the primary source for vegetables.

EatGRIM is making an online sales platform where farms can upload their class II produce and kitchens can order fresh vegetables and fruits directly.

EatGRIM has a network of 32 organic farms in Denmark and Europe. The environmental and resource savings so far have been:

- **321 tons** of food
- **128 tons** of CO^2 equivalents
- 56 million litres of fresh water
- **378 thousand m²** per year of land
- Created over **3.2 million DKK** additional income for farmers (12.09.2020)

EatGRIM have shaped their business concept and logistics around farmer's needs. This has enabled them to build loyal with suppliers, without which the project could not take place. This loyal cooperation has further ensured a financially sustainable business model for the farms involved.

By being vocal and clear about the the motivation behind the project, EatGRIM have managed to be the voice of the farmers and present the issues of beauty standards in the food production that causes alarming amounts of food waste in the primary production. This communication has also fostered loyal and understanding customers among private consumers.

Today, EatGRIM are still expanding their market among the professional kitchens, whose habits, needs, and expectations are harder to change and overcome. With financial support from GUDP – a program under the Danish Ministry of Environment – EatGRIM has started a project together with Danish restaurant- and canteen businesses to investigate how to develop the market for call II produce in professional kitchens.

For the farmers, the economic incentive has been to increase the value per harvest; and by that lower the costs per item sold. By using more of the food produced on the land, less land is needed to meet demand[230].

Fruta Feia

Fruta Feia Cooperative seeks to overturn the standardisation trends regarding appearance of food. The project aims to fight a market inefficiency by changing consumption patterns and by creating an alternative market for ugly fruits and vegetables, one that values farmers and consumers and that can prevent food waste and the associated resource and environmental impacts. Fruta Feia does not affect the market for "non-ugly" products since farmers only sell to the Cooperative produce that is not demanded by retailers. This means that an increase in ugly fruit consumption does not imply a decrease in non-ugly fruit consumption.

Fruta Feia Cooperative's first delivery point was launched in November 2013 at Intendente in Lisbon and has been replicated in several Portuguese cities including Porto, Almada, Amadora, Cascais, Vila Nova de Gaia and Matosinhos. Fruta Feia has a network of 309 farmers in Portugal and the project has saved approximately 3,500 tons of food from being thrown out or ploughed back into the ground in the period 2013-2018.

The cooperative business model is based on autonomous associations of consumers united voluntarily to meet their common needs. Individual members are not only consumers, but joint owners of the business securing its financial sustainability. For the farmers, the business model provides a good measure of certainty in their own economic planning, which enables goods and services at below

[230] Eat Grim (n.d.): Kasser med økologiske og nogle gange grimme frugter og grøntsager leveret – Bekæmp madspild med friske, klimavenlige afgrøder direkte til dig fra bæredygtige landbrug.

market prices to consumers-owners. Additionally, and given the environmental ground of the project, farmers are located within 70km of delivery points, ensuring an efficient process flow of no more than 180km of collection routes per day.[231]

Sotenäs Symbioscentrum[232] [233]

Sotenäs municipality in Sweden is home to a large cluster of the marine food industry – around 8% of the marine food produced in Sweden is from this cluster. With this industry as a key driver, a network called the Symbioscentrum has been evolving within the municipality.

Symbioscentrum (SS) is being developed by the municipality together with industrial actors and academy to create green, local jobs while contributing to a sustainable future both locally and globally.

The initiation of the SS was incentivised by the municipality's heavy reliance on the oceanic resources and the otherwise large cost of building a new wastewater treatment plant (WWTP) in the municipality. The WWTP was required to handle the wastewater from the already large fishing industry. Instead of building a new plant, the municipality initiated the SS and Rena Hav, the biogas company, was put in charge of cleaning the wastewater from the industry.

Industrial symbiosis is being developed through synergies between industrial actors involved in renewable energy, food production, aquaculture, algae production, and marine technology in order to improve material and energy efficiency in the region. As a part of the process, SS provides the companies with a test facility with small prototype machines (shredders, injectors, compression machines) and business development consulting, that they can use to develop their ideas. The companies are aided by environmental analyses from RISE (Research institute of Sweden) to ensure that truly sustainable solutions are found. In 2017, the Swedish Environmental Institute – IVL conducted an environmental and socio-economy analysis of the ongoing development, which points to a significant reduction potential:

One Industrial Symbiosis connection developed though SS is the cooperation between the companies West Coast Smolts, Smögenlax, and Swedish Algae Factory is directed at land-based aquaculture in recirculating aquaculture systems (RAS). Here, the companies are working together on utilizing the nutrient rich wastewater from the salmon production to grow algae. The symbiosis ensures that wastewater is cleaned in the process and led back to the salmon production as opposed to being funnelled into the ocean.

- Reduction of nearly 60 000 tons CO_2-equivalents emissions pr year.
- Eutrophication impact reductions of 388 tons of PO_4-equivalents per year.
- Reduction of over 19 million tonne-km per year in transportation of wastes and other products.
- €16 million in savings on waste disposal transport compared to reference model levels.

[231] Fruta Feia (n.d.): Início.
[232] Sources for case description: Interview with representatives from Sotenäs Symbiosecentrum, October-November 2020.
[233] Martin & Carlsson (2018): Environmental assessment of the Sotenäs Industrial Symbiosis Network.

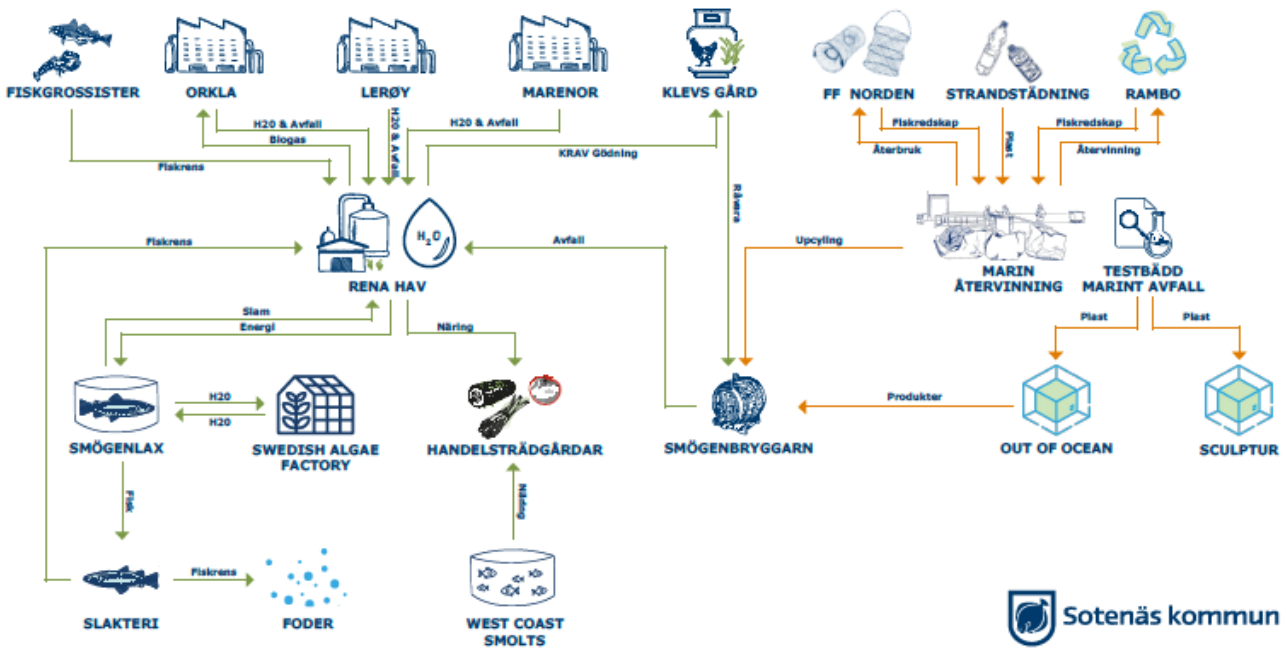
According to the study, all companies within the network were shown to benefit from the sharing of resources and energy, where reduced impacts as well as a significant potential for reduction in transportation where achieved.

As Sotenäs is a fishing community, the symbiotic network improves the use of sea-based resources and reduces the potential impacts to the aquatic and natural environment. The biogas plant function as an "upcycling tenant" in the symbiosis network to further improve environmental benefits through wastewater and by-product handling in addition to replacing and supplying tradition forms of heat and fertilizer.

Among the main reasons for the success of the SS is the important level of transparency, longevity, and ability to facilitate a common ground for companies to discuss and develop solutions to shared challenges. Gaining knowledge from a variety of actors (universities, companies, and experiences from other countries) has been a key driver in the SS; both in convincing the local and national policymakers of the environmental and economic benefits of the project, and to further develop the possibilities within the industrial symbiosis. The transparency and openness have been essential in attracting new companies and actors to the network.

Part of the Sotenäs symbiosis also includes Sweden's first and only marine recycling centre. The centre manages the discarded fishing gear, ocean, and fish waste. In Sotenäs they manually separate the fishing gear and waste (a difficult fraction to recycle, that otherwise would end up in landfill as incineration plants normally does not accept it). Ways to use the sorted waste are then identified. A process that often revolves around companies that views the waste as a resource for their production of both new and similar (to the original) products.

One of the main obstacles has been to find the appropriate actors for a given issue. Sotenäs municipality strictly controls development of business in the area, and together with the possibilities given to the companies in the symbiosis centre, this has enabled the municipality to attract companies to the symbiosis, that already had or were willing to adopt a more circular business model. SS has been key in facilitating the dialogue between companies, which has led to the co-created development of solutions to (often common) issues.



Overview of the Sotenäs Symbiosis, source: http://www.symbioscentrum.se/

SS is funded by the municipality, which also works with development through several externally funded innovation- and development projects together with various companies and experts. There were no national or EU policy directly supporting an industrial symbiosis at the time of implementation, but the municipality of Sotenäs recognised the potential of industrial symbiosis between the municipality's existing companies and needed a hub to connect them.

According to SS, many municipalities already have the basic building blocks in place for industrial symbiosis and giving local governments the mandate to work with secondary raw materials could further support the development of industrial symbiosis. Regulation that incentivises the use of SRM or disincentivises the use of virgin materials also has the potential to support the formation of IS.

Like Sweden, Portugal is home to a large fishing industry and the SS demonstrates how industrial symbiosis can contribute to higher environmental and economic performance of the companies and products within the sector. Furthermore, utilisation of biowaste from this sector has a significant potential for increasing circularity and reducing pollution of the ocean and surrounding environment.

Fishmeal from fish waste - FLAG Huelva - ES[234]

This project offers an example of utilising fishery by-products by supporting an aquaculture company in the production of its own fishmeal from local fish waste.

The aquaculture company, Salinas del Astur, which breeds and commercializes sea bass and gilthead, saw a business opportunity in the discards and fish waste produced by the local fish auction. Until then, this fish waste produced no added value but was sent for incineration.

With support from national and regional funding, the company was able to invest in machinery that would allow them to produce its own, high-quality fishmeal from this local fish waste. With the new machinery and by combining fish waste with breadcrumbs (also produced by the company from bread waste collected locally), the project has turned waste into a valuable resource while having positive side effects for the environment. Salinas del Astur now produces 50% of the fishmeal consumed by its aquaculture activities. Moreover, they are currently working to find new ways of improving the quality of the fishmeal by reducing its water content (currently at 80%). At a later stage, the company foresees scaling up the production of fishmeal by also collecting discards from a neighbouring fish auction (Isla Cristina) as well as other types of fish and seafood waste from the local canning industry.

Improving the current management of algae through composting – FLAG Vilaboa - ES[235]

In the north of the Vigo estuary is Vilaboa, a village with shellfish farming activity. The local shellfish farmers often need to remove substantial amounts of algae that has accumulated on the water's surface. They do this by using tractors and other machinery with adapted devices which they have specifically developed for this purpose.

Until recently, the biomass stemming from the algae was not used. To make better use of this resource and minimise potential environmental problems and contamination due to uncontrolled degradation of the algae, the local Cofradía (small-scale fishermen's' association) and the municipality of Vilaboa developed, together with the FLAG, processes that could turn the algae waste into organic fertilizer for the green spaces of the municipality.

[234] EC (n.d.g): Fisheries – Farnet, Fishmeal from fish waste – FLAG Huelva – ES.
[235] Farnet (2018): FLAGs and local resource management – Field Visit: Ría de Vigo – A Guarda FLAG projects.

The FLAG supported the technical accompaniment of the planning and implementation of the composting process. The project is now looking to develop a marketing strategy for the algae compost

Whey - from by-products to main source of income

The cooperative dairy giant Arla Foods have developed a way to utilise the biggest waste stream in their production of cheese and other milk-based products. In the production of cheese most of the milk used, roughly 90%, end up of as whey. Whey is the liquid excreted when the curd solidifies under the production of cheese, containing mostly water but also some protein, sugar and minerals. For some time, whey was seen as a by-product, used as a feedstock for pigs[236]. This changed in 1976, when Arla Food conducted the first pilot production of whey proteins, making it possible to establish domestic and export sales of whey protein concentrate in 1980. The Whey concentrate is used as a protein supplement for medical, infant and sports products[237]. Today Arla Foods converts whey into various kinds of protein powder though hydrolysis, contributing over 20% of Arla's total earnings[238].

Arla Foods next step in their circular economy concept is to maximise the value created from waste streams. This means that the side-streams from the conversion process from raw whey material to protein powder should be also used. This side-stream is a water-like product containing the last remaining high-quality intact proteins and useful amino acid compositions. To further reduce the waste from the production lines, Arla Foods plans to reuse wastewater from the extraction of whey protein for technical applications like process cooling. They are also investigating recycling the chalk from the wastewater, by excreting it and pressing it into fertiliser pellets[239].

8.2.1. SUMMARY

The review of best practices within the agro-fishing- and food production industry showcase how private initiatives can pave the way for new, innovative approaches that reduce and utilise waste as a SRM and by-products. The highlighted examples cover a range of sustainability initiatives such as:

- Waste reduction activities.
- Innovative technologies utilising by-products and residues.
- Consumer Cooperative models & promoting alternative consumption models.
- Inclusion and knowledge sharing with consumers.
- Networks with the purpose of utilising waste and by-products.
- Trans-sectorial collaborations, though industrial symbiosis.
- Higher economic and environmental performance.
- Closed loop production.
- Making alternative raw materials to artificial fertiliser available and
- Facilitating the development of innovative technologies and knowledge sharing.

The best practices examples illustrate both niche activities and established initiatives, which aid the transition towards more sustainable production and consumption models. The initiatives have a significant impact in reducing food waste, freshwater usage, land use, transportation and the promotion of environmentally responsible behaviour. The examples illustrate pathways promoting circular economy and environmentally responsible consumption patterns, but also the possibilities of

[236] Food Supply (2018): Arla skovler penge ind på valle.
[237] Arla Food Ingredients Group (n.d.): History.
[238] Food Supply (2018): Arla skovler penge ind på valle.
[239] Arla Food Ingredients Group (2019): Corporate Responsibility Report – Supplement – 2019.

exploiting unutilised and unregistered residues from production, farming and fishing industries for new application, minimising waste, and consumption of virgin resources.

8.3. DRAFT STRATEGY OBJECTIVES AND OUTPUTS

The following section proposes long-term strategy for increased utilisation of bio-waste and surplus materials from the Portuguese agriculture, fishing, and food processing sectors. The suggested goals are made operational with strategy objectives and related outputs and activities.

Long-term goal

The development objective and long-term goal are related to visions and strategies described in the previous sections, including the Circular Economy Action Plan:

By 2030, less residual biomaterials from agriculture, fishing and food production industries are wasted and the residual biomaterials are recognised and utilised as Secondary Raw Materials

Strategy objectives

The strategy objectives express the desired situations that the strategy seek to achieve in perspective of the overall goal:

1. Knowledge on options and possibilities for utilising residual industrial biomaterials as secondary raw materials is acknowledged in the industry
2. Cost efficient solutions for commercial use of residual industrial bio-waste are implemented

8.3.1. STRATEGY OBJECTIVE 1: KNOWLEDGE ON SRM OPTIONS AND POSSIBILITIES ACKNOWLEDGED IN THE INDUSTRY

The project has revealed that the value chain actors are largely ignorant of the possibilities for utilising secondary raw materials in commercially attractive and environmentally sound business models. A knowledge base should be established, information and knowledge must be shared, and possibilities made known to the industry – helping stakeholders consider secondary materials as potentially valuable raw materials. To achieve this, two outputs should be delivered.

Strategy Output 1.1 - Available/potential SRM and by-products are mapped

Establishing an overview of the available – or potentially emerging – types and quantities of industrial waste and surplus materials is a prerequisite for engaging commercial stakeholders in the pursue of new productions based on secondary raw materials. To ensure that data are reliable, the registration must be practised homogenously and correctly throughout the value chain.

Activities to achieve the strategy output:

- Involve stakeholders within the bio-materials value chains.
- Decide scope of the mapping of materials with potential for use as secondary materials.

- Establish system for mapping[240];
- Create structure for supporting stakeholders' mapping.
- Disseminate information on new procedures and systems to key stakeholders.
- Support stakeholders' monitoring and
- Compile data and make results available to the stakeholders.

Strategy output 1.2 Knowledge on solutions distributed within the sector

All stakeholders in the value chain – including both the companies generating the waste materials and the potential business customers to the secondary raw materials – need to be aware of the different potential solutions for increased utilisation of the SRM to co-create new products. Information on economically viable solutions should be disseminated broadly.

Activities to achieve the strategy output are:

- Develop a platform (information channel) to share solutions.
- Compile good examples from Portugal and EU MS on commercially attractive utilisation of secondary bio raw materials.
- Develop information material for the industry and the public that share initiatives and solutions.
- Create networks to foster cooperation between stakeholders and to establish trustful relationships.
- Disseminate information on Portuguese and European funding options for I&D projects and
- Support co-creation and partnerships in different value chains (agriculture, water services, tec.).

8.3.2. STRATEGY OBJECTIVE 2: COST EFFICIENT SOLUTIONS FOR COMMERCIAL USE OF RESIDUAL INDUSTRIAL BIOMATERIAL ARE IMPLEMENTED

To ensure that less biomaterial is wasted and biowaste is used as by-products and SRM, cost efficient solutions need to exist and be available for stakeholders in the industry. Strategy objective 2 focuses on how to increase the market for bi-products that are currently wasted, how cost-efficient facilities and solutions can be promoted, and industries can adopt new approaches.

Strategy output 2.1 Barriers for sale of unfit products are removed

Products with imperfections are often treated as waste or not used efficiently because they are considered unfit for the market. This is often due to strict specifications from retails and consumers' grand expectations to the appearance of fruits and vegetables. Strategy output 2.1 focuses on reducing the amount of biomaterial being wasted from the agriculture, fishing and food production industries.

One significant barrier is that consumers have grand expectations on the appearance of fruit and vegetables regarding shape, size, and colour. It can be seen as cultural barrier that "ugly" fruits and vegetables are not demanded. This can be challenged by awareness-raising and rebranding of imperfect products. If consumers are made aware of the issues of food waste, they can help solve the

[240] Methodologies for this mapping has been developed by researchers and environmental authorities – refer to, for example: Patsios, Sotiris: High impact biowastes from South European agro-industries
as feedstock for second-generation biorefineries; or Scoma et al, 2014: High impact biowastes from South European agro industries as feedstock for second-generation biorefineries;

problem by choosing to buy imperfect food products. To avoid strict requirement from retailer's new channels for selling imperfect products should also be established this could be markets where the farmers can sell directly to the costumers. Imperfect products unfit for the market can, in many cases, be used more efficiently once recognised as valuable products rather than waste or fodder.

Activities to achieve the strategy output:

- Creation of markets where farmers can sell "ugly" crops directly to consumers.
- Awareness-raising targeted companies and consumers.
- Storytelling and branding of products and awareness-raising targeted consumers and
- Support public procurement processes on 2nd class fruits and vegetable.

Strategy output 2.2 - Industries are working with more efficient utilisation of the waste and SRM

As with other SRM, the business sector requires financial and research support to increase the use of SRM.

Activities to achieve the strategy output:

- Create systems and solutions for utilizing seasonal waste/by-products in the production of other products– overcoming issues with unstable production or high costs.
- Fund systems for pilot trials and national investments in equipment for recycling of the SRM.
- Scale up pilot projects to industrial scale with economic viability.
- Map value chains of possible new synergies – inspired by the case examples in this report and taking the mapping of material amounts as starting point.
- Develop a sectoral guide for how to establish symbiosis and
- Establish a symbiosis centre to facilitate and guide CE transition and symbiosis processes.

8.4. MONITORING FRAMEWORK

A strategic plan is only as effective as its implementation, and successful implementation requires proactive strategic monitoring. While the potential benefits of strategic planning are vast, many strategic plans fail to achieve desired outcomes in the implementation phase. A strategic plan that collects dust on a shelf and fails to be integrated in other government initiatives will not be successful.

The beneath draft monitoring framework illustrates how APA can monitor the implementation of the biowaste strategy.

Overall objective and long-term goal:
By 2030, less residual biomaterial from agriculture, fishing and food production industries is wasted and the residual biomaterials are recognised and utilised as SRM

Strategy element	Indicator	Means of verification
Objective 1: Knowledge on SRM possibilities acknowledged in industry	• Industry express awareness and knowledge on the SRM options.	• Survey among industries.
Output 1.1: Available/potential SRM and by-products are mapped	• Data on SRM are available to the stakeholders.	• Review of data from the platform for SRM registration.

Strategy element	Indicator	Means of verification
Output 1.2: Knowledge on solutions distributed within the sector	• Information material disseminated to industries.	• Account of communication and dissemination efforts.
Objective 2: Cost efficient solutions for commercial use of residual industrial biomaterial are implemented	• New SRM solutions are implemented covering substantial amounts of bio-SRM	
Output 2.1: Barriers for marketing of unfit products are removed	• Increased amount of residual produce is being sold for consumption.	• Survey in the agricultural sector.
Output 2.2: Industries are working with more efficient utilisation of the waste and SRM	• Industrial knowledge of benefits of SRM use increased. • Projects and infrastructure, including symbiosis centre, have been established.	• Survey in the agricultural sector.

9. WOOD WASTE FROM THE PORTUGUESE FURNITURE INDUSTRY

Furniture manufacturing in Portugal generated 29 358 tonnes of wood wastes in 2018, of which 36 tonnes were hazardous wood waste[241]. Roughly 24% of all waste generated by the sector is wood waste. This is 12 percentage point lower than the EU average, where 39% of the waste generated by the sector is wood waste[242]. This could indicate that more wood is being used as a SRM within the factories in Portugal than in the average furniture industries in Europe, or that some residue materials are not registered as waste.

According to Eurostat, the Portuguese furniture sector recovers about 80% of all its waste and close to 100% of its wood waste (operations R2 to R11). The main use of wood waste from the furniture industry is manufacturing of compressed wood, e.g., plywood and wood pellets. In situations where recycling into new products is not economically viable, the wood waste is incinerated in the production facilities to generate energy/heat. In the case of smaller producers/family business, the dust from wood cuts can be used on animal farms and/or heat stoves. The dust can also be compacted for biomass/biofuel.

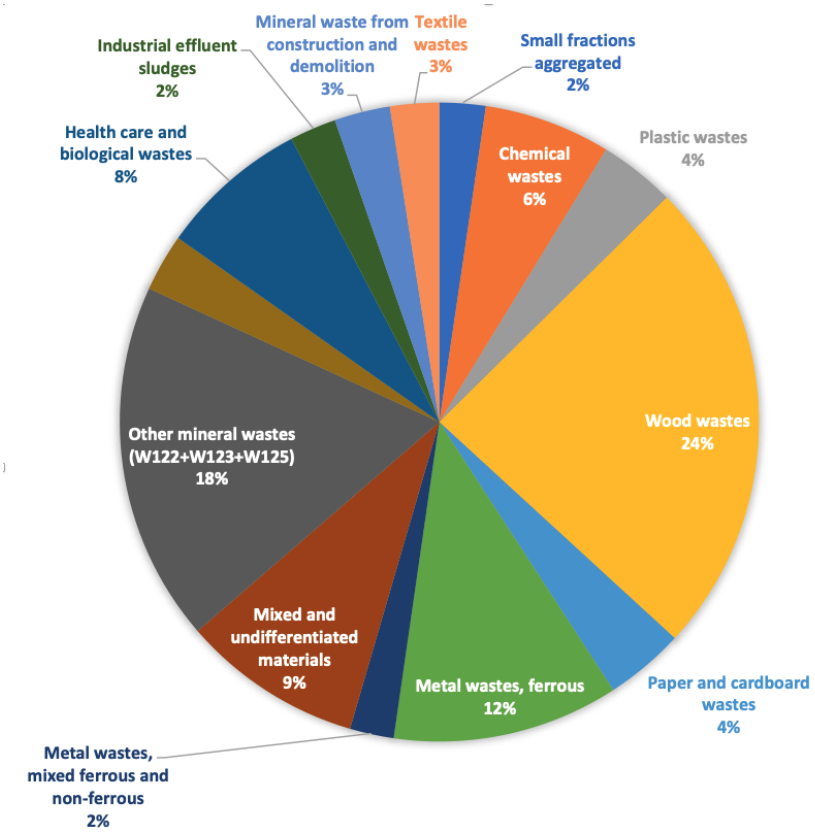


Figure 26 - Distribution of waste from the Portuguese furniture industry

[241] Wood wastes (EWC Stat code 07.5) is a classification within recyclable wastes (EWC-Stat code 06+07/07.7). Furniture manufacturing is assigned to the category - Manufacture of furniture, other manufacturing, repair and installation of machinery and equipment

[242] Eurostat (2021d): Generation of waste-by-waste category, hazardousness and NACE Rev. 2 activity.

Furniture production is a key industrial production sector in Portugal: most of the companies are small companies with only a few large companies. The furniture industry in Portugal primarily produces medium to high quality products using old traditions and handcraft methods – resulting in long product lifetimes. Wood is one of the most expensive raw materials used in the sector, so it is used as efficiently as possible. Since the utilisation of the furniture industry's SRM is already well established, the project has focused on possibilities of introducing wood waste from other sectors as a substitution for virgin wood, which today is mostly imported. This could increase the overall recycling rate in Portugal and furthermore help the furniture industry be more self-sufficient in terms of material input.

9.1. OPPORTUNITIES FOR THE FURNITURE SECTOR TO UTILIZE RECOVERED WOOD FROM OTHER SECTORS

The Portuguese furniture sector comprises approximately 5 200 companies, primarily SMEs[243] and consumes an annual 138 100 thousand tons wood[244]. By increasing the input of recovered wood from other industries and from household waste as a SRM, the furniture production sector would play a significant role in cascading the use of secondary wood and minimising the use of virgin materials[245].

Most of the furniture companies in Portugal focus on high quality furniture with a long tradition of manufacturing processes, which could impede the introduction of wood waste as a material input, with the difficulties this can create. Furthermore, in some cases the recycled materials can be more expensive than virgin wood and in particular transitioning the production process to facilitate odd shapes and types of wood can be costly. For this reason, best practise cases are needed to showcase an economically and environmentally sound utilisation of wood waste from other sectors to stimulate a transition in the Portuguese sector.

Based on statistical data from Eurostat on the major wood waste sources in Portugal, combined with stakeholder engagement and inputs, the following potentials for new sources of wood material have been investigated:

- Wood from construction and demolition sector.
- Wood from households / bulky waste and
- Wood from other 'Manufacture of wood products except furniture.'

9.1.1. WOOD FROM CONSTRUCTION AND DEMOLITION SECTOR

The construction sector constitutes a huge source of secondary wood. The recycling of CDW is still fairly new in Portugal (2007), although gaining momentum[246], but illegal dumps are still a reality[247].

Wood used in construction primarily enters the waste stream when buildings are demolished, but wood material in the form of offcuts, broken pieces and casings are also generated during the construction processes. At individual building sites, the amount of wood waste might be considered small, but at a national level substantial quantities of CDW wood waste are generated and could be an important source of SRM for the furniture sector if current barriers in collection and logistics can be overcome.

[243] Novibelo (n.d.): The evolution of the Portuguese Furniture Industry.
[244] INCF (2019): Portugal Market Report 2019.
[245] Cascading use is the efficient utilisation of resources by using residues and recycled materials for material use to extend total biomass availability within a given system.
[246] Coelho & de Brito (2007) : Construction and Demolition Waste Management in Portugal.
[247] De Melo et al. (2011): Contruction and demolition waste generation and management in Lisbon (Portugal).

One of the general challenges of using wood from the construction and demolition sector as SRM is that it is often contaminated with other materials. Chemical regulation encompassing and prohibiting a growing number of substances has led to a gradual reduction in the use of the most hazardous substances in Europe, and detection technologies are also continuously improving[248].

The EU-founded CaReWood (Cascading Recovered Wood) Project, conducted by the Fraunhofer Institute for Wood Research, focused on the use of wood as a SRM several times over by identifying suitable techniques to detect the presence of contaminants in wood and develop sufficient surface cleaning processes. This resulted in methods to identify whether recovered wood was contaminated, the depth of the pollutants and how much surface material must be removed to eliminate the contaminants. The methods used, makes it possible to identify both heavy metals and organic wood preservatives. By removing a few millimetres of the outer layers of the wood, it becomes possible to recycle wood underneath the surface layer. The Fraunhofer researchers argues that by combining the methods identified in the project with a suitable stripping and sorting processes, a not insubstantial volume of wood could be recycled to make furniture or in construction[249]. Nevertheless, not all wood material from CDW will be possible to recover in a sufficiently clean quality to serve as SRM. In such cases incineration will be the preferred solution.

To use waste wood from the construction and demolition sector in the production of furniture, the wood needs to be available, separated from other waste streams and have a suitable quality. Today logistical challenges in waste collection, such as poor source separation of wood at construction and recovery sites makes it difficult to reuse/recycle the wood. For an effective cascading of recovered wood from C&D sector, verified information relating to the expected amount and quality of the recovered wood is essential. Germany is one of the most successful Member States in regard to recovery of wood, with close to 100% recycling. This is strongly influenced by the implementation of a landfill ban regarding biomass-based materials

New furniture from historical building demolitions

The Slovenian furniture company, M SORA (established in 2006) manufactures windows solutions and doors. M SORA have collaborated with local municipalities in a project funded by the European Union with a goal of using wood residues and waste wood from industrial plants in the production of their windows solutions.

The discarded wood is recovered from characteristic historical building structures such as barns, mills, sheds, homesteads, or hayracks and is recycled into a modern, high-value product. The high-quality wood material was before used in domestic or industrial furnaces or ended up in landfills. With M SORAs approach, up to 30% of the wood from old structures can be recovered and recycled.

M SORA further participates in the project RecAPPture dedicated to the development of a mobile and web application connecting M SORA to users with waste wood available for use in the production of windows. M SORA is a prime example of a high-end circular approach creating long-life products.

Together with the Slovakian Ministry of Education, Science and Sport M SORA co-founded a talent competition in 2015 called ReWin. University students together with mentors from M SORA developed and produced products with timber from old windows and SRMs from the window production. The successful project showed how cooperation between private companies, research institutions and students can generate innovation and education about ecodesign.

Source: M SORA. ReWin - M SORA talent competition: http://www.symbiosis.dk/en/

[248] Reichenbach et al. (2016): Cascades – Study on the optimised cascading use of wood.
[249] Fraunhofer (2017): A second life for recovered wood.

implemented in 2003 and the Act for Promoting Closed Substance Cycle Waste Management issued in 2012, that regulates a five-waste hierarchy[250]. The implementation of similar resource cascading on a legislative level in Portugal would support the availability of recovered wood for use in furniture manufacture and the C&D sector, and it could make implementation of cleaning technologies more economically feasible.

During the workshop different solutions for increasing the collection and use of wood from C&D waste was investigated:

Improve sorting and collection

It is important that construction site waste managers understand the different fractions, possible contamination and, depending on the site and the activities taking place, be able to assess the quality of the materials. Specific local circumstances must be taking into consideration regarding trade-offs in the impact of transporting materials, options for recycling or reuse depending on quality in addition to the benefits that can be achieved through different recycling routes[251]. Furthermore, it is equally important that site workers understand the waste system and have the competency and capacity to sort waste correctly. A way of overcoming obstacles of minimal space and difficult collection and construction sites is to design CDW collection containers specifically to accommodate different parcels by wood type. This approach has been successfully developed by the Danish project 'GENTRÆ,' which is presented in the CDW strategy draft section 6.3.

Recent technology could be used as an aid in the sorting of CDW, such as a mechanical sorting by an air separator. A study was conducted with mechanical separation of a material mixture from a renovation site and a construction site, using commercial sorting equipment consisting of a roller screening and an air separator unit. With this technology it was possible to separate the construction and renovation waste into nine fractions and regulate the purity levels of the separate fractions. This approach is technically proficient at sorting CDW, but for economic reasons it is not generally appropriate to produce the highest purity level of fractions yet. In certain cases, some impurities are acceptable, e.g., a mixture of wood and thermoplastic recycled into composite materials[252].

Give training and education for companies and universities about eco-design

Novonovo is a Portuguese organisation, which facilitates and promotes the practice of reuse and recycling as an essential tool for sustainable development. The organisation aims to generate materials of necessary quality by gathering production surpluses, unused leftovers from construction projects and unsold stock etc. The organisation also offers professional training, workshop facilitation and debates on circular design, and creates content to help teachers develop programs and content on circular design and systematic thinking[253]. Novonovo was created in 2019 through the 'Creative Business Studio' organised by Impact Hub Lisbon. The organisation supports the development of sustainable projects in both the design and production phases, offers consultancy to companies that want to adopt more sustainable production and support educational institutions in the didactic development of contents related to circular economy and design[254]. To support the circular design movement among designers, architects, artist, and makers who seeks new material solutions, Novonovo have created an online platform to help find recoverable materials easily and quickly. The

[250] Höglmeier et al. (2017): Potentials for cascading of recovered wood from building deconstruction
[251] JRC (2011): Supporting Environmentally Sound Decisions for Contruction and Demolition (C&D) Waste Management
[252] Hyvärinen, M., Ronkanen, M. & Kärki, T. (2020): Sorting efficiency in mechanical sorting of contruction and demolition waste.
[253] Novonovo (n.d.c): Education.
[254] Novonovo (n.d.a): About.

platform is based on three foundations: Outcycling, upcycling and networking. Companies, professionals, and other organisations have the opportunity to sell or donate materials and objects that they consider useless though the outcycling process. Professionals from the creative industry gain access to valuable materials at affordable prices and thereby be a part of an upcycling process[255].

9.1.2. WOOD FROM HOUSEHOLDS / BULKY WASTE

Household waste is heterogeneous, and the quality of the wood varies considerably. A significant share of furniture is collected separately from other mixed household waste streams by municipalities but is not subject to differentiated treatment. As such, a significant amount of the material is lost. According to Portuguese stakeholders, the heterogeneous nature of the household waste and the quality of the wood it contains are key barriers to incorporating this type of wood waste into furniture production. Improving separation and collection technologies is therefore essential. Today the cost of separating the waste is often too high to be economically viable.

Key drivers for valorisation of wood waste are clear legislation and classification of wood waste. Many Member States have already developed their own classification systems, but there is no common harmonised system at EU level[256]. In the Netherlands, bulky household waste often contains a considerable amount of wood, which is often separated into the national classification A, B and C timber waste. The 'clean' wood waste from households consist mostly of furniture and demolition wood. A and B class wood is utilised in the pallet, chipboard, and energy industry. C classified wood is primarily used for energy purposes[257]. The Horizon 2020

Particleboard Industry

The particleboard industry is currently the primary route for wood recycling in Europe. Particleboards are made from wood chips, sawmill residues and sometimes recovered wood flakes. The wood input is mixed with a binder e.g., a synthetic resin. Since particleboards can be produced from a variety of wood raw materials, the process is well suited to using recovered wood as input. Today the particleboard industry uses large quantities of recycled wood that originates from the packaging, furniture, and construction sectors, as well as industrial residues from the sawmill industry[1]. The proportion of recycled wood in particleboard varies across countries. In Italy, for example, the proportion of recycled wood is close to 100 %.

In 2019, 37.07 million m^3 of particleboard was consumed in Europe. The furniture industry is one of the major consumers of particleboards. Particleboards are easy to work with and can replace solid wood in a variety of applications. They are often used as a base material in furniture manufacturing.

The main driver for using wood waste in particleboard production have been a lower material price for recovered post-consumer wood compared to other possible wood inputs. Another driver is the low moisture content in post-consumer wood waste, which reduces the amount of energy required for drying. The demand for recovered wood waste in particleboard production has triggered efforts to establish wood waste recovery systems. This is especially the case in Italy.

Sources: Besser et al. (2021): Cascading Recycling of Wood Waste: A Review. Reichenbach et al. (2016): Cascades – Study on the optimised cascading use of wood.

[255] Novonovo (n.d.b): Manifesto
[256] Nannoni, S. (2019): Valorising wood waste for energy and materials in Europe.
[257] NL Agency (2013): Sustainable Bio-Mass – Competition in wood waste: Inventory of policies and markets

project BIOREG included five model regions that have established renewable wood waste-based systems at distinct stages of the value chain (pre-sorting, sorting, collection, recycling, and wood waste treatment) Alentejo and Lisboa are included in this project. The project concluded that an efficient collection and sorting process requires increasing and enhancing the local circuits and platform[258].

A set of more specific solutions to inject wood waste back into the economy as secondary raw materials have been co-developed during the workshop with 88 experts within sectors producing, managing, and incorporating wood waste. After intensive and structured discussions, the participants developed the following ideas to overcome the identified barriers to valorize wood waste:

Legislation that insures separate collection of furniture

The collection of furniture separately from other bulky waste could facilitate better handling and recycling of furniture. There is significant potential for reusing wood furniture. The main challenge is to develop collection schemes that allow collection of old furniture without damaging the materials. In Dhaka, Bangladesh, approximately 90 second hand furniture shops were identified in three specific areas of the city. The second-hand shops collect old furniture, such as wooden beds and chairs from houses through advertisement in posters, newspapers, and the internet, and sell them at a low price to primarily low- or middle-income people and students, creating value and accessibility for material and products that would otherwise have been considered waste[259].

Opportunities for recycling wood from household / bulky waste not suitable for reuse should also be examined. Today the only wood-based production in Europe using recovered post- consumer wood is particleboard production[260]. As the furniture industry is one of the major consumers of particleboards, the industry can play a key role in cascading the use of wood. For example, if more recycled material becomes acceptable in furniture production, it will become more attractive for particleboard producers to offer panels with a high proportion of residues and recycled material.

Increasing the use of recycling stations

Several options for increasing and improving the use of recycling stations for wood collections was discussed at the workshop. Examples:

- Simplifying the process of establishing recycling stations in Portugal.
- Making sure all recycling stations have different containers for bulky waste such as wood as well as mattresses, carpets, beds and sofas.
- Incentive systems that encourage consumers to deliver their furniture or to recover it (e.g., giving credit to citizens who deliver their bulky wastes).
- Divert street collection for bulky waste to be sorted at recycling stations and ban the direct landfilling.
- Communication material for citizens: Municipalities should provide more and better information about the solutions available.
- Additional support for collection schemes in low density areas and
- Online platforms or apps which can identify materials/wood available to use/reuse.

[258] Nannoni, S. (2019): Valorising wood waste for energy and materials in Europe.
[259] Chakraborty et al. (2015): Reusing and Recycling Practice of Old Furniture in Dhaka.
[260] Reichenbach et al. (2016): Cascades – Study on the optimised cascading use of wood.

The large Rilegno network is a showcase of excellence in post-consumer wood waste and recycling logistic, enabling a competitive recycling market with up to 2 million tons of collected material annually, maximizing the benefits of an integrated circular value chain and market approach for the entire wood and furniture sector.

The entire Italian wood collection and recycling system stands upon the activities of Rilegno - the national consortium for the collection, recovery, and recycling of wooden packaging. Rilegno consist of a dynamic group of 2000 companies, which transforms wood, produce packaging, supply, and import semi-finished packaging. Besides this, the Italian national consortium also consists of voluntary members, including recycling companies, producers of boards, pulp, blocks, panels, and pallets.

The collection network covers the entire country with 419 private collection platforms serving the industrial and commercial sector. Besides this, more than 4,500 municipalities representing over 42 million inhabitants have signed agreements for urban collection. 15 major panel producers recycle large volumes to supply board products to e.g., furniture industries, amounting for about 3,2 million tons of released items. 63% of the materials recycled into boards comes from wooden packaging such as pallets, crates for fruit and vegetables, boxes, cable reels and cork stoppers.

Source: Wood Circus (2021): Good Pratices in Circular Economy – Rilegno Particle board Industry

9.1.3. WOOD FROM OTHER 'MANUFACTURE OF WOOD PRODUCTS EXCEPT FURNITURE'?

Since wood waste or secondary resources from the furniture production industry to a high degree is already used, a way of increasing the use of SRM in the industry could be to look at other production industries with wood waste available.

At the workshop ideas from stakeholders about how to overcome barriers was gathered:

- Improve sorting at the source. For example, wood packaging in roof markets or removing carpet from wood coming from exhibitions.
- Waste managers cooperate to "teach" waste producers the best practices, and also to charge the real costs of waste collection, transportation, cleaning and sorting.
- Implement an efficient collection and separation network (like Sociedade Ponto Verde) and
- Incentivise companies to collect reverse logistic (similar to what is already done with the finishing products).

Aside from from furniture production, the market for wood in Portugal feeds a broad variety of industries. with a forestry industry oriented towards both domestic demand and export. The paper industry is particularly well developed in Portugal, accounting for half of the wood- related products exported. The cork industry is also prominent subsector, around 50% of the global cork production is located in Portugal[261]. However, logistical solutions for collection and separation are needed to utilize wood waste from other sectors in the furniture industry, while new business models and opportunities within these industries and value chains should be explored. This requires knowledge and skills in identifying and securing a stable source of reclaimed wood, either through partnerships with waste handling companies, industries and/or local public authorities. Through partnership, other barriers to recycling could also be overcome for example, finding alternative solutions and substances such as chemically processed glues and varnishes that can increased recycling possibilities[262].

[261] SGS (2017): Market analysis Availability of forest products and by-products Portugal, Project No. 130373.
[262] Erasmus+ (2018): Circular Economy in the Furniture Industry: Overview of current challenges and competences needs.

Collaboration, partnership, and industrial symbiosis can play an essential role in transforming wood waste streams into SRM. Experience from national and European examples such as 'Relvão Eco Industrial Park' are useful in the conceptualisation of models for industrial development[263].

Since paper is already collected by Sociedade Ponto Verde (SPV), this could be the access point for the furniture industry. There are only a few examples of recycled paper used within the furniture industry, such as the PaperBricks project, a furniture collection made from newspaper pulp and glue and pressed into moulds[264]. Another inspiration could be the designer Vadim Kibardin, who only uses recycled cardboard and glue in his furniture production line. The furniture is produced by hand cutting cardboard, layering, and gluing sheets of cardboard together. Kirbardin's products are all 'one-of-a-kind' products[265]. Both examples should be considered niche projects, and since there are many other applications for recycled paper such as the production of toilet paper, the economic sustainability must be taken into consideration.

The cork industry constitutes greater potentials to promote reclaiming of Portuguese production waste streams. Since cork is highly recyclable, collaborations between organisations such as Green Cork (PT), Cork Stopper Recycling Bin (PT) and Crokscrew initiative (PT)[266] and Sociedade Ponto Verde or Novo Verde could help spread awareness of cork recycling potentials and the collection of used cork. This approach could facilitate an industrial symbiosis between the furniture sector and cork collection organisations. The many properties of the cork material could serve as an opportunity of innovative applications within the furniture sector. The low density of cork makes it fire retardant, non-slip, non-toxic, flexible, and highly resilient[267], all properties that could be seen as favourable for the furniture sector if used properly. Examples of the use of cork in the furniture industry have already surfaced in Europe and internationally: in the Morten Husum design 'OAK,' a children's chair that utilize the formability of the cork[268] or in the 'Kork, table and lightning' series from TwoDesigners[269]. The Brazilian brand, Humberto & Fernando Campana, have illustrated the

Dieffenbacher is a leading manufacturer of press systems and complete production plants for the wood-based panels, composites, and recycling industries. Dieffenbacher has developed a recycling wood processing concept based on a novel combination of proven screen and sifter technology and sensor-based X-ray sorting for the wood-based panels manufacturer, Pfleiderer in Neumarkt, Germany. Both were integrated into the existing Pfleiderer plant structure. The intelligent cleaning and sorting systems reliably eliminate impurities and increase plant availability. Since it went into operation in January 2018, Pfleiderer has significantly increased the proportion of recycled wood in the production of particleboard while retaining the same high level of panel quality. Particularly in the preparation of fine materials, the wood loss was notable since the technology make it possible to reach the required degree of cleanliness in all particle sizes. Pfleiderer expect, that the technology will continue to expand the economic benefits of using recycled wood in their production line.

Sources: Diffenbacher (n.d.): More recycled wood in particleboard production.

[263] Ferrão et al. (2016): Industrial ecology and Portugal's National Waste Plans.
[264] Fonder (2016): Furniture Made from Recycled Newspaper Offers Up Eco-Friendly Elegance – WooJai Lee's PaperBrick project, fresh out of Dutch Design Week 2016.
[265] Samwell (2021): Vadim Kibardin creates furniture from recycled paper and cardboard.
[266] APCOR (n.d.a): Recycling.
[267] Advameg (n.d.): Cork.
[268] MortenHusum (2013): OAK OAK.
[269] Itsliquid (n.d.): TwoDesigners: Kork, table and lightning, Design.

possibilities for furniture made only of cork in their 'The Sobreiro Collection' with two cabinets made from agglomerated cork. The furniture from this collection is both recyclable and biodegradable[270]. The cork industry would also benefit from diversification in the use of cork, making it more resilient against changes in the use of cork stoppers in the wine industry[271]. At the moment 72% of all cork export consist of stoppers with the remaining 25% of cork exports relate to construction and decoration activities[272]. The furniture sector could be a part of the diversification in the use of cork, and at the same time utilizing the cork not suited to produce cork stopper, virgin cork, secondary cork, and by-products such as cork granulate or dust. At the moment, the main application for the virgin cork is generally cork panels and shoe soles, which are less profitable than the use of reproductions cork in the stoppers industry[273].

Cooperation between the government, academia, and private sector in Portugal, based on industrial ecology principles improves waste management, environmental performance, and economic growth and job creation simultaneously[274]. Whether this would be through end-of-waste criteria, facilitation collections or improvement of sorting at the source of waste streams, cross-sectoral collaborations would promote the use of recycled of wood in the furniture industry.

9.1.4. CONCLUSIONS

Although wood waste in the furniture industry is already largely reprocessed or otherwise treated within the industry itself, there remains potentials in the collection, reuse, and recycling of wood wastes from other industries and from post-consumer waste streams. Collaboration between the furniture industry, (wood) waste management and recycling companies, and industries that produce viable quantities of wood waste could provide an additional and valuable source of SRM for the furniture industry and reduce dependence on wood imports. While wood waste from some industries – most notably the construction and demolition industry – is likely to be contaminated with other materials or unwanted treatments, recent technologies and methods of sorting and cleaning these wood wastes have been shown to be effective and potentially economically viable. Close collaboration between the actors within the furniture industry and those generating wood waste could help generate a cleaner waste fraction that is easier to integrate in furniture production. Where wood cannot be directly used, it can be cleaned and become a raw material for particleboard and fibreboard production - a core input to the furniture industry.

Of particular interest to Portugal, there could be valuable potential in utilising waste from the cork industry. This would both make better use of cork residues and potentially provide an addition revenue stream for the cork industry, which is currently higher dependent on the wine and bottling industry.

9.2. EU BEST PRACTICES EXAMPLES

Kronospan (M)

Kronospan is a leading manufacturer and distributor of wood-based panels (including Particleboard (PB), Medium density fibreboard (MDF), Laminate flooring, UF, MUF and MF resins for wood-based panels and oriented strand board (OSB)). Kronospan manufactures wood-based panels at more

[270] Frost (2018): Designers Push Cork with Furniture Collection.
[271] Mestre & Gil (2011): Cork for sustainable product design.
[272] APCOR (n.d.b): Cork in Numbers.
[273] Tedjditi et al. (2020): Potential of using virgin cork as aggregate in development of new lightweight concrete.
[274] Ferrão et al. (2016) Industrial Ecology and Portugal's National Waste Plans.

than 40 countries (mostly EU Member States) using wood residue from the sawmill industry[275]. Kronospan uses low grade wood residues, small and oversized roundwood and recycled wood to produce technically advanced engineered products. When a waste material cannot be used in one of the onsite processes, they seek out recycling opportunities in partnership with other companies. Kronospan monitors their use of water and energy to identify opportunities to reduce consumption and have invested heavily in processes that generate energy from wood-based carbon neutral fuel[276]. Furthermore, they accelerate the circular economy in general for the wood-based panel industry by recycling wood residue from other producers and by only collection wood responsibly, supported by recycling and sustainable forestry, to produce carbon negative boards. Their wood-based panels are certified by PEFC or FSC and Kronospan ensures that suppliers do not use wood from national parks, natural preserves, virgin forest, and other conservation areas[277].

EGGER Group's Timberpak recycling enterprise

EGGER Group produces furniture and interior design, building products and flooring around the world. With an annual production capacity of 8.9 million m^3 wood-based materials and production sites and sales locations all over the world, Egger Group have the possibility of making an important contribution to a more sustainable sector, illustrated by their commitment to public accountability for its environmental and social impacts, both of positive and negative character. One of their commitments is to the environmental oriented ISO 14001 standard implemented in 15 out of 20 locations[278]. EGGER Group have invested in a resource saving technology and include recycling in the process. Up to 30% of the wood used in their chipboards comes from waste wood - furniture, pallets, wooden packaging materials, and from construction and demolition. In the UK, Germany and Romania, the EGGER Group runs its own recycling enterprises under the name Timberpak. Suitable recycled wood is processed there and used for chipboard production. Large volumes of by-products and recyclable wood are generated by the plants. Timberpak upgrades them into materials or use them to generate heat and electricity[279].

Clarity Environmental

Clarity Environmental specializes in environmental compliance, recycling, and waste management. They provide are tailor made solutions for waste producers and energy recovery plants, diverting waste from landfill, and enabling waste-to-fuel conversion across the UK & Europe[280].

Clarity makes it possible to recycle wood waste one last time in compliance with the UK standard for recovered wood. In the UK grade Some wood is classified as 'clean' recovered wood such as pallets and secondary manufacture that can be recycled into animal bedding and mulches. Grade B is the industrial feedstock grade, including grade A materials and construction and demolition waste suitable to be recycled into e.g., panel boards. Grade C, also called the fuel grade, stemming from civic amenity and municipal collections, suitable to produce biomass and energy production. Grade D is hazardous waste[281]. Their service has been designed to work around the demands and challenges

[275] Kronospan (n.d.b): Our Commitment.
[276] Kronospan (n.d.c): Respect for Nature and its Materials.
[277] Kronospan (n.d.b): Our Commitment.
[278] E EGGER (2020): More from wood. More transparency. 2019/2020.
[279] E EGGER (n.d.): Recycling.
[280] Clarity (n.d.a): Our Services – waste to fuel.
[281] ENVA (2009): Recycled wood grades defined for the first time.

faced by the wood market, with a guaranteed year-round service and a fixed gate fee, which allows customers to plan their annual budget and in compliance with the Environment Agency regulations[282].

Holy Wood, Belgium

The small Belgian cooperative association of craftsmen, designers and joiners, Holy Wood, creates designer furniture with locally recovered wood in an ethical and holistic micro-value chain approach. Furniture that cannot be sold and solid wood pieces are collected locally in the town of Ghlin[283]. Thereafter, the furniture and wood pieces are dismantled, recovered, and reused to produce new furniture. The cooperative experience an abundance of waste that can be transformed to secondary raw materials, making it possible for the furniture Holy Wood produce to be made from 85-100% recovered wood. In a social sustainable initiative, much of the old furniture is obtained from Emmaüs social cooperative, which acts against poverty and exclusion. The Holy Wood approach gives a second life to wooden furniture that would otherwise have been incinerated[284].

Melu

Melu is a Slovenian company manufacturing internal doors that are mostly produced from locally sourced wood, from producers taking the general sustainable development into account. The only non-locally sourced wood used in the production of doors, is obtain from Finland and FSC certified. Melu reuse recovered wood from old doors and old wooden constructions as core-material for new, custom-made solid wooden doors. By doing so, wood that would otherwise have been considered waste gains a second life, prolonging the carbon storage and maintaining its value. Their custom-made design is known for their high quality, long lifetime, and valorisation of the natural material wood, which helps raise awareness for circular economy[285].

[282] Clarity (n.d.b): Waste-to-fuel – Wood energy recovery.
[283] Holy Wood (n.d.a) : Qui sommes-nous ?
[284] EU (n.d.): Holy-wood upcycles old-fashion furniture into designer creation
[285] WoodCircus (2020b): Good Practices in Circular Economy - Melu doors.

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11. NOTE ON INDUSTRIAL SYMBIOSIS

The term *industrial symbiosis* is a reference to organic eco-systems found in the biological domain, where distinct organisms gain mutual benefits by sharing resources in co-dependent cooperation. In the *industrial* context, the biological organisms are simply replaced by economic entities.

Industrial symbiosis (IS) engages traditionally separate economic entities in a collective approach to competitive advantage, involving the exchange of products or by-products (including residues and waste materials) with the aim of utilising these in a processing industry. In other words, IS describes the situation where secondary raw materials from one or more companies becoming resource inputs another company. The resources exchanged in an IS are often material, but modern understandings of IS often expand the traditional definitions to include non-material exchanges such as the exchange of water, energy, logistics, assets, and even expertise[286].

IS is a circular economy strategy; it closes the materials loop, reduce resource usage, and provide a more circular economic model for modern companies, compared with the traditional linear 'use-disposal' model.

It is easy to confuse the term IS with cascade utilisation, so it is important here to make a distinction: Cascade utilisation is when a by-product from one company is converted into a product by another company. The exchange can be one-way and might involve just two companies. IS on the other hand, is a more comprehensive form of cascade utilisation that often involves several companies. Chertow, 2007 whom have been cited in an Interreg Europe policy brief, defines industrial symbioses as at least three different entities involved in a two-way exchange of at least two different resources[287].

A famous example of industrial symbiosis is the Kalundborg Symbiosis consisting of twelve public and private companies that have formed an industrial symbiosis around the exchange of water, energy, and by-product materials. Since 1972, they develop the world's first industrial symbiosis with a circular approach to production.

A specific result of this symbiosis is the establishment of Kalundborg Bioenergy by four of the companies in the symbiosis. Kalundborg Bioenergy receives biomass from the companies Novozymes and Novo Nordisk in a biogas facility. The gas produced is upgraded in a refinery that removes CO_2 and hydrogen sulphide before it is sent to two other local companies, Gyproc and Equinor as well as to the local natural gas supply network. Finally, Sulphur from the hydrogen sulphide fraction is collected and used as a sub-component in fertilizer products produced based on the biogasified residual biomass. Like this one, more projects have emerged over the last six decades ranging from algae production facilities to bio-ethanol production, with projects already being implemented at larger scales.

The main principle is that side streams from one production are passed on as an input resource to another production, benefiting both the environment and the economy. Such symbiosis creates growth in the local area and supports the companies' CSR efforts and climate change mitigation. In other words, it increases resilience and economic gains, while reducing the environmental impact and expenses of each company.

Source: Kalundborg Symbiosis, 2021. Explore the Kalundborg Symbiosis: http://www.symbiosis.dk/en/

[286] International Synergies (n.d.): What we do.
[287] Chertow (2008): "Uncovering" Industrial Symbiosis.

Definitions[288,289]

Industrial symbiosis: is when three or more economic entities are collectively engaged in a two-way exchange or products or by-products, such as heat, water, energy, logistics, assets, or expertise, with the purpose of simultaneously increasing competitiveness and reducing environmental impacts.

Cascade utilisation: when products or by-products from one entity become the resource input for the production in another economic entity.

The economic entities may be private companies and organisation, or public institutions, suppliers, or waste operators e.g., Often IS involved both public and private entities, as seen in the Kalundborg Symbiosis.

An IS configuration typically takes the form of the exchange either[290]

- among firms co-located in a defined eco-industrial park
- among local firms that are not co-located
- among firms organised "virtually" across a broader region

As such, it is a misunderstanding that IS must be in close connection to one another. However, it is still an advantage when the material exchange requires strong infrastructure and logistics for instance as with the exchange of heat, water, energy etc. Therefore, it is the case for many IS that they are in eco-industrial parks.

11.1. DRIVERS AND PRE CONDITIONS FOR INDUSTRIAL SYMBIOSIS

Understanding the drivers and required preconditions to establish IS is especially interesting since there are many economic, environmental, and social benefits associated to its formation: regions may benefit by attracting companies to locate or to remain in the municipality, and thus ensuring jobs and tax revenues, while they may also create a local environmental brand by managing resources better through the transition to circular economic models. IS formation has been vastly investigated by several scholars and common traits, especially within direct and indirect policies, have been identified.

Of course, establishing IS also consists of overcoming economic, social, technical, communication, and information barriers given its immense complexity. And table 4 presents a list of examples within each category of the listed barriers. However, and despite the existing barriers there is a sizeable number of very successful cases of IS around the globe.

Two recent Interreg reports from 2020[291] and 2021[292] focuses on the role of national agencies and municipalities, respectively, in supporting IS by playing a strong role in seeding, development, and expansion. The reports are based on the analysis of specific cases in the Baltic Sea region. Even though both reports focus on case studies in the Baltic Sea Region the findings can be replicated in other locations, namely in Portugal.

Table 4 Barriers for industrial symbiosis

[288] Chertow (2000): Industrial Symbiosis: Literature and Taxonomy.
[289] Lybæk et al. (2021): Enhancing Policies for Deployment of Industrial Symbiosis: What Are the Obstacles, Drivers and Future Way Forward?
[290] Chertow, M. R. (2000): Industrial Symbiosis: Literature and Taxonomy.
[291] Svendsen et al. (2020): Policies Supporting Industrial Symbiosis in the Baltic Sea Region.
[292] Svendsen et al. (2021): Guide: How can Municipalities Support the Development of Industrial Symbiosis?

Category	Barriers[293,294].
Economic	High investment costs, long payback periods, uncertainties about the profitability of partnerships, cheap raw virgin materials, lack of marked demands.
Social	Reluctance to changes, lack of trust among competing companies, and lack of time and resources for companies work outside core business etc.
Technical	Long physical distances between companies, and lack of technical solutions for the specific cascade utilisation.
Information	Lack of knowledge about possible side-streams and potentially collaborating partners.
Policy	Lack of comprehensive and coherent strategies, strong investment in existing industrial structures, and uncertainty in legislation.

Table 5 combines the main findings of the two reports with the drivers and pre-conditions being clustered under four categories: Network / stakeholders condition, Planning framework conditions, Energy and environmental policy conditions, and Conditions for economy gains.Table 5 Drivers and pre-conditions for industrial symbiosis

[293] Johnsen et al. (2015): The potential of industrial symbiosis as a key driver of green growth in Nordic Regions.
[294] Moodie et al. (2019): Industrial Symbiosis in the Baltic Sea Region: Current Practices and Guideline for New Initiatives.

How national agencies can support industrial symbiosis.	How municipalities can support industrial symbiosis.	Overarching conditions[295,296,297,298]
Network / stakeholders condition		
Establish a national network on IS. **Facilitate matchmaking of companies that can potentially constitute an IS.** **Increase coordination between national and local levels of governance.**	Promote the benefits of IS among businesses. Be a neutral facilitator between (potential) partners. Network building and maintenance through matchmaking events and knowledge exchange initiatives. Engage stakeholders to align vision (visual outlook of heavy industry, noise, smell, increased traffic, etc).	Local political support. Engagement of local communities. Strong, enthusiastic, and committed leaders that push for mentality changes and visionary ideas. Stakeholders must be complementary and diverse: one man's waste is another man's resources.
Planning framework conditions		
Increase regional or local level capacities and inform on the possibilities of IS when in dialogue with businesses. **Support companies in conducting screening of side-streams.** **Build up a national digital platform mapping the side-streams of all companies.**	Identify industrial strengths within the municipal area (ex: aquaculture, agriculture, or heavy industries), as well as waste streams, resources, and demands. Promote entrepreneurial and collaborative culture with room for innovation. Plan land use to secure companies with potential to exchange resources are located closely to one another. Support infrastructure such as areas of renewable energy, grits, transportation, and waste collection and management including dialogue across the value chain.	Interplay existing public supply net infrastructure and even household waste management facilities. Development of platform providing information on the availability of by-products and cooperation opportunities to foster private initiatives. Stakeholders must be in the same territory to minimize transportation costs and facilitate communication.
Energy and environmental policy condit**ions**		
Integrate IS in the national political agenda as a key element of the circular economy.	Fostering procurement criteria that award points or otherwise give advantages to circular products and services.	Flexible regulative framework as IS often interplays with several legislative areas that are not

[295] Lybæk et al. (2021): Enhancing Policies for Deployment of Industrial Symbiosis: What Are the Obstacles, Drivers and Future Way Forward?
[296] Johnsen et al. (2015): The potential of industrial symbiosis as a key driver of green growth in Nordic Regions.
[297] Desrochers (2008): Cities and Industrial Symbiosis: Some Historical Perspectives and Policy Implications.
[298] Desrochers (2008): Cities and Industrial Symbiosis: Some Historical Perspectives and Policy Implications.

Place the responsibility of promoting IS to a single government agency. **Identify and remove regulatory barriers where this does not compromise environmental protection.**		usually related nor enforced by a single public body. Stable and predictable legislative structure enabling companies to plan and integrate IS as a strategy to comply with future regulation. Environmental regulation such as high taxes on landfill and incineration of waste, bans on landfilling organic waste, and 'pay-as-you-throw' schemes, to incentivize better waste management. Element of circular economy strategy. Developed green criteria for (public) procurements. Centralised authorities dedicated to foster and implement circular economy agenda and initiatives.
Conditions for economic gains		
Offer long-term funding ear marked for IS. **Create incentives through taxes and subsidies.**	Overcoming excess of energy taxation by establishing a 'Harbour model,' meaning the municipality rents the plot to an administrative body, which again rents it out to companies so taxes on energy are only paid for the first use.	Geographical proximity securing lower transportation costs[299] and consequently lower environmental costs. Flexible (public) funding schemes. Overall beneficial programs and fiscal incentives to attract industries from different fields involving different material flows.

[299] Chertow, M. R. (2000): Industrial Symbiosis: Literature and Taxonomy.

11.2. POLICY CONTEXT IN PORTUGAL

EU policies have already addressed industrial symbiosis through the Circular Economy Action Plan, Horizon 2020, Resource efficient Europe and A Stronger European Industry for Growth and Economic Recovery Industrial Policy Communication. For instance, in the Roadmap to Resource Efficient Europe[300], EU Member States are encouraged to help industries to cooperate to increase their use of waste energy and materials. Extensive savings and earnings are predicted by applying industrial symbiosis.

A stronger European industry predicts that European industries will rely on highly efficient manufacturing processes in the future. By applying IS business models, such efficiencies will be facilitated. The circular Economy Action Plan encourages waste exchanges within industry by clarifying rules regarding by-products within the EU, and it creates an arena for implementation of IS throughout Europe. Horizon 2020 supports research projects in IS in the 2016-2017 priority area of 'Industry 2020 in the Circular Economy' focus[301].

In the context of Portugal, the project of Relvão Eco-Industrial Park is the only identified explicit example of a collaborative strategy among different stakeholders for IS at national level. Some policy instruments are already contributing to the development of symbioses, for instance mandatory electronic information reporting on waste, landfill and incineration taxes and the principle of free trade of waste. The later implied the creation of a voluntary instrument named Organised Waste Market (MOR), managed, and coordinated by a private entity and backed by public institutions financially. The aim is to promote a market for secondary resources, facilitate the transactions and promote the use of recycled products[302].

Ecoparque do Relvão in Chamusca, the Portuguese eco-industrial park for waste management infrastructure results of the synergy between 12 companies who decided to collaborate in 2006. In rough numbers, the establishment of the IS lead to new jobs creation going from 50 to nearly 350 positions in 14 companies. Finally, the development of the industrial region has until today attracted an investment of over 19 million euro.

Which conditions enabled the development of the eco-industrial park?

Environmental policy conditions: Law Decree 3/2004, with the objective of calling for a novel approach to hazardous waste management.

Local political support and strategy: Municipality of Chamusca to host an integrated recovery, treatment, and elimination centre for hazardous wastes (CIRVER) aligned with its strategy to attract business within the environmental, waste, and renewable energies sectors.

Local communities' engagement: local government facilitated events to secure the interaction between the local community, industry, and university.

Planning framework conditions: supported infrastructure for the installation of companies (e.g optical fibre).

Information about available biproducts: planning based in the principles of industrial ecology.

Source: Associação Ecoparque do Relvão, 2021: http://aepr.pt/

The use of secondary raw materials as a substitute for raw virgin materials is considered an option under the Portuguese waste management regulation (e.g., cement producers receive ash from power

[300] https://ec.europa.eu/environment/resource_efficiency/about/roadmap/index_en.htm
[301] Lybæk et al. (2021): Enhancing Policies for Deployment of Industrial Symbiosis – What Are the Obstacles, Drivers and Future Way Forward?
[302] Costa et al. (2010): Waste management policies for industrial symbiosis development: case studies in European countries.

plants). However, such efforts are scattered, uncoordinated and are often confined to large industries. The reason is partly related to the bureaucracies to obtain the necessary permits[303].

11.3. CONCLUSION

In this section the concept of industrial symbiosis has been explored, and the necessary conditions for its development explained. We can conclude that there is a big potential to develop industrial symbiosis in Portugal as there is already one successful national case, there are policy instruments set in place (e.g. mandatory electronic information reporting on waste, landfill and incineration taxes and the principle of free trade of waste), and the EU has specific programs encouraging industrial cooperation to increase their use of waste energy and materials. If more industrial symbiosis were to be developed in Portugal, it would be recommended to do so in certain regions where the economy is mostly dependent of one sector, or where most of the companies from a certain sector are located. Such is the case with the textile industry, the ceramics, and the wood industry. In the case of the wood, and as it has been mentioned in section 9.1, industrial symbiosis could be quite relevant to enable a transition toward transforming wood waste streams to secondary raw materials and utilising bi-products from manufacturing given the geographical proximity of the sector's enterprises.

[303] Costa et al. (2010): Waste management policies for industrial symbiosis development: case studies in European countries.

12. NOTE ON MODELS FOR MULTI-STAKEHOLDER ENGAGEMENT

Effective delivery of government services and implementation of new regulation is fundamental to the successful running of government. Both Arm-Length Bodies and Triple Helix Cluster organisations can play a vital role in supporting and delivering government objectives; having such bodies and organisations set in place and used optimally can be critical to carry out what are often complex functions.

For certain tasks, government can deliver these services and implement new regulation using in-house resource from within central government departments. However, in case with multi-stakeholder engagement and where government does not have the necessary skills, capability, or capacity itself, it may deliver through the private sector – either directly or indirectly. There are several ways to do this, and, depending on the nature and complexity of the services or regulation in question, options available to government is delivery through an Arm-Length Body ("ALB") or through a strategic partnership with a Triple Helix Cluster organisation.

This chapter discusses these different models for multi-stakeholder engagement that can serve as vehicles for implementation of new government regulation. First the models are presented, including definitions, funding and governance models, and feedback processes on activities and innovation. Then, strength and weaknesses are discussed for each model. This chapter also includes international case studies of ALB's and Triple Helix Cluster organisations. Finally, recommendations for further discussion with the Portuguese stakeholders are presented.

12.1. ARM-LENGTH BODIES (ABL)

An Arm-Length Body is an organisation or agency that is financed by a government but that acts independently of it. 'Arm-Length Body' (ALB) is a general term, used to cover organisations which operate at varying, and often contested, degrees of independence from government. They regulate some of the most sensitive areas of public and private activity and are often established to support delivery of public policies with a certain level of control from the government.

The ALB term is commonly used to refer to a wide range of public bodies, including non-ministerial departments, executive agencies, and non-departmental public bodies, but also other bodies such as public corporations, regulators, and tribunals.

There is a significant amount of government guidance relating to ALBs, for example on the process for setting up new ALBs, what constitutes effective governance, and how to manage the relationships between ALBs and their parent department. Activities and innovation conducted by the ALB is regulated in performance contracts between the ALB and their parent department to secure progress and direction.

To make the decisions required to run and operate an ALB effectively, the ALB and its key personnel will need appropriate delegations and potentially, subject to agreement, freedoms from certain government controls. Further, if these freedoms are eroded over time, and the level of autonomy impacted, the benefits of a body being at arm's length can be reduced. At the same time, the delegations must reflect the needs and timescales of each project or service, and departments should consider both the degree of risk and capability of the ALB in setting these, whilst also giving regard to wider value for money considerations as required.

ALBs can play a unique role in specialized delivery where government departments cannot achieve delivery in-house, and that the outcomes required are of a complexity that direct outsourcing alone would not be an effective means of delivery. The ability to flex form and function when establishing an ALB, to recruit and retain specialist capability, and to grant certain levels of autonomy mean that the ALB model can be particularly suited to specialized delivery.

However, it is equally important to recognise that there are critical enablers that government must put in place to optimize its ALBs and ultimately to ensure that our ALBs deliver value for money for the taxpayer. There are several critical success factors, based around purpose and objectives; accountabilities; sponsorship; capability and capacity; delegations and controls; transparency; management information; assurance and risk; and behaviours that will help ensure a high performing ALB and consequently successful delivery of the service or implementation of new regulation.

12.2. TRIPLE HELIX CLUSTER ORGANISATIONS

A triple helix cluster organisation is a complex regional system which has differing types of operation, depending upon the country. A cluster is a system that seeks to implement collaboration between government, business, and academia. In Europe, it is becoming steadily a common type of model of collaboration.

Triple Helix Clusters can focus on several types of thematic areas, such as renewable energy, waste management, circular economy, further on. Triple Helix Cluster organisations are politically and technologically independent organisations with a main purpose of supporting economic development, creating jobs, and fostering innovation within a sector specific field.

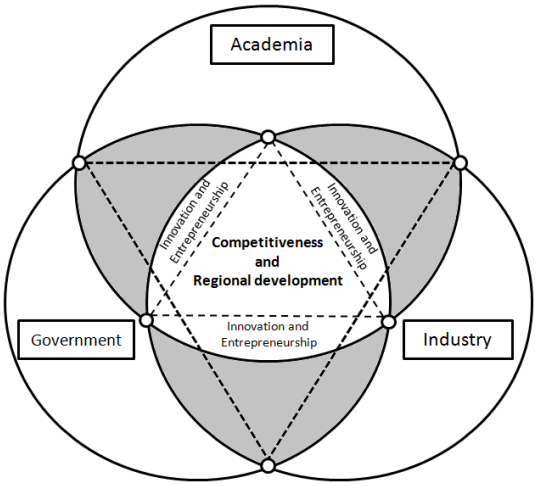


Table 6 The triple helix triangulation model by Farinha and Fereira 2016

By a cluster organisation, one should understand organised efforts to facilitate cluster development, which can take various forms, ranging from non-profit associations, through public agencies to companies. A cluster organisation typically functions as a mediator between various cluster members and adds value by stimulating collaboration both within the cluster and between the cluster and the outside world. As an independent organisation representing triple helix, cluster organisations can serve as an effective vehicle for implementing new government regulations and policies.

The presence of universities, research centres and supporting structures, and a geographical concentration of high-tech companies has shown a positive effect on the economic performance of companies in a cluster. As a result, knowledge-intensive clusters play a key role in driving innovation, regional development, and competitiveness. The ability of clusters to deliver high economic performance is often labelled as cluster excellence.

Cluster excellence can, for example, be expressed in terms of cluster growth, added value, productivity, and innovativeness. One of the factors that is seen as essential for achieving cluster excellence refers to high quality cluster management or cluster management excellence. Cluster management excellence is often linked to the strength and professionalism of the cluster organisation.

Cluster governance represents the interests of cluster stakeholders (e.g., universities and research institutes, large and small companies, government, supporting structures etc.), while cluster managers strive to serve the needs of cluster stakeholders. Cluster management addresses day-to-day cluster activities such as planning, allocation of human and financial resources, monitoring cluster progress etc. Governance, in turn, among others refers to appointing cluster managers and evaluating their performance, setting the vision and strategy of the cluster, and approving action plans.

Cluster organizations can be both public and privately funded and most clusters are non-profit. Cluster organisations are partly funded by membership fees from private companies and partly funded by public funding, i.e., local, regional, or international project funding.

12.2.1. WHAT MAKES A CLUSTER SUCCESSFUL?

Regarding the success factors for Triple Helix Cluster models a lot of research have already been done, most of it is condensed by the European Secretary for Cluster Analysis (ESCA)[304], which is responsible for giving awards, in three different Quality Labels, to qualified cluster management organisations.

Research that used the data available in the PITEC database (Technological Innovation Panel), which took a sample comprising 11,769 Spanish firms from different sectors for the 2007–2016 period reveals the importance of the cooperation of firms with any Triple Helix to increases the likelihood of innovation. It also concludes that the greater the number of Triple Helix model agents who cooperate, the greater the chances of business innovation, which shows the synergy effect between different agents[305].

To reach a higher level of performance and create more innovation a cluster should have a variety of services that should include at least the following service areas: information/market intelligence, matchmaking, initiation of R&D and innovation projects, promotion of the cluster and internationalisation. Other key areas to explore are the human development initiative and the support of entrepreneurship.

Good services demand for a great strategy, there are 5 pointed out by ESCA, which result in the development of new value chains across industrial sectors and create networking across boundaries:

- Market intelligence: Identifying opportunities in other industries
- Matchmaking: Finding partners in other industrial sectors
- Technology transfer: Spreading capacity and knowledge
- Project development: Translating market intelligence and matchmaking into cross sectoral innovation
- Innovation vouchers: Channelling funding through a cluster organisation

To be integrated in a proper way in the national and regional system is also an essential factor for the cluster´s success. This will make way for the cluster to expand and have a real impact in the country.

One key requirement for the successful development and implementation of cluster projects pointed out by the ESCA is the committed participation of companies and research actors, financially and on the activities of the cluster, such as projects or matchmaking events. 57% of European cluster have

[304] Lämmer-Gamp, Thomas/ Kergel, Helmut/ Nerger, Michael; Cluster Organisations in Europe – Insights from Bronze and Gold Label assessments; 2014

[305] Fitriani, Somariah; Success Factors in Triple Helix Coordination, Small-Medium Sized Enterprises in Western Java 2019

an unbalance between committed and non-committed cluster participants and often non-committed cluster participants are often just looking for access to advantages without costs.

Another important aspect is to find the right balance between the number of companies, universities and research actors that are part of the cluster, many clusters struggle because of the lack of research actors, or because the number of companies is too minor compared to the number of research actors. Several studies reported on the necessity of a growing company base for cluster success, highlighting the role both of start-ups and of established companies. Among the earlier studies, it was highlighted the importance of having the presence of at least one strong actor within a cluster, often referred to as 'anchor' or 'lead' firms[306].

It is crucial to give technical and management training to the staff on a regular basis, since there are always new developments happening within the industries and for the clusters to able to innovate, they must be aware of what has been done already. A study made by ESCA, points out that 77% of the clusters don´t pay enough attention to this factor and often is due for the lack of budget.

Some studies also bring to the fore the importance of physical infrastructure expanded on the requisite, which includes technology parks, research institutes, and support facilities for the organisation of conventions and fairs, and the attractiveness of the region hosting the cluster. This can also influence the level of staff attraction from outside the cluster, another key aspect for the cluster success

A stable financial outlook must be created, and this should start by the development of a convincing "business case" that encourages cluster participants to finance the cluster management on a more long-term basis, otherwise it is difficult for clusters to have financial stability since most of them live on support from public programs that are often limited in time.

Most clusters in Europe can improve their communication. To have a website is the first step, but it is important that the website provides all the valuable information, in a clear, and relatable way, to inform the cluster participants, and to attract other potential partners. In the website clusters should present success stories to provide evidence of their effect on industry development. Specially, if they qualify as "excellent success story," stories that are ground-breaking and change existing structures in a profound way.

A great way to collect helpful feedback, which will help to develop strategies is to conduct satisfaction surveys among the cluster participants. This will also allow for the cluster to possibly develop services for which the cluster participants are willing to pay it will also help to create ground for the development of ideas and projects.

12.2.2. CLUSTERS IN PORTUGAL: OPPORTUNITIES AND CHALLENGES

Portugal has a fertile environment for clusters. Currently, there are 18 different clusters spread around the country, with different thematic areas, such as textile, food, sustainable living, and smart cities. IAPMEI (Agency for Competitiveness and Innovation) is the government body in Portugal responsible to follow up, monitor and evaluate the activities and the agreement of objectives of the Portuguese clusters. The agency also promotes the clusters' activities internationally to foster business opportunities and visibility for the Portuguese markets.

In the development of this study, three national clusters have been interviewed: AEC Cluster, InovCluster, and Cluster Habitat Saudável – all the 3 clusters have the official recognition from

[306]Klofsten, Magnus; Bienkowska, Dzamila; Laur, Inessa, Success Factors in Cluster Initiative Management: Mapping Out the 'Big Five'

IAPMEI to be a cluster in Portugal. Two of these clusters also have the Golden Label of Excellency, issued by the European Secretariat for Cluster Analysis (ESCA), which shows their important level of professionalism and continuous commitment and improvement to their organisational structures.

The path to become a cluster in Portugal has started in the 2000s and has been receiving some massive investment and attention from the Government in the 2010s. From this period until nowadays, clusters in Portugal have had the chance to institutionalize themselves, grow their member capacity, improve their activities, and get the well-deserved recognition on developing EU-funded projects with partners from other European regions.

The exchange of best practices and cooperation between SMEs and clusters is one of the most remarking points from their interactions. All the clusters interviewed noted how relevant it is to be aware of the current market, the demands from it, and create a path to foster circular innovation and sustainability. In other words, clusters can offer the necessary tools to promote the key sustainable innovation in the different fields they are currently working on. Hence, clusters can play a key role in reaching innovation and market growth objectives, especially if endorsed by local governments. Aligned with this aspect is the perception that the government could work more closely with clusters leading to more consistent policies, which is not the case nowadays according to the interviewees.

Clusters are an incredible vehicle for the government to have access to the developments, opportunities, barriers, and needs faced by the industries. Despite the existing reluctances from companies to publicly share business information, clusters are the one body that is on the ground, created by the sector and for the sector, and therefore is familiar with the required conditions that can lead to economic growth within its industry, as well as required conditions to foster innovation, job creation, etc. Clusters can also be a vehicle to disseminate results from the government and help it achieve certain agenda points on circularity due to is closeness with sector's reality. By fostering this relationship and trust from the governance in clusters, developed policies could reflect more the current Portuguese reality, making it easier for implementation and enforcement of laws.

With regards to innovation, all interviewees agreed that a lot still needs to be done to foster innovation, starting from reducing the degree of bureaucracy. The current system is incompatible with the desired innovation culture according to interviewees. For example, the website of Compete and Fundo Ambiental, two national public funds, could be more user-friendly and easier to navigate in. To overcome the high degree of bureaucracy, it was suggested that the innovation funds could invite the clusters to observe, function as an external consultant, or as an auditor. Because of the complexity of national available calls, all clusters said that it is easier to apply for EU funds than for the ones available in Portugal. Specifically, to do with circular economy, the interviewed clusters foresee an immediate need for accelerate this agenda in Portugal and they can help to do so. However, they also feel their influence is limited by local context – meaning that more could be done if clusters were seen and used more as an active strategic partner of the government, to which the government would go to seek for advice and recommendations given the clusters' knowledge on the industrial sectors' needs.

Clusters as vehicles for implementation – case study from Denmark

In Denmark, the first cluster organisations were launched 25 years ago. They were inspired by the theories of Michael Porter and the Harvard School of Economics and were organised by private actors with little governance involvement. This gradually changed, and the Swedish traditions became the inspiration for the Danish cluster organisations to develop into triple helix organisations with enhanced public involvement.

Over time, about 50 cluster organisations have developed, all seeking public funding for their work. In 2020, the Danish government decided to reorganize the Danish industry clusters. After a thorough preparation, it was decided that there should only be 10 national cluster organisations, which represented the Danish strongholds, and which were given priority when applying for public cluster funds from the state. The many cluster and network organisations were encouraged to merge and apply to become one of the 10 national cluster organisations. Today the Danish triple helix clusters focus on knowledge sharing, internationalisation, and innovation. The government intervention in the Danish cluster ecosystem secures that clusters do not have to compete for the available fund and can strictly focus on their activities: supporting their members in growing, creating business opportunities, and fostering innovation in the specific areas.

Innovation

The innovation projects should promote new technological solutions and bring them to market, as well as create new companies, and match them with larger companies. In addition, the clusters can facilitate innovative tenders that boost a development in the market that would otherwise have taken longer if the market itself should handle the task. In Denmark, we see two models for triple helix cluster organisations here exemplified by two of the Danish cluster organisations that have a clear green focus.

Energy Cluster Denmark, (ECD)[307] is in Esbjerg, which is the centre for offshore wind turbines. For the past 10 years, the cluster's focus has been on organizing innovative collaborations between knowledge institutions and innovative SMEs that were subcontractors to large wind turbine manufacturers, including Vestas and Siemens, as well as Danish supply companies such as Orsted and CIPP, which operate offshore wind farms. The wind industry was initially heavily supported by public subsidies, and it has long been a political goal for the sector to be able to do without subsidies.

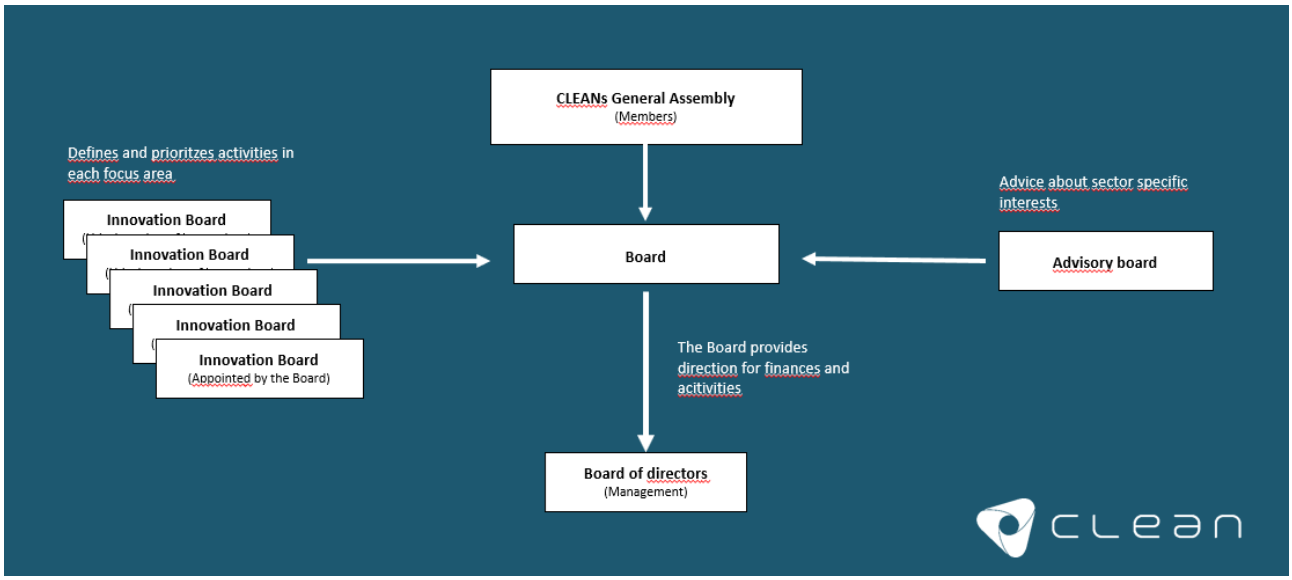
The technology in the wind sector has been known for a long time, and the need for innovation is therefore of an incremental nature. The common challenge for the sector has been to reduce costs. The ECD has developed an innovative tender model that is designed to reduce costs. The model is based on challenges where problem owners, typically larger companies within the sector, tender their challenges to find solutions that can reduce costs. ECD matches the problem owners with innovative SMEs that develop novel solutions for the market that can reduce costs.

The other cluster organisation is CLEAN[308], the Danish environmental cluster which was launched more than 10 years ago. The cluster’s focus is to promote environmental technology and circular economy in the areas of water, climate adaptation, waste & resources, air, soil & nature. In connection with the reorganisation of clusters, an Innovation Board has been set up for each area. It is the Innovation Boards' task to guide CLEAN in which activities are initiated, as well as how the cluster can contribute to achieve national goals in the field.

CLEAN focuses on innovative collaborations to develop high-tech solutions that promote circular economy in its focus areas. The main challenge for all areas, including waste and resources, is the lack of value chain collaborations or no technologies on the market, for that radical innovation is required. CLEAN therefore works with an innovative tender model that can contribute to radical innovation.

[307] https://www.energycluster.dk/en/
[308] https://cleancluster.dk/en/

Table 7 CLEAN governance model by CLEAN



The Danish environmental also serves as a vehicle for implementation of new regulations and reaching national goals. In 2020, the Danish government has launched a climate agreement supported by a majority in the Parliament, where several EU goals are implemented in Danish legislation. In the field of Waste and Resources the climate plan aims to have a CO2 neutral waste sector before 2030 and to develop an international competitive high tech recycling industry. It is CLEAN's focus within Waste and Resources to contribute to achieving the climate goals.

CLEAN has organised a series of network meetings with triple helix participants from the waste sector to discuss how to develop an internationally competitive recycling sector. The cluster is in close contact with the Ministry of Climate, universities and knowledge institutions, public and private waste companies, as well as companies in the recycling industry.

The network meetings have so far led to a consensus that two roadmaps must be made: One that maps barriers and opportunities for a triple helix collaboration to realize opportunities for all waste fractions: 'How do we make public-private interaction work?' The other roadmap should map development activities based on innovative technology to give more weight to a development track a high-tech recycling industry. In this way, clean supports the government's goals in the area and serves as a vehicle for implementation.

Cases of ALB in Portugal #1: Collaborative Laboratories

CoLabs or Collaborative Laboratories are non-profit private associations or companies, consisting of companies, research units, associated laboratories, higher education institutions, technological interface centers and others. The main goal is to create, directly and indirectly, highly qualified, and scientific employment through the definition and implementation of research and innovation agendas focused on creating economic and social value.

In Portugal, the operationalisation and constitution process of a CoLab is provided by *Fundação para Ciência e Tecnologia,* inside of *Programa Interface* and *Programa Nacional de Reformas*. The National Agency of Innovation (ANI) is the entity in charge to monitor the implementation of the Research and Innovation of all CoLabs. Today Portugal counts with 35 Collaborative Laboratories, and just from the summer of 2019 until the end of 2021 9 new ones were implemented.

Currently, the main challenges that Collaborative Laboratories face in Portugal is its effective densification in terms of knowledge-based activities, by enabling a growing institutionalisation of collaboration between science, technology and higher-education institutions, companies, hospital and health systems, cultural institutions, and social organisations. Collaborative Laboratories are key entities to consolidate and promote the capacity and potential of the scientific, academic, and business communities and should be part of economic growth and innovation strategies.

Relationship with Clusters

Many CoLabs work as an arm of a cluster. The CoLab is responsible for the development of knowledge and scientific investigation area inside of a cluster. In essence, it fulfils the important mission of aggregating knowledge for the enjoyment and enhancement of the sector.

CoLabs as an Arm-Length Body

CoLabs can be an essential partner for the Portuguese Government when promoting a green agenda and help to target goals. Their relevance has been noted in the new General Regime for Waste Management (RGGR) that will be fully implement starting July 1st, 2021. There, in article 91 states about by-products where the verification and agreement regarding what are conditions to be a by-product is asserted by the CoLabs. Furthermore, CoLabs can also experiment, innovate, and utilize new applications for the by-products, which leads to a crucial step for innovation inside the field.

Cases of ALB in Portugal #2: Digital Innovation Hubs

In 2020, the Portuguese Government approved a Regulation for the Recognition Process of Digital Innovation Hubs[309]. The Digital Innovation Hubs are collaborative networks made up of specific digital competence centres, and their objective is to stimulate the adoption of advanced digital technologies by SMEs, through the development, testing and experimentation of these technologies.

Since the levels of digitalisation in Portugal differ from region to region, the National Network of Innovation Hubs will happen through the collaboration of different partners, such as a Collaborative Laboratories and Clusters.

12.3. CONCLUSION AND RECOMMENDATIONS

The conclusion of this section is that given the role of arm-length bodies and clusters in facilitating collaboration among researchers, innovators, end-users, and public authorities, they are well-placed to provide policy makers with feedback on the effectiveness of their policy instrument. A series of recommendations are proposed to foster this collaboration between the Portuguese Government and the industries, leading to more successful policies, namely in the environmental and circular economy topics, such as the promotion of secondary raw materials usage as an alternative to raw materials:

- Establishment of an arm-length body specialised in the topics of circular economy, environment, waste management and material efficiency, with mandate over the topic's implementation.
- Integration of clusters as strategic entities in Portugal's roadmap for economic growth and competitiveness by focusing on the country's economic strongholds and emerging industries.

[309] Available at: https://perin.pt/portuguese-government-approves-regulation-for-the-recognition-process-of-digital-innovation-hubs-application-process-till-the-8th-of-january-2021/

- Improvement of the process to apply for national funds, namely within Fundo Ambiental and program Compete.
- Foster inter-clusters collaboration as it would also have an influence in fostering the usage of secondary raw materials by means of innovation, knowledge, and resource exchange between sectors.

13. NOTE ON REQUIREMENTS OF A PLATFORM TO SUPPORT BY-PRODUCTS AND SECONDARY RAW MATERIALS TRANSACTIONS

This chapter will form the foundation for the creation of a platform to facilitate transactions of by-products and secondary raw materials, enabling an easier and more efficient trade and utilisation of such materials as the basis for manufacturing processes. A safe marketplace for raw materials will bring together vendors and buyers of valuable commodities from all over Portugal. This platform will be an important part of the implementation of the circular economy package in Portugal.

To investigate the requirements of a platform to support SRM transactions in Portugal the needs and wishes for such a platform were discussed with local stakeholders from all the value chain. Following, existing platforms for by-products and secondary raw materials in other Member States were analysed and key parameters for its successful operations identified. This process enabled the formulation of the scope and requirements for a platform in the context of Portugal, which will be presented as last in this section.

13.1. NEED FOR A NATIONAL PLATFORM FOR SECONDARY RAW MATERIALS TRANSACTION

The option of a national platform of SRM was discussed in 50 interviews. During the interviews it was possible to identify a common interest in having such a platform developed. It was shared by most of the interviewees that the non-existence of stable flows of materials is one of the causes to not have a stable market of recycled and reusable products in Portugal. There are two other aspects that are important to mention, shared by all interviewees, and that a platform per se will not be able to solve: the competitive price of virgin raw materials and the declassification of waste.

Recycling companies must be able to rely in a stable volume of input to secure their production, but today this stability is not a given.

A few examples of industries that could use by-products from other sectors if they were available were mentioned in the interviews, collected in table 8, and analysed with more detail in the sections 6, 7, 8, and 9 of this report. An interesting case, and often mentioned when discussing construction and demolition waste, is the there are several options to dispose CDW, however providing the waste to recyclers is often the least attractive financially, in contrast to delivering the waste to quarries. Today, the cement industry in Portugal works below its installed capacity having the possibility to manage at least 250-300 thousand tons of construction and demolition waste. However, only 30-40 thousand tons of waste reaches their installations mostly because of competitive prices of quarries or mine filling for environmental recovery. When it comes to biowaste, there is a seasonality problem that hinders the constant flow of materials, not to say that biowaste is also commonly used for feed stock or re-introduced in the land as compost. This process prevents innovative solutions, such as the creation of new natural fibres, to go from testing to piloting and scaling up. The furniture sector is eager to have access to more wood as the virgin material is expensive and increasingly scarce; the Portuguese industry must import wood from Spain and the UK. If an alternative to have access to more wood, and locally, was set in place, the furniture sector would benefit from it. And in fact, there is a lot of wood from the demolition sector, for example, that is not reused, and end-ups in the landfill when it could potentially be reused if a proper separation and treatment process were set in place.

Table 8 Opportunities to use SRM identified throughout interviews

Industry potentially providing SRM	Industry potentially integrating SRM	SRM usage
Paper	Agroforestry, agrochemicals, textiles, construction and demolition, and cosmetics.	The paper and cellulose industry has identified a large list of potential synergies to be developed with other industries based on international existing cases. Documentation including the barriers that would need to be lifted has been shared with APA.
Construction and demolition	Furniture	The wood and furniture industry seems to be an efficient sector in terms of optimization of resources. However, access to raw materials is becoming scarcer. Most wood from the sector is imported from Spain and the United Kingdom. There is an urgent need to find new ways to have access to materials, as for example wood from demolitions. For this link to be successful wood must be properly separated on site, and the channels must be created.
Construction and demolition	Cement	CIMPOR has an installed capacity to produce 10 million tons of cement per year from about 250-300 thousand tons of construction and demolition waste. However, the company only produce 4 million tons of cement and only 30-40 thousand tons of waste reaches their installations, and just to obtain this amount of waste a significant effort is required.

Declassification of waste and the competitive price of virgin materials are major barriers that must be lifted if Portugal wants to increase the rate of reused materials, as it has been analysed in section 6.4.3. For example, Dr. Smith, an English containerboard and speciality paper producer with paper mills spread around in 9 European countries and North America, aims to reach 2030 with zero landfill waste. But it is most likely that the company will not be able to reach its target because of its Portuguese production. The reason given is the fact that existing solutions are not yet accepted in Portugal. In this line of argument, it was equally mentioned that it is very time consuming and expensive for companies to request for materials to be considered as by-products turning the process often not financially worth. The declassification process consists of companies storing waste, paying a certified lab to run all the required tests, and have the documentation approved by APA. This process can take years, sometimes making the requester lose the business opportunity. Additionally, there are cases where APA would request for more proofs of concept so companies need to collect proves of how solutions work abroad, benchmark with other countries, and in some cases arrange international site visits so the local authorities can see in first-hand the solutions process and result. This process also comes with an excessive cost, which can most likely be borne by large enterprises. But as mentioned in section 8.1.1, this process is already less complex today than it was at the end of 2021 with the adaptation of Art. 91 DL 102-D/2020. In terms of price of raw materials, it has been

suggested by several interviewees that this problem could be partially solved if the lower VAT were applied to reused materials.

Hence, different industries wish to have access to more stable flows of by-products and secondary raw materials, mostly for innovation purposes (development of new materials and products) and to scale-up existing solutions. However, the development of a platform will not solve the declassification of waste, nor the competitive price of virgin materials per se. These barriers still need to be managed in parallel with the development of the platform. But as stated by Adam Smith, the constant interplay of individual pressures on market supply and demand will cause the natural movement of prices and the flow of trade[310]. The growth of a SRM market fostered by a platform can have an impact in the price of SRM.

Finally, it is also important to note that there are successful cases of reintroduction of SRM by industries in Portugal. Today the cement industries integrate by-products from the paper and pulp industry in its production. Primary sludge, carbonate sludge, dregs, grits, lime mud, bottom ash, and sand are used in the production of fibre cement, bituminous mixture for regularization layer and industrial mortars. In the textile sector, a partnership with the textile business association, CITEVE, and FEUP, the Faculty of Engineering of the University of Porto, and the companies SEDACOR and TÊXTEIS PENEDO, lead to the development of the first cork yarn, which is already in the market and being used by several companies in home textile sector. By-products from the agro industry are also used by the cosmetics sectors. Collagen from agri-food sector is used by the cosmetic sector in the production of skincare. These are just some examples from a broad range of existing national best practices. Still, these and new cases could be scaled-up, and novel solutions developed, if there was a real time information about available resources.

13.2. EXISTING PLATFORMS FOR SRM

Repositorio de Materiais – APRUPP / Portugal

Online shop for construction sector

Repositorio de Materiais started as na initiative of Associação Portuguesa para Reabilitação Urbana e Proteção do Património (APRUPP) but quickly became more independent of the association as it got media exposition. Repositorio de Materiais consists of an online shop where one can buy construction materials by selecting the available item and the product will be shipped to the customer's address. To sell on the platform, one needs to fill in a form with detailed information about the product for sale. After APRUP's approval the product goes to the online catalogue.

It emerged to safeguard and enhance materials and components from disassembled buildings, (de)construction, demolition, and rehabilitation projects, with potential for reuse. It is mainly a tool that seeks to bring together and centralise the various stakeholders that work with these materials and those looking for them. The platform goal is to promote circular economy in the construction sector, as well as the creation of novel places for the deposit of materials, through a Material Repository Network, which may include municipalities, construction, and demolition companies, among others.

Its activity started as a pilot in Porto, having later expanded to Lisbon. The goal was to expand to the entire national territory. However, the platform has faced certain challenges that hindered its expansion plans. Although the project was successfully running for 5 years, it is currently in stand-

[310] Smith, A.: 1776, 'An Inquiry into the Nature and Causes of the Wealth of Nations', R. H. Cambell and A. S. Skinner (eds.), (Liberty Press, Indianapolis). (Same as Oxford University Press, 1976.)

by as it has been challenging to turn Repositorio de Materiais financially sustainable. Today the platform runs mostly with volunteers and donation based. Among the identified challenges were the transportation, storing, need to have artisan with skills to restore materials, cost of materials rehabilitation, and lack of variety in the offer, which leads to a lack of demand.

Key aspects from the Repositório de Materiais case:

- ✓ National platform.
- ✓ Sectorial focus.
- ✓ Media attention.
- × Complex logistics: transportation and storage.
- × Fixed and variable costs with logistics and HR versus volatile income relying on donations based

The lack of variety is explained by the low enforcement in disassembling before demolishing, meaning making sure that all valuable materials are carefully removed and separated for reuse before the demolition phase. The lack of demand can be justified by the lack of culture in Portugal to use second-hand materials, and the lack of motivation from contractors and architects to spend time searching for specific materials in second-hand marketplaces.

My Waste platform (from Be Circular Be Smart project - Smart Waste Portugal) / Portugal

Market place for by-products

The "Be Smart - Be Circular" project, promoted by the Smart Waste Portugal Association (ASWP), is focused on the dynamisation of the national business sector, through the creation of tools and events, to disseminate and reinforce knowledge in a perspective of transition to the Circular Economy model. The project's strategic purpose is to raise awareness, dynamise and train national SMEs with relevance to the waste sector. The idea is to give them knowledge, information, and tools that contribute to business transformation, to transition to the Circular Economy, based on activities and innovative systems that allow the creation of a waste and raw material exchange system, to maximize its economic use, reducing the need for resource extraction and its associated negative environmental impacts.

To achieve the objective, and to deal with the identified market failures, ASWP defined a set of activities, which comprise initiatives of different scopes in favour of national SME´s with relevance to the waste sector, namely the construction of the MyWaste by-products Platform.

MyWaste, is a B2B pre-consumption waste platform, financed by the Compete 2020 program. The pilot version was launched in August 2021, only for the Smart Waste associates. The post pilot version is expected to be launched to the public in early 2022.

One strength of the platform is that the association has consulted the Portuguese Environmental Agency throughout its development, securing the final product complies with local regulations. Another strength is the role ASWP plays in the industry. Even though it is not recognised as such, Smart Waste Portugal acts like a cluster with a special focus on waste management. In general, the association has a good reputation having a non-biased role. ASWP will be more likely to be trusted

Key aspects from the My Waste Platform:

- ✓ National platform.
- ✓ Development in dialogue with Portuguese Agency for the Environment.
- ✓ EU funded.
- ✓ Non-biased role of ASWP, and its trustee reputation.

with secondary raw material data from companies, as it was not the case with similar solutions that have been developed in Portugal and which failed because of lack of trust in the platform owner – a waste management operator.

SymbioSys Tool / Spain

The SymbioSyS tool has been developed by the School of Industrial Engineering and Telecommunications of the University of Cantabria in Spain. Its purpose is to facilitate the detection of industrial symbiosis synergies and connections among companies. It has been conceived to promote and visualize synergies that otherwise, naturally, or accidentally, would be unlikely to happen. This tool enables the identification of synergies based on the use of wastes and by-products as resources and on joint waste management actions among the companies. SymbioSyS has been developed by means of information and communication technologies and it is easily accessible using a web link. It will provide access to certain data as: which companies generate the same flow and the amount of flow generated, which in turn enables specifics strategies to be developed.

The user of this tool can find, expand, or unveil new opportunities to valorise his resources in companies placed at any geographical emplacement, from neighbouring companies located in the same industrial park to worldwide companies.

Moreover, SymbioSyS is a powerful instrument to analyse an industrial and/or urban system of interest (industrial park, city, or region) in order to support the decision-making of managers and policy makers about the actions and strategies to be implemented for an efficient management of resources.

Currently the SymbioSyS Tool team is working together with the Government of Israel to foster synergies between industries and promote circularity through the platform. As in this case, clients can acquire the permit to use the tool, which in turn can be customized to the clients' needs, maintained, and updated, when necessary, by the SymbioSyS Tool research group. In the case of Israel, each company is responsible for uploading the information on the app.

Key aspects from the SymbioSys Tool:

- ✓ One-stop-shop solution with the option to be adapted to clients' needs.
- ✓ Design and clients' interface can be adapted to look regional.

Madaster (and BAMB) / The Netherlands

Materials passport

Note: *For more detail on the Madaster case go to section 6.3 EU Best practise example of this report*.

Madaster is a widely used Dutch online platform where building owners, contractors, and architects, register buildings by uploading detailed information about the materials and products used in the construction and so creating a 'materials passport.' A material passport not only provides insight into materials and quantities in a building, but the passport also contains information about the quality of the materials, their location, their economic value, their life expectancy, and a 'circularity index' informing about what percentage of the materials in a building can be recycled.

The platform can be used to (1) demonstrate the sustainability of a building and manage demolition costs, (2) plan and adjust proposed materials, products, and construction methods already in the design phase, (3) plan maintenance costs. Registering materials in buildings and construction also

makes re-use easier, encourages smart design and eliminates waste, ad all building becomes a material bank.

Access to the platform is free to all users, from private individuals, to companies, governments, and scientific organisations.

In 2018, Madaster started a partnership with the engineering company Re Use Materials, which conducts inventory lists of buildings. The partnership enables existing buildings to be registered in Madaster by using Re Use Materials building inventory lists, which allow building owners to gain insight into both the circular and economic value of all materials used. Madaster is also working towards collaborating with several online marketing platforms with recycled materials to further promote the sale of recycled materials.

Facilitating the access to materials available and in good conditions from previous project has led to some successful cases of new constructions made of reused materials. The Schiphol Airport and the Circular Building, both in Amsterdam, have been built with materials from other projects. The old prison area in Amsterdam, Bajes Kwartler Amsterdam, is currently being rebuilt into a residential area and it is a priority that all the materials from the prison are reused in the new site. For example, the cell doors from the prison cells will be used as small bridges over small rivers that exist in the area. These examples are the proof that it is possible to foster materials reusage in the construction sector as the material passport is showing particularly good results and good acceptance within the Dutch construction companies.

Key aspects of the Madaster case:

- ✓ Free access to buyers and sellers.
- ✓ Clear added value for different stakeholders in construction value chain.
- ✓ Showcase success stories resulting from the Madaster platform existence.

OPALIS / Belgium

Online inventory of salvaged building materials around Brussels

Note: *For more detail on the OPALIS case go to section 6.3 EU Best practise example of this report.*

OPALIS an online directory of professional operators who sell construction materials resulting from the dismantling of old installations or buildings. Around 250 tons of used material are sold on the platform each year consisting mostly of ceramic tiles, claddings, stone, wood, and doors. In addition to the offer of reused materials, the operators also use the platform to offer their core services (e.g., deconstruction, cleaning, resizing, advice, etc.) In many cases, relying on this expertise in the context of a project makes it possible to achieve optimally for reuse ambitions. OPALIS also provides technical documentation on the most common construction products on the re-use market: main characteristics, availability, frequency, indicative prices, etc.

OPALIS was created by Rotor, an association with more than 15 years of experience working with reuse of

Key aspects of the OPALIS case:

- ✓ Rotor, the platform owner trustee role: non-biased and with experience in the topic of reused materials.
- ✓ Governmental support.
- ✓ Public funding support which allows to focus on the goal: foster SRM reusage.
- ✓ Resources allocate to verify users' credibility.
- ✗ Time-consuming and expensive process to verify users.

materials. The online directory started with support from regional funding and funding from the Ministry of Environment for Brussels to encourage reuse in construction. Resulting from the projects' initial screening phase for recycling and reuse market in Brussels, the Rotor Deconstruction cooperative was established to organise the reuse and recycling of construction materials and demonstrate the active use of the materials. Since it started OPALIS has received funding four times. Most of the funding, roughly 80% is allocated to site visits to the companies selling on OPALIS. The visits prevent from scammers to try to sell on the platform. This specific concern has been the main challenge of the project - to make a distinction between the most professional dealers and the smaller ones selling material on the side. Today OPALIS must conduct surprise visits, but in it is currently working on solutions to make the process more efficient and less costly.

ResiduoRecurso / Spain

ResiduoRecurso is a Spanish online private owned platform where companies register to buy and sell by-products, waste, and secondary raw materials. The creation of the platform was fostered by the wish to promote companies to reuse and exchange waste.

It started on 1992 as an Initiative of the 13 Catalan chambers, coordinated by the General Council of Chambers of Catalonia with the commitment of Waste Agency of Catalonia and Territory and Sustainability Department. Since then, the platform has evolved together with technology going from a on paper service to a digital platform. Today ResiduoRecurso works with 4 pilot entities: IS facilitator, Industrial business association, Regional Council – supra-municipal entity, and they plan to incorporate more public and private entities in 2021.

Key aspects of the ResiduoRecurso case:

- ✓ 30 years of experience working with reuse of materials.
- ✓ Support of local government.
- ✓ Endorsement of local waste agency.

Combineering

Note: *For more detail on the Combineering case go to section 6.3 EU Best practise example of this report.*

Combineering A/S is a privately owned Danish company, with more than 25 years of experience developing recovery solutions for industrial residues and setting up the market between between producer(s) and end user(s). Combineering's services can include development of a solution, securing the necessary environmental approvals, logistics (administration of all daily transports including paperwork with cross-border transports), financial management, etc.

Combineering usually works with a no-cure- no-pay model when developing solutions for a company's residual product. Combineering will in turn also gain the right to handle the given residual product for an agreed period. Their clients (Novo Nordisk, Rockwool, Leca among others) receive a more environmentally friendly business profile at a low or unaltered expense compared to their current alternative (often landfill or incineration). Because of their wide-ranging industrial networks in Europe and many years of experience in recovery of residual products, Combineering can sustain their no cure no pay business model.

When developing solutions, the most important aspect, and often the main challenge, is to safeguard a large quantity of residual products to secure a cost-effective developed solution. A yearly flow of approx. 100 tonnes of a given residual product is required. The residual product does not have to come from a single producer but must at least be relatively homogenous.

Combineering always opts for specific solutions for specific and thoroughly analysed residual products. Several producers and end users can however easily be involved in a single solution for a (relatively homogenous) residual product.

Key aspects of the Combineering case:

- ✓ Reputation
- ✓ No cure-no pay business model
- ✓ Minimum required volume of waste, and homogeneous
- ✓ Foster partnership in solution development.

Materiaalitori

Materiaalitori, a Finnish meeting place for producers and users of waste and by-products, has been developed in 2019 as part of the revision of the Waste Act (646/2011). The Waste Act states that waste holders must try to find a market-based waste management service before it is possible to request waste management by the municipality's waste facility, hence the need to develop a platform to assist this search. The new policy aims to foster the transition to high-value recycling and circular economy practices. The platform was developed by Motiva Services Oy, a medium-sized sustainable development company owned by Finnish government and provider of sustainable development related services to businesses and municipalities and financed by the Finish Ministry of Environment. The platform development consisted of high-level engagement with key stakeholders from the waste management value chain to secure they feel ownership of the solution developed and are eager to use the final solution as it will fit their needs.

From early 2021, it became mandatory for waste producers to communicate in the platform the waste that they must handle, unless the need for the secondary waste management service of the municipality to be acquired is less than 2000 euros per year, or when the waste management service is needed quickly due to unforeseen urgency.

Registered companies can use Materiaalitori transparently and free of charge by notifying in the platform a material stream with appropriate description: characteristics, amounts, pictures, and a note if the stream is classified as waste. On the side of the demand, users can search or receive notifications for specific materials at specific locations.

Key aspects of the Materiaalitori case:

- ✓ Co-creation process with market players leading to shared vision and ownership for the platform.
- ✓ Mandatory for companies to use the platform as part of the national waste management regulation.
- ✓ Policy-driven solution.
- ✓ Financial sustainability secured by government.
- ✓ Waste streams connected to waste code.
- ✗ Not possible to follow the transaction.
- ✗ Not yet as many users as predicted.

The project is currently in its pilot phase and comments will be collected regarding the use of the service to further develop the platform. The platform does not have yet as many users as it was anticipated, with around 1500 registered users. Motiva can follow the process as it goes regarding organisations and waste uploaded, but they cannot track or monitor transaction or follow the destination or use of the material sold on the platform. This will be investigated next year.

The platform is divided into different material categories according to the national waste statistical categories, and today most products available on the platform come from construction and demolition.

The review of best practices shows a variety of individual innovative circular waste solutions implemented across the EU. The analysis shows that a series of institutional factors are key for creating a conducive framework for innovative circular transformation, including[311]:

- A strong national vision having CE solutions or a CE model as a goal.
- National support structures and systems for innovative CE solutions.
- Maturation and diversity of market and networks.
- Inherited values and established culture and patterns of cooperation.

In the next section a list of recommendations for the development of a platform for secondary raw materials transaction will be provided based on the needs and wished shared by the interviewees, as seen in section 13.1, and based on the 'pros' of each best case analysed in this section.

13.3. RECOMMENDATIONS

Based on section 13.1 and 13.2 a list of conditions is put together to secure the successful development and implementation of a national platform for SRM transactions. Even though the conditions are not mandatory, having them in place will simplify the platform's successful implementation and general acceptance. The conditions are the following:

a) **Nationally made platform**: in no case it is stated that it is a requirement that the platform must be national, but that happens to be the case in all the analysed cases studies. Based on the interviews conducted throughout the project this is most likely to be because waste is a very regulated sector, for multiple reasons. Dealing with waste management, one needs to take into consideration health and safety, data collection and data possession, local culture, and behaviour towards waste. Furthermore, the volumes and type of waste generated will differ a lot of from country to country given the different national policies, targets, and the countries' main industries.

b) **Non-biased owner**: sharing business information, namely with regards to waste generation and management, has been indicated as a sensitive topic for Portuguese stakeholders. Portuguese companies have reluctance in sharing information about waste generated, and this concern will be heightened depending on the entity managing the platform and having access to the data.

c) Stakeholders' engagement: involving key players in the conception and design phase of the solution generates an ownership filling of the solution developed, which leads to higher chance that key players will use it as they see added value and their needs and wishes incorporated in the solution developed.

d) **Digitalisation**: for users with private companies' profile, cross information between companies VAT numbers and waste category which will also facilitate the verification of users. The national developed solution can benefit from the e-GAR – the electronic waste monitoring guide system. Interviewees have declared that e-GARs are not used at their full potential even though the system is set in place. This tool can be used to facilitate real time waste availability and track its transportation or transaction. By doing so, APA could identify

[311] Inspired by the organisational model presented in section … and Henrysson & Nuur (2021): The Role of Insitutions in Creating Circular Economy Pathways for Regional Development.

which and how much waste is being recovered, identify patterns, and monitor in real time if its targets will be achieved.

e) **Regulation endorsement**: as it is the case in Finland, the waste holder must first try to find a market-based waste management service with the help of Materiaalitori before it is possible to request waste management by the municipality's waste facility.
f) **Share cases of success stories**: showcase products made from secondary raw materials (ex: buildings, new textiles, etc) will serve as motivators for potential new users to try the platform, as one of the identified barriers for use of SRM in Portugal is the lack of showcased best practices and success cases.
g) **Verification of users:** Secure that users are verified avoiding scammers, and consequenly avoiding jeopardizing the reputation of the platform.
h) **Simplicity**: as identified with the Portuguese case – Repositório de Materiais, one of their challenges was the transportation and storing of materials, as well as wanting to have an artisanship with skills in restauration. This aspect does not seem to be an issue for the other cases that have been analysed in this section as the platforms work solely as open marketplaces where buyers and sellers communicate between themselves. The deliveries and treatment of waste and SRM are not responsibility of the platforms.
i) **Type of organization and financial sustainability**: This point is aligned with point b) non-biased owner and c) stakeholders' engagement. The type of entity responsible for the platform will impact the platform vision and mission, as well as its financial model. This translates the difference between a mission-driven solution and profit-driven solution, being the first option the aimed goal for a successful platform for SRM[312]. The goal is having a transparent body that will easily gain potential users' trust. A mission-driven entity will also more likely be beneficiary of public funds.

13.4. CONCLUSION

The conclusion on the development of a platform for secondary raw materials transaction is that there are drivers in Portugal to build a solution to accelerate the transition toward a more circular economy.

According to the interviewees representing different economic sectors, especially when interviewing CoLabs, clusters, and sectorial associations, there is a demand for stable and reliable volumes of SRM to test new - and scale-up existing solutions made of reused materials. For certain sectors, synergies have even been already identified. Furthermore, the development of such a platform could also support Portugal in improving its data collection and information management systems beyond the legislative requirements. However, similar solutions have already been developed in Portugal – we have explored cases that have not succeeded and have presented a case that is currently under development, soon reaching the after-beta version after feedback from first users will be integrated and improvements made.

To increase the chances of success of a national platform, considering either the further development of the platform of Smart Waste Portugal, or the development of a new platform, it is recommended that a benchmark is conducted based on the list of suggested conditions for a successful development and implementation of a national SRM marketplace.

In this section, waste declassification and price of virgin materials have also been identified as key aspects to have in consideration when developing solutions to foster the market of by-products and SRM. Declassification must be addresses in parallel with the development of a platform as it is a

[312] Mukhopadhyay, S. & Bouwman, H. (2019). Orchestration and governance in digital platform ecosystems: a literature review and trends. Digital Policy, Regulation and Governance 21 (4), pp. 329-351.

matter of regulation and cannot be solved without government intervention, but improvements have been made recently, and more discussions are undergoing to simplify even further this process. With regards to the price of materials, it can be that the price of SRM undergo a natural movement if the market is nurtured by other means than interfering with the price of virgin material, such as the successful development and implementation of a platform. However, options such as the application of minimum VAT on reused materials, or products made of SRM, should be considered by the Portuguese authorities as a mechanism to turn secondary raw materials more attractive and dynamise the substitute and recycled market. Complementarily, extending the mandatory use of second-generation materials as it is already the case in public construction which must incorporate 10% of reused materials according to the Decree-Law no. 102-D/2020[313], of 10 December, could also increase the market of SRM.

So, even though bridging the channels between sellers and buyers might not be the sole solution to secure and increase the usage of SRM and put less pressure on raw materials, it will be a big push. The platform will secure a reliable and consistent flow of materials solving big part of the challenge faced by recycling companies, researchers, scientists, and innovative industries that want to go forward with their circular agenda. While doing so, Portugal will be paving its way to a more circular economy. This process could be enhanced if Portugal would address the topic in the national policy framework and make it mandatory to find second generation market for one's waste before resorting to waste management operator, as it is the case of the Materiaalitori in Finland and have a proactive role in the solution development. As law enforcement has been identified as an aspect to be improved in Portugal, it is important that the government shows active participation in solutions development in close collaboration with key partners securing that regulation and specific tools developed incorporate the industrial sectors wishes and needs. Such behaviour would equally have an impact in the perception of the government as one that fosters participation, inclusion, responsiveness, and accountability. Consequently, it will be more likely that industries will comply with the law and collaborate with the government in reaching common sustainable goals.

[313] DL 102 contains three decree laws in one document: one for the general waste management (the one that matters for the present project), one for landfill, and one for extended producer responsibility. Reference to DL 102-D in this report refer directly to annex I of DL 102-D.