# Stakeholder Analysis in the Valorization of Plastic Waste Supply Chains

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Thesis to obtain the Master of Science Degree in

## Industrial Engineering and Management

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**December, 2019**

# Acknowledgements

Firstly, I would like to particularly thank my supervisor, Prof. Ana Carvalho, for all the support, guidance and for the opportunity of joining this project.

To all the teaching staff, who contributed to my academic development, and who contributed towards establishing Instituto Superior Técnico as one of the most prestigious institutions in Portugal, my sincere appreciation.

Finally, I would like thank to all my family and friends, for continuously helping me push my limits.

# Abstract

The recurrent use of plastics in a wide variety of markets has led to exponential growth of worldwide plastic production. However, this extraordinary growth has come at the cost of alarming rises in plastic waste levels across the world. Several resources and investment have been deployed to waste management sectors, with plastic waste being particularly targeted across the EU, Portugal included. Despite promising research and technological developments, recycling rates have stagnated as approaches seem to be hampered by the ample number of the system's stakeholders, and the complex nature of their relationships. Waste management now calls for the more integrated approaches that Circular Economy concept provides, targeting all stages of the value chain. Therefore, this research aims to provide a holistic stakeholder analysis of Portuguese plastic waste supply chains, based on the framework developed by Reed et al. (2009). Thus, enabling the formulation of best-fit strategies targeting an improved valorization of the system. A state-of-the-art review on Circular Economy (CE) and stakeholder analysis methodologies for the identification, categorization and investigation of inter-stakeholder relationships was carried out, which provided a theoretical basis for conducting semi-structured interviews with key actors of the system and an evaluation of the system's performance. The results of the analysis, which included a stakeholder-led assessment of the remainder in terms of 'Power', 'Interest', and 'Support', and Social Network Analysis, allowed to pair generic stakeholder analysis strategies with efficient CE practices for developing research-supported strategic action plans to address the valorization issue.



**Keywords:** Plastic, Waste Management, Circular Economy, Stakeholder Analysis, Recycling

# Resumo

O uso recorrente de plásticos numa ampla variedade de mercados tem levado a uma expansão exponencial da produção deste material. Contudo, este crescimento excessivo impulsionou um aumento dos níveis de resíduos plásticos a uma escala global. Têm sido mobilizados inúmeros recursos para o setor da gestão de resíduos e os plásticos têm sido alvo de particular atenção na União Europeia e em Portugal. A despeito das inovações e avanços tecnológicos promissores, as taxas de reciclagem têm estagnado, ao que indica que as iniciativas têm sido prejudicadas pelo amplo número de stakeholders no sistema e a complexa natureza das suas interações. Assim sendo, esta complexidade sugere uma necessidade de abordagens mais integradas como as introduzidas pelo conceito de Economia Circular (EC). Este estudo visa proporcionar uma análise de stakeholders às cadeias de resíduos plásticos em Portugal, tendo por base a estrutura desenvolvida por Reed et al. (2009), permitindo uma subsequente formulação estratégica que vise uma melhor valorização do sistema. Foi elaborada uma revisão bibliográfica sobre os tópicos de EC e metodologias para a identificação, categorização e investigação de relações entre stakeholders, que fundamentou a realização de entrevistas semiestruturadas com entidades chave, e uma avaliação da performance do sistema. Os resultados da análise, que incluem uma avaliação dirigida pelos próprios stakeholders sobre o 'Poder', 'Interesse' e 'Apoio' dos restantes, e uma análise da rede social, possibilitaram a conjugação de estratégias genéricas de análise de stakeholders com práticas de EC para o desenvolvimento de planos estratégicos fundamentados que abordem o tema da valorização.

**Palavras-chave:** Plástico, Gestão de Resíduos, Economia Circular, Análise de Stakeholders, Reciclagem

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# Acronyms

ALM – Actor-Linkage matrix

AMs – Association of Municipalities

EC – European Commission

EPR – Extended Producer Responsibility

NGO – Non-Governmental Organization

OECD – Organization for Economic Co-operation and Development

PRO – Producer Responsibility Organization

SGRU – Sistema de Gestão de Resíduos Urbanos

SIGRE – Sistema Integrado de Gestão de Resíduos de Embalagens

SME – Small and Medium Enterprises

SPV – Sociedade Ponto Verde

SSE – Steady State Economics

SWOT – Strengths, Weaknesses, Opportunities and Threats

UWMO – Urban Waste Management Operators

WMO – Waste Management Operators

# 1. Introduction

## 1.1. Brief contextualization of the problem

Modern day societies are inevitably correlated with the production of large per capita volumes of waste. As a rule of thumb, the higher the life quality standards and GDP, the higher the waste generation per capita (APA, 2018). In primitive societies, small communities would bury solid waste in middens just outside their settlement. As communities grew in size, more organized forms of waste management became necessary (Seadon, 2010). But current human activities, changes in lifestyle and consumption patterns have resulted in an exponential rise in solid waste generation rates. Waste is increasing not only in quantity but also in complexity. Constant technological developments mean waste is composed by ever differentiating materials. Plastic is one of those materials, and over the last decades it has been target of increasing attention due to the environmental threats it poses (Demirbas, 2011).

Plastics have become an integral part of contemporary society due to its outstanding material properties and innumerous applications. The drivers for such growth include their low density, strength and low cost. They are the recurrent preference not only in the packaging sector, as in automotive and industrial applications as well (Mwanza & Mbohwa, 2017). In 2015, world production of plastics surpassed 300 million tons. In Europe alone, this resulted in the generation of 24.6 million tons of post-consumer plastic waste concentrated in the packaging, construction, automotive and electrical and electronic equipment sectors (Lazarevic et al., 2010). Half of this waste was disposed in landfills, whilst 20% was recycled and 30% was recovered as energy (PlasticsEurope, 2018).

This intermittent usage and current recovery and recycling rates combine for a vast set of environment related negative externalities. Adding the implied fossil fuel consumption, also newer concerns regarding sustainability and resource depletion start to emerge (Rasmussen, 2018).

Not just plastic, but solid waste management has been pushed forward by European waste and natural resource policy. Historically, health and safety issues dominated waste management concerns. Those issues remain relevant to date, but the current push has also been directed by a rationale regarding sustainability (Seadon, 2006).

Although in compliance with most EU targets and legislation, the Portuguese waste management system remains highly complex due to complicated networks of arrangements that arose from changes in legislation. As so, plastic waste management also portrays particular major challenge in this fragmented system (Simões et al., 2012).

Nonetheless, the plastic industry has (partially) successfully identified workable technologies for recovering, treating and recycling waste from discarded products. Secondary plastic material has been reintroduced in the production of a wide variety of industries, including newer sectors such as 3D printing (Al-Salem et al.,

2009). Still, looking into the reigning waste hierarchy – Prevention, Reuse, Recycling, Recovery and Disposal – recycling is only the third most preferred alternative of all the waste management strategies (van Ewijk & Stegemann, 2016). The raising issues of sustainability and this need to foresee recycling as part of a bigger transition towards an integrated balance within the planet's boundaries, promote the adoption of closing-the-loop production patterns and also betray Circular Economy (CE) developments as the answer to the current 'take, make, use, dispose' prevailing model (Ghisellini et al., 2016).

Altogether, as the picture surrounding the enhancement of recycling rates broadens, so does the magnitude of the number of actors who play a preponderant role in the system. Plastic waste supply chains now comprise a wide range of activities encompassing a large number of stakeholders, and are characterized by complex direct and indirect relationships. When conducting work on issues of this dimension, it becomes essential to include methodologies for identifying and integrating all relevant entities (Reed et al., 2009). Stakeholder analysis has become increasingly popular with a wide range of organizations in many different fields as it allows to properly identify and manage the relevant actors in a wide variety of subjects. So, it proofs to be particularly useful in enhancing the valorization of plastic waste supply chains as it provides several tools that promote collaboration and materialization of the benefits that derive from a correct analysis of stakeholders and their relationships (Prell et al., 2009; Reed et al., 2009).

## 1.2. Dissertation objectives

This dissertation aims at developing a holistic stakeholder analysis to the Portuguese plastic waste supply chain with the aim of an improved overall valorization of the system. The research seeks to provide:

1. A brief contextualization of the plastic industry and waste management systems in Europe and Portugal;
2. A state of the art on Circular Economy and stakeholder analysis methodologies, with emphasis to stakeholder categorization and relationship analysis tools;
3. Definition of the methodology adopted during the development of the Master's dissertation;
4. Implementation of a multimethodology novel that includes stakeholder identification techniques, stakeholder categorization through 'Power vs. Interest' matrix and 'Support vs. Opposition' grid, and relationship analysis through social network models, to the Portuguese plastic packaging waste supply chain;
5. Development of suggestions for strategic action plans through Circular Economy practices towards improved valorization of the system, that cope with the factors that were identified during the stakeholder analysis procedure.

## 1.3. Dissertation Structure

The presented dissertation is composed by the following six major chapters:

- Chapter 1 – Introduction – This present chapter, were a brief contextualization of the problem is presented, as well as the dissertation's objectives and structure;
- Chapter 2 – Contextualization – Starts by presenting a general overview of the plastic industry, followed by a contextualization of the waste management sector in Europe and Portugal and the characterization of the existing plastic waste supply chains. The chapter culminates with the definition of the problem to be addressed;
- Chapter 3 – State of the Art – Provides a literature review on stakeholder analysis and circular economy. For the former, several methodologies covering stakeholder identification, categorization and relationship analysis, are presented. For the latter, the theoretical and practical understandings of circular economy are investigated, culminating with an assessment of crucial activities in circular economy strategies;
- Chapter 4 – Methodology – Where the methodology that was adopted during the development of this dissertation is presented;
- Chapter 5 – Results and Discussion – The results from the implementation of the stakeholder analysis multimethodology are presented and discussed, culminating with the development of strategic action plans towards improved valorization of the plastic waste supply chain;
- Chapter 6 – Conclusion and Future Work – Which is the final chapter, were the major conclusions from the dissertation are presented, as well as the suggestions for future work.

# 2. Contextualization

This present chapter starts by providing a short overview of the plastic industry and the consequences that are associated with the excessive production of this material. Then, a brief contextualization of waste management activities in Europe and Portugal is presented, and the chapter is brought to conclusion with the problem statement to be addressed during the development of this dissertation.

## 2.1. General Overview on the Plastic Industry

The term 'Plastic' originally meant "pliable and easily shaped", only later it came to be the more generic term for a category of materials called polymers. For over a century now humans learned how to produce synthetic polymers, most often using fossil fuels like petroleum. These synthetic polymers are made of long chains of atoms, such as carbon (highly abundant in fossil fuels) and it is the manipulation of the length, patterns and other characteristics of these chains that will determine the physical properties, such as the strength and flexibility, of the plastic material (Geyer et al., 2017).

Due to these unique properties and manipulability, this material plays a substantial role on tackling many present society challenges - Plastics' light weight means they are used in many transportations means as it allows savings on fuel and emissions cut. Its versatile properties in the packaging industry help ensure food safety while reducing food waste (Geyer et al., 2017). And its use in industries such as 3D printing allowed considerable worldwide growth of new businesses and enabled major breakthroughs in sectors such as medicine. In Europe alone, it gives direct employment to over 1.5 million people and had a turnover of 355 billion euros in 2017 (Geyer et al., 2017). So, this vast, and still expanding usage has led to an accelerated growth of its production. As depicted in Figure 1, annual production in 2015 surpassed 300 million tons, led by the packaging sector, and at this rate it is expected to double in the following 20 years (Ellen MacArthur Foundation, 2016).

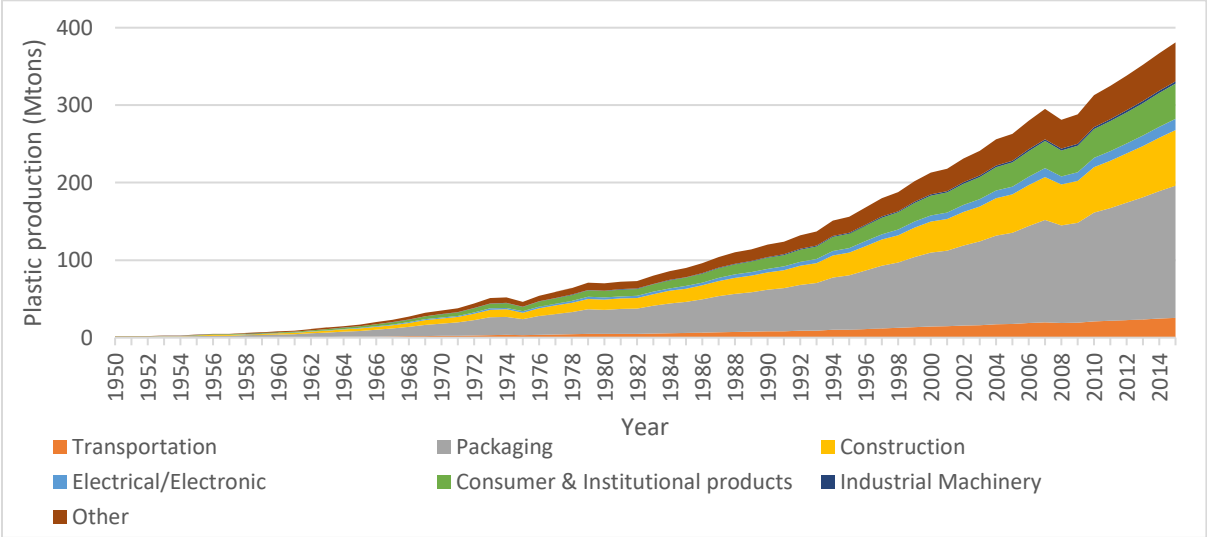


*Figure 1 - Evolution of global plastic production per market sector (Geyer et al., 2017)*

But the noticeable growth of the plastic industry has not come without drawbacks. Poor plastic waste management has contributed to significant greenhouse gas emissions, pollution of the natural environment and the loss of material inherent to current poor recycling rates, represent a substantial lost to the economy (Ellen MacArthur Foundation, 2016). In the packaging industry alone, after the usual (short) first-use cycle, 95% of plastic packaging material value is lost (Ellen MacArthur Foundation, 2016). In addition, this is also the most representative sector in plastic consumption. In Europe it is accountable for 40% of total plastic demand, which then convert into about two thirds of total plastic waste (Velis, 2015). And, as it will further be enlightened, this has substantial implications in the way this waste is managed.

## 2.2. Waste Management in Europe and Portugal

### 2.2.1. Brief Contextualization of Waste Management Activities

Plastic is not the only material posing a threat to the environment. Overall waste levels have escalated worldwide. Waste Management is now one of the major environmental concerns in the world, and it has undeniably expanded and evolved over the years. The main drivers for supporting this expansion have varied over time. Wilson (2007) identified three broad groups of drivers that can be distinguished as the motivators for the evolution of the solid waste management systems over the last millennium (Wilson, 2007):

- Public health: Even though it is considerably 'taken for granted' in many developed countries, it was a main driver during past centuries and it is still a main subject of concern in developing countries.
- Environmental protection: A key driver that emerged in the early 1970s following the environmental movement of the 1960s. Later on, an important dimension was brought out - climate change - which still remains as one of the main drivers for improving waste management.
- Resource value of waste: This could be considered as the first main driver to spurt waste collection initiatives. In the beginning of the past millennium, resources were scarce for a large amount of people whilst streets were piling up with waste. So, many 'consumer' items would be repaired and reused instead of directly entering the 'waste stream'. Since the 1980s, rising disposal costs and realization of resource scarcity led developing economies to reinvent its administration of waste, resulting in the outburst of a redesigned recycling approach. Providing an alternative 'competitive' market to waste disposal and leading to greater perception of the inherent value in waste material.

Modern waste management can be said to comprise the operational, financial and administrative activities involved in the collection, transport, processing, recycling or disposal, and monitoring of waste material (Kan, 2009). Demirbas (2011) breaks down the four main parts that should be included in modern waste management systems: i) waste production), ii) collection and transport systems iii) treatment or reprocessing (of waste materials) iv) final disposing. Advanced waste management systems should also include prioritized management strategies to minimize negative environmental impact and preserve

resources (Kan, 2009). The several steps that constitute each part of a waste management system is tabulated in Table 1.

*Table 1 - General components of waste management systems (Demirbas, 2011)*

| Main Parts | Subparts |
|---|---|
| *Waste production* | Waste sources<br>Source separation<br>Internal collection<br>Production rates<br>Waste types |
| *Collection and Transport* | Collection<br>Transport<br>Transfer |
| *Treatment or Reprocessing* | Physical reprocessing: Shredding, sorting, compacting<br>Thermal reprocessing: Anaerobic digestion, aerobic composting<br>Biological reprocessing: Anaerobic digestion, aerobic composting |
| *Final Disposing* | Recycling<br>Landfilling<br>Energy Recovery |

In addition, according to Kan (2009), modern waste management systems should include the following goals:

1) Reducing total amount of waste by reduction, recycling and reuse.
2) Recycling and re-reintroduction of viable groups of substances into production cycles as secondary raw material or energy carriers.
3) Re-introduction of biological waste into the natural cycle.
4) Best-possible reduction of residual waste quantities, which are to be disposed on “suitable” landfills.
5) Flexible concepts concerning fluctuations in waste quantities and the composition of domestic waste. New developments in the field of waste management must be included into the system (Mwanza & Mbohwa, 2017)

After prevention and reuse, recycling is considered as the best option in the solid waste management hierarchy to reduce the impact of end-of-life and end-of-use post-consumer plastic waste, indicating that recycling could be categorized as the most positively perceived type of solid waste management practice and an essential part of sound waste management (Milios et al., 2018).

Challenges arise in waste management and the recycling activity especially due to the fact that for each of the activities it compromises, regardless of the waste source and destination, it comes at a financial and environmental cost. Coping with this trade-off is one major key for successful waste management in today’s society. Minor or null investment to waste management tend to incur considerable higher costs to society and economy in general than proper investment and mobilization of resources, a recurrent case in low income societies. On which evidence suggests the costs to both society and economy could be 5 to 10 times larger than a sound solid waste management would cost per capita (Milios et al., 2018).

### 2.2.2. Waste Management and Policy Framework

Plastic recycling remains consistently low in Europe when compared to other recyclable materials. In general, paper (and cardboard), metal and glass have considerable higher recycling rates than plastic – Current global rates for plastic are thought to be around 20%, whilst glass sit over 30% and metals might exceed 50% (Milios et al., 2018).

At the EU level, Portugal included, plastic waste was characterized as being addressed through a variety of waste legislation targeting separate waste streams, but no specific targeting plastics. The collection and recycling of this material was indirectly addressed as part of the Municipal Solid Waste in the Waste Framework Directive (2008/98/EC) and Packaging Waste Directive (2000/53/EC). This apparent lack of specific policy measures targeting plastic and alarming low recycling rates led the EC to prioritize plastics in the new Circular Economy Package. The key targets and legislation on which plastics are addressed can be summed in to (European Commission, 2018):

- Development of quality standards for secondary raw materials to increase the confidence of operators in the single market;
- A strategy on plastics in the circular economy, addressing issues of recyclability and biodegradability;
- A common EU target for recycling 65% of MSW and 75% of packaging waste by 2020;
- Promotion of economic instruments to discourage landfilling;
- New extended producer responsibility (EPR) requirements (producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle);
- Economic incentives for producers to put greener products on the market and support recovery and recycling schemes.

In the case of Portugal, latest legislation on plastic waste is included in the PERSU 2020 (*Plano Estratégico de Resíduos Sólidos Urbanos*). And the following are identified as the most relevant measures:

- Decrease in the production of waste until 2020: The country should produce only 10% of the value from 2012, reaching numbers of under 410kg/hab.
- Until the end of 2020, the country should recycle 70% of the packaging waste, by weight.
- Reduction of the deposition in landfills. Maximum value of 35% of all the waste in 2020.
- Preparation of waste for recycling of 50% by 2020. This target encompasses plastics, cardboard, paper and glass.

Other relevant legislation on waste management is included in the law decree regarding responsibility for the management of packaging:

- Small Producers of Waste (less than 1100l/day) have their waste managed by the public systems;

- For the remaining, the managing of the residue throughout its life cycle is the producers' responsibility, unless it is delegated to a licensed waste management operator.

Particular attention should be taken when handling with the Portuguese waste management system. In Portugal, waste management services have been historically produced directly by public authorities. However, due to a significant change in legislation in 1993, private participation in the waste sector started to flourish, adopting several forms. Now, waste management in Portugal is composed by a complex network of arrangements where concessions (contractual PPP) on waste treatment services are the highlighted trend (Simões et al., 2012).

### 2.2.3. Plastic Waste Supply Chains Characterization

Almost half of the European post-consumer waste plastics that were 'recycled', were actually exported to China. This means that the circular economy of plastics in EU is largely materialized via international shipment, reprocessing and product manufacturing in China. Not only this raises a series of questions regarding the environmental performance of such circularity as it reflects a poor valorization of current plastic waste management systems in the European countries (Velis, 2015).

This can be the result of poorly organized plastic waste supply chains and recycling systems, that depreciate the value and attractivity of the sector. Waste supply chains vary considerably across different countries, per waste source and per waste type. Still it is possible to acknowledge a general structure for the relevant plastic waste streams targeted in this research.

<u>Europe</u>

There are two relevant general streams for European plastic waste – commercial and industrial waste (C&I) and municipal solid waste (MSW). The supply chain for these two plastic waste streams are depicted in Figure 2.

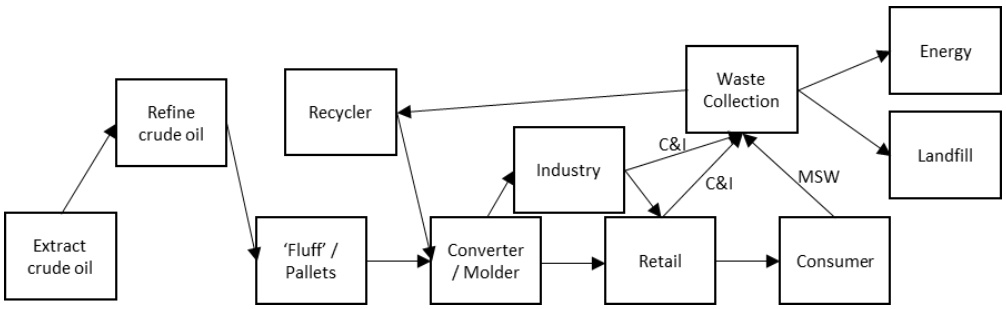


*Figure 2 - General plastic recycling chain for MSW and C&I (Wong, 2010)*

<u>Portugal</u>

Due to the complexity of the plastic waste management and legislative background in Portugal, the description of the plastic waste supply chains is based on four main categories of processes. They vary according to capacity (i.e. 'big' or 'small' producers) and to the typology of plastic (i.e. packaging or non-packaging). The three diagrams (Figures 4,5 and 6) depict an overview of the activities and responsibilities

of each of the main structural entities for the following three scenarios, order by decreasing level of complexity:

i. Plastic Packaging Waste for Small Producers (final consumers or SME's);
ii. Plastic Non-Packaging Waste for Small Producers (final consumers or SME's);
iii. Plastic Waste for Big Producers.

Plastic Packaging Waste for Small Producers (final consumers or SME's)

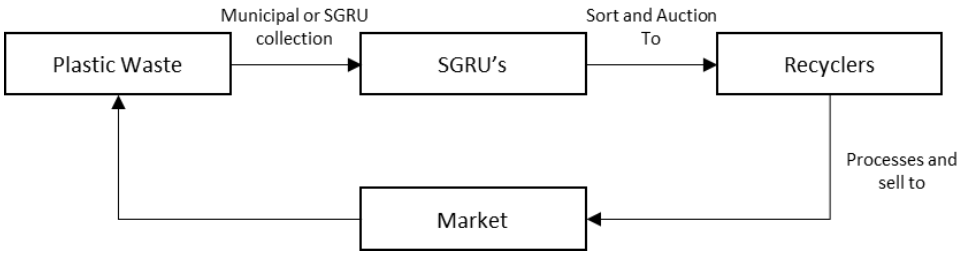


*Figure 3 - Activities diagram in the plastic waste supply chain - packaging, small producers*

In the case of final consumers or SME's, more commonly known as urban flow, plastic packaging waste is managed by the integrated system of packaging waste management (in Portuguese, SIGRE – *Sistema de Gestão de Resíduos de Embalagens*). SIGRE was created to answer to the EPR schemes, due to the unfeasibility in companies collecting individually their products waste. After receiving the plastic waste, SIGRE auctions it to the recyclers who will process it and reintroduce it to the market.

Plastic Non-Packaging Waste for Small Producers (final consumers or SME's)

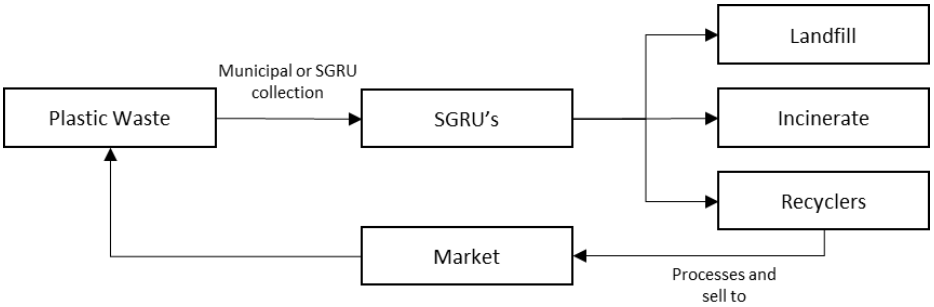


*Figure 4 - Activities diagram in the plastic waste supply chain - non-packaging, small producers*

As in the case of plastic packaging waste, collection for small producers is publicly guaranteed. However, the final output is entirely managed by the SGRU's and not by SIGRE. This results in plastic waste following either one of three destinations, recycling, incinerating or landfilling.

Plastic Waste for Big Producers.

In this last scenario, big companies hire private (licensed) waste management companies to manage the plastic waste produced. These companies can either treat and process the waste for later auction, or auction the collected waste with no previous treatment.

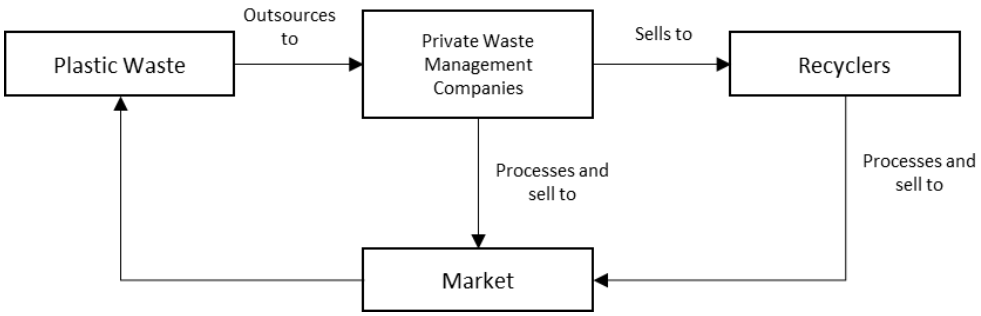


*Figure 5 - Activities diagram in the plastic waste supply chain - plastic waste, big producers*

## 2.3. Problem Statement

The Portuguese waste management sector, portrayed in a wider European scenario, comprises a highly complex and apparently fragmented system. Although recycling rates in Portugal are increasing, it is still a long way towards desired sustainable levels. In order to maximize the added value of plastic waste supply chains and actively coerce the attractivity of the recycling concept it is crucial to develop strategies which promote understanding and cooperation of the several entities involved (Magrinho et al., 2006).

Raising sustainability and resource depletion questions calls for placing the recyclability issue within the broader picture of a Circular Economy. CE provides tools and theories that promote greater overall comprehension and best fit solutions towards the implementation of effective closed-loop systems (Ghisellini et al., 2016).

In order to effectively deploy CE strategies that can valorize the plastic waste supply chain, increase recycling rates and therefore move closer to a circular model, it is important to acknowledge the multiplicity of existing stakeholders that play an important role in the system. Proper identification and analysis of these stakeholders is a critical step in achieving the overall valorization goal. Therefore, two major questions arise regarding the two theoretical developments that are relevant for tackling the problem:

- Which CE principles and tools are the most relevant when dealing with recyclability and secondary markets related issues?
- How to properly identify, categorize and manage the network of stakeholder relationships in the plastic waste sector?

## 2.4. Chapter Conclusions

The negative externalities from a rising plastic industry have been systematically addressed in modern day societies. The development of strategies to cope with the rising concerns has mobilized substantial resources and supported significant technology breakthroughs (Hahladakis & Iacovidou, 2018). However, despite the effort and promising potential of existing initiatives, there seems to be no significant impact at scale. Currently only about 5% of material value of plastics is captured after one use cycle. The failure to achieve meaningful results reflects the fact that present-day plastics economy is highly fragmented (Hahladakis & Iacovidou, 2018). Poor coordination and failure to implement universal standards allowed

proliferation of waste formats, collection schemes and reprocessing systems, which results in a hampered effectiveness of existing markets. New and potential filled initiatives are also being introduced far too fast and in an uncoordinated way to achieve any quantifiable positive consequences (Ellen Macarthur Foundation, 2015). This decentralized management of both industry and waste management creates confusion and hinders public understanding. Overcoming the barriers of fragmentation is a critical step towards moving the plastic industry into a sustainable path of improving value capture and more positive environmental outcomes (McKinsey, 2011).

It is clear that promoting plastic recycling through the valorization of the plastic waste supply chain poses a complex challenge. The economic, environmental, and social dimensions associated with this challenge mean this is a multifaceted aspect that requires a multidimensional valuation, and any conclusions should only be made when sorting and recycling is assessed in combination with aspects faced at the design, use, and collection stages, along with all the stakeholders from the supply chain (Hahladakis & Iacovidou, 2018).

It is crucial when promoting innovation and investment in the plastic recycling industry, to methodically consider the strengths and needs of each key actor at each stage of the supply chain, and provide the innovations that can make a difference in the way plastic is recovered and recycled (Hahladakis & Iacovidou, 2018). In light of these challenges, to subjects of literature review emerge – Circular Economy and Stakeholder Analysis. A state of the art of these two theoretical conceptualizations is presented in the following Chapter 3.

# 3. State of the Art

## 3.1. Circular Economy

Looking back to the beginning of the industrial revolution, new manufacturing methods enabled mass production of goods resulting in low cost and high availability products, which then sustained the new consumer societies. This staggering growth of both industrial and human activities consequently led to an also impressive and unprecedented rise in emissions, waste generation and severe landfilling, all coming at the cost of extreme natural resource consumption (Lieder & Rashid, 2016). Given that the planet's resources are limited, the requirements for this exponential economic and human growth cannot be met (Meadows et al., 1972). So, the current scenario not only compasses the challenges of environmental pollution, but also the challenges of global resource scarcity (Lieder & Rashid, 2016). In the light of the discussed series of challenges, over the last decade, the concept of a Circular Economy (CE) model has been subject of worldwide growing attention, with the aim of providing a sustainable alternative to the dominant "take, make, use, dispose" economic development model (Ghisellini et al., 2016; Ness, 2010). The term 'Circular Economy' has both a linguistic and descriptive meaning. Linguistically it serves as an antonym of a 'linear economy' – defined as converting natural resources into waste, via production (Stahel, 2016). Whilst the second inferred, descriptive meaning of the word 'circular' relates to the idea of cycle (Murray et al., 2017).

CE relevance is now recognized worldwide, and innumerous initiatives are being deployed across the globe. But the idea of circularity in a society is far from recent, and a successful implementation of the concept is complex and requires overall comprehension of its principles, goals and restraints. Aiming understanding and correct application of Circular Economy knowledge this section presents the relevant theoretical and practical topics of interest that were identified in CE literature.

### 3.1.1. From Linear to Circular Economy

Despite rampant technological evolution and constant diversification, current industrial economy has only slightly, and quite insignificantly, moved beyond the fundamental characteristic inherent to the beginning of industrialization, which is a linear model of resource consumption (Ellen MacArthur Foundation, 2012) – the basis of a linear economy. The premise of this model relies on the mentioned "take, make, use, dispose" pattern. This means companies will extract natural resources, manufacture products by applying energy and labor, and sell it to an end consumer, who will later discard it when it no longer serves its purpose (Ellen MacArthur Foundation, 2012).This linear model of resource consumption is supported by an anthropocentric neoclassical environmental economics perspective. From this perspective, the environment is acknowledged to fulfill four basic welfare economic functions: i) amenity values, ii) a resource base for the economy, iii) a sink for residual flows or iv) a life-support system (Andersen, 2007).

Firstly, 'Amenity values' are the pleasures that the environment provides directly to humans without interference from the economic system. Secondly, the environment provides a resource base in the form

of inputs for the economy, with these being both renewable and non-renewable resources. Thirdly, the environment functions as a sink for residuals derived from economic activity. Lastly, the life-support function of the economy, for both humans and non-humans, derives from the inherent biological character of the environment (Andersen, 2007; Pearce & Turner, 1990). As so, this neoclassical line of thinking focuses on efficient resource allocation in markets and provides no analytical tools that take into account the limited and exhaustible aspect of natural resources (Ghisellini et al., 2016).

Current economy is locked into a system where mindset and regulation favor this linear system of production and consumption. Moreover, growing midclass in emerging markets and declining resource prices means higher propensity to buy manufactured goods. Therefore, prognosis points that the impact of the consumer goods industry is set to rise exponentially (Steffen et al., 2011). The consolidation of this excessive consumption and the "take, make, use, dispose" throwaway mindset surfaces several concerns and depletion problems (Lieder & Rashid, 2016). One major problem is pointed out by the Ellen Macarthur Foundation (2012) as being the unnecessary resource losses inherent to the linear model. And it is possible to group these redundant leaks into four major groups:

i. Waste in the production chain: In the production of goods, significant volumes of materials are commonly lost in the chain between resource extraction and final manufacturing. In fact, it is estimated that the manufacturing process in OECD countries consumes over 21 tons of materials that are not physically incorporated to the products themselves (this includes overburden from mining, by catch from fishing, etc.) (Ellen MacArthur Foundation, 2012).
ii. End-of-life waste: Most materials have substantially low conventional recovery rates after the end of their functional life when compared to primary manufacturing rates. In Europe alone, 2.7 billion tons of waste were generated in 2010, but only about 40% was reused, recycled or composted (Ellen MacArthur Foundation, 2012).
iii. Energy use: The current linear system leads to a two-way energy loss. When all products have a disposable end, not only the residual energy of those products is lost, as exceeding amounts of energy are consumed in transforming new resources rather than recycled material (Ellen MacArthur Foundation, 2012).
iv. Erosion of ecosystem services: The planet's natural capital is constantly compromised by the unsustainable practices performed by humanity. The Millennium Ecosystem Assessment examined 24 ecosystem services and found out 15 out of the 24 are being used unsustainably (Steffen et al., 2011).

The negative externalities inherent to the linear model are portrayed by Ghisellini et al. (2016) as "threatening the stability of the economies and the integrity of natural ecosystems that are essential for humanity's survival". And the perceived unsustainability of such model is not a concept of novelty, originating from recent developments. Boulding (1966) did not refer to the linear concept itself but describes a so called reigning "cowboy economy" as an open system in which the natural environment is typically

perceived as limitless, arguing that this conceptualization is built around a flawed understanding of the planet's physical capabilities in the long run (Andersen, 2007; Boulding, 1966). However, businesses have started to notice how a linear economy increases their exposure to volatile resource prices and risks in resource supply (Wijkman et al., 2016). And governments have begun to realize that this prevailing linear model imposes considerable threats to the welfare and wellbeing of society (Wijkman et al., 2016). As waste volumes become worrisome and evidences of resource depletion escalate, overall consent moves towards realization that the 'take, make, use, dispose' model is reaching its physical limits (Ellen Macarthur Foundation, 2015).

Alternatives to the linear model and sole pursuit for economic growth have already been conceived and are becoming increasingly prominent. Charonis (2012) identifies three major alternative discourses to growth – Sustainable Degrowth, Steady State Economics (SSE) and Circular Economy – that share a number of important principles and goals, in spite of the existence of non-negligible differences. The three frameworks share the same request and aim for the economy to operate within the planet's ecological limits (Ghisellini et al., 2016).

Broadly speaking, sustainable degrowth entails "an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level, in the short and long term" (Schneider et al., 2010). The adjective 'sustainable' does not mean that voluntary degrowth must be sustained indefinitely, but rather that the end-state should be sustainable in a sense of mutual benefit for both environment and society (Schneider et al., 2010). On the other hand, the steady state discourse is more welcoming of the possibility for a zero-growth economy to function within a capitalist society (Collier, 2011). Still, the underlying principles of SSE are, to a great extent, quite similar to those of degrowth (Charonis, 2012), often offering identical transition policies. Therefore, Charonis (2012) and Ghisellini et al. (2016) recognize the complementarity between each framework towards a possible alternative to fill the gap imposed by the present model.

SSE interpretation of the environmental problem starts from the point of view of matter and energy constraints imposed by the second law of thermodynamics and depicts a kind of economy where a population and commodity stock kept at constant level and the low flow rates of energy and material can exist continuously (Ghisellini et al., 2016; Xia & Yang, 2007). Thus, SSE represents the balance between two systems – human and material wealth. For the human system, constant levels mean low rates of birth and deaths. Whilst low flow rates for the wealth system rely on low and controlled rates of resource extraction (Sauvé et al., 2016). So, it is clear that this model of a steady state economy with relatively stable, mildly fluctuation levels of consumption, to be preceded by a transitory degrowth where the economy operates within the planet's ecological limits, is very attractive and supported by degrowth proponents (Ghisellini et al., 2016).

However, the premise of degrowth pattern, a planned and equitable transition to a state of lower production and consumption seem unlikely to be imposed externally as policy imperatives (Schneider et al., 2010).

And degrowth as a voluntary social choice and active resource extraction reduction at a consequential scale seem unattainable in face of a raging population growth and intensifying middle-class demand for products.

Even though degrowth and SSE discourses point out relevant subjects of change, "any system based on consumption rather than on the restorative use of resources entails significant losses all along the value chain" (Jawahir & Bradley, 2016). Thus, CE emerges as more than a trend-based model. It can be considered as a way to design an economic pattern aimed at increased efficiency of both production and consumption (Ghisellini et al., 2016). CE allows to decouple prosperity from resource consumption, i.e., "how can we consume goods and services and yet not depend on extraction of virgin resources and thus ensure closed loops that will prevent the eventual disposal of consumed goods in landfill sites" (Sauvé et al., 2016). This restorative and regenerative approach is the key element to enable the leap from the "take, make, use, dispose" pattern to keeping products, components and materials at their highest utility and value at all times (Ellen MacArthur Foundation, 2012). Also drawing a clear line between consumption and use of materials, and the inclusion of this reusing-mindset is what differs CE from the Degrowth and SSE frameworks. It envisions a "future where nothing is wasted; a future where every 'waste' becomes an asset; a future where all products at the end of their primary use are recovered and either reused, remanufactured or recycled for multiples generations" (Jawahir & Bradley, 2016). Therefore, a holistic study on the main principles and tools of CE is essential for providing the correct guidelines for efficient implementation of the concept.

### 3.1.2. Main Principles

It has been stated that current conceptualization of CE reflects the contribution of a vast number of theories (Reike et al., 2018). And the previous section laid clear, CE should be perceived as an "alternative growth discourse" and not an "alternative to growth discourse" (Charonis, 2012). The CE model provides multiple value creation mechanisms that are decoupled from the consumption of finite resources. Ellen Macarthur Foundation (2012, 2015) assimilates the several theoretical contributions and provide three main principles they identify as the fundamentals of a CE model.

i. <u>Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows</u>: It is essential to distinguish between renewable and non-renewable resources. This principle concerns strategies aiming to minimize, and even eliminate, the inputs of non-renewable resources and adjust extraction rates of renewable resources to suitable values for planetary boundaries (Suárez-Eiroa et al., 2019). Natural capital is also enhanced by encouraging the flows of nutrients and creating the conditions for regeneration of the living systems (e.g. the soil) (Ellen Macarthur Foundation, 2015).

ii. <u>Optimize resources yields by circulating products, components, and materials at their highest utility at all times, in both technical and biological cycles</u>: This principle entails two clear goals, to improve durability of products and maximize the recirculation of resources through the different stages of a product life cycles (Suárez-Eiroa et al., 2019). Therefore, designing for refurbishing,

remanufacturing, and recycling to extend the time products, components and materials circulate and contribute to the economy (Ellen Macarthur Foundation, 2015). The use of this practices also promotes waste-free systems and reduces disposal needs (Wijkman et al., 2016).

iii. Foster system effectiveness by revealing and designing out negative externalities: A circular economy would reveal the cost of the externalities of economic activity by outlining their risks and quantifying potential economic impact. These externalities include, among others, all types of pollution, climate changes and negative health effects. And aim to reduce the damaged derived from such externalities (Sauvé et al., 2016).

The detailed management of material flows leads to two main categories of resources: biological nutrients, that are easily re-entered into the biosphere and build natural capital, comprising the biological cycle; and technical nutrients, which will enter the technical cycle, and should be designed to circulate at high quality without reentering the biosphere due to higher material complexity (Braungart et al., 2007). By adopting these notions of biological and technical cycles, Ellen Macarthur Foundation (2012) builds a conceptual model where it becomes possible to incorporate several other relevant theoretical contributions that constitute the pillars and tools of contemporary CE. The model, illustrated in Figure 6, will serve as a framework for analyzing further relevant conceptions that were recognized in CE literature.

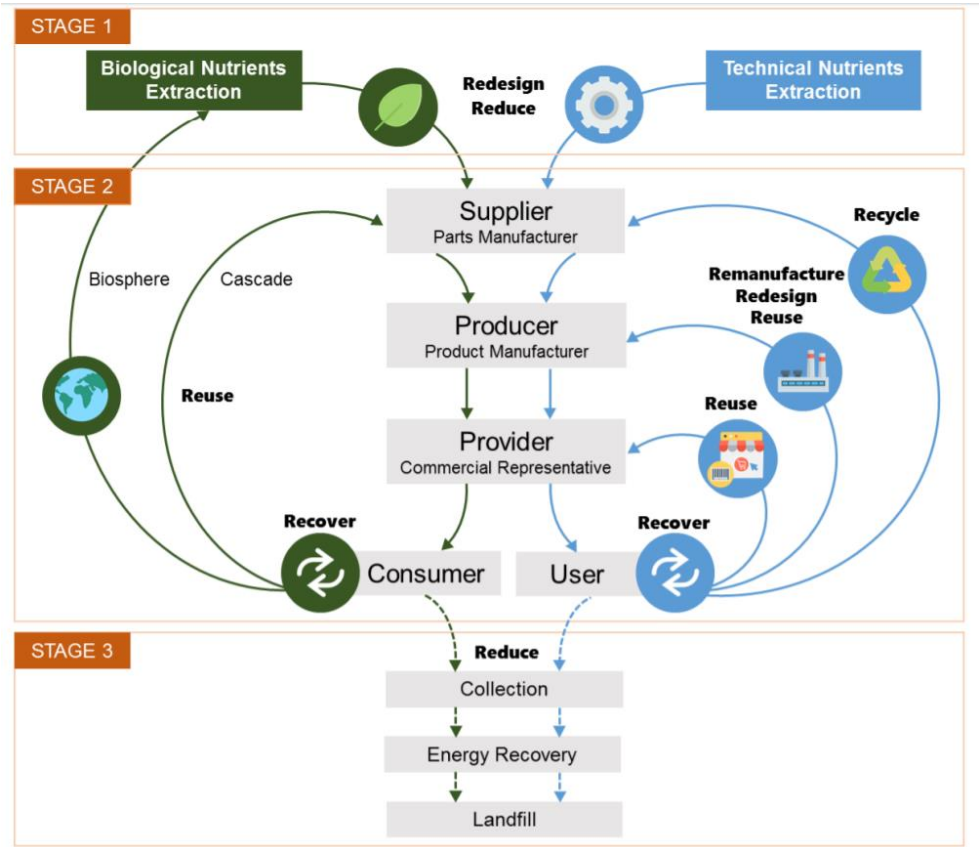


*Figure 6 - The circular economy model (Ellen MacArthur Foundation 2012; Leite 2018)*

The model is divided into Stage 1, Stage 2 and Stage 3. Each stage and associated tools will be explained in detail after an initial overall perspective of the model. Stage 1 starts with resource extraction. These resources can be either biological or technical, according to type of material and end use. Each type of resource has its corresponding cycle, the biological is represented in green whereas the technical is represented in blue. The extraction is usually performed by the supplier, which represents the organizations responsible for resource extraction and preliminary material preparations for the producer, who will then manufacture the final product for market consumption. The providers are responsible for selling the product to the end consumer or user, depending on the cycle. If the product is composed by biological 'nutrients', due to the easy and fast decomposition, they are called products of consumption. Hence the buyers in that cycle being called consumers. On the other hand, in the technical cycle, the buyers are called users since the products are meant for extended use and cannot be discarded easily. These steps and entities from supplier to user/consumer comprise Stage 2. In the end of Stage 2, when the product no longer serves its originally intended purpose, it has two main possible scenarios: It can remain in Stage 2 (or even return to Stage 1, if biological) by initiating the circular path through recovery; Or it can be collected for posterior subsequent disposal, therefore initiating entering Stage 3.

In essence, Stage 2 represents the basis of work for CE. Its main approaches and tools are focused within the organizations and processes involved in this stage. Nevertheless, Stage 1 and 3 are still relevant and its inclusion in the model emphasizes the necessary reduction of raw material extraction and waste generation. After the overall description of the model, a more detailed analysis requires the understanding of three main conceptions: The biological and technical cycles and the 6Rs.

Biological and technical cycles

In a purely circular economy, consumption should only happen in effective bio-cycles where biological processes regenerate disordered materials despite or without human intervention and the flow of biological nutrients is to be managed so as not to exceed the carrying capacity of natural systems (Donaldson & Preston, 1995; Ghisellini et al., 2016; Sakai et al., 2011). But not all materials can be easily and effectively reintroduced into the biosphere, therefore McDonough and Braungart (2002) identify two distinct ways of turning materials into nutrients: Through biological metabolism and through technical metabolism. Which then reflect the biological and technical cycles, respectively.

The materials that flow optimally through the biological metabolism are called biological nutrients. They comprise the biodegradable materials that are easily reabsorbed by the environment, depict or without human intervention, and pose no immediate or eventual hazard to living systems (Donaldson & Preston, 1995; Ghisellini et al., 2016; Sakai et al., 2011). For example, natural or plant-based materials, textiles, brake pads and shoed soles.

The materials that cannot be viably regenerated through the biological metabolism but have the potential to remain safely within a closed-loop system, such as metals, glass and plastics, constitute the technical nutrients (Donaldson & Preston, 1995; Ghisellini et al., 2016). The idea is that circular economy technology

and business models will try to maximize their value through many product life cycles, hence arising mutual benefits for manufacturer and customers (Ellen MacArthur Foundation, 2012, 2015). "The manufacturer maintains ownership of valuable material assets for continual reuse while the customers receive the service of the product without assuming its material liability" (Ghisellini et al., 2016; Sakai et al., 2011).

The 6Rs

CE often emerges in the literature through three main actions, i.e. the 3R principles – Reduce, Reuse and Recycle (Donaldson & Preston, 1995; Sakai et al., 2011). Jawahir and Bradley (2016) reinforce the importance of introducing three more elements – Redesign, Recover and Remanufacture – in the conceptualization of a CE model, therefore leading to the 6R methodology. Each R consist of:

i. Reduce: The reduction principle aims to minimize the inputs of primary energy, raw materials and waste by improving efficiency in production and consumption processes (Ghisellini et al., 2016).
ii. Reuse: This principle refers to the reuse of the product as a whole, or its components, after its first life-cycle, for subsequent life-cycles. Consequentially reducing the usage of virgin materials to produce newer products (Jawahir & Bradley, 2016). The main idea is to "to use products to its maximum capability with frequent maintenance and reclamation to prolong its endurance" (Su et al., 2013).
iii. Recycle: It involves the process of converting material that would otherwise be considered waste, into new products. It offers the opportunity to benefit from still usable resources and reduce waste generation (Jawahir & Bradley, 2016; Lazarevic et al., 2010).
iv. Recover: This activity can be foreseen as a processor for some of the other principles. It comprises the process of collecting products at the end of use stage, dissembling, sorting and cleaning for utilization in subsequent life-cycles (Jawahir & Bradley, 2016).
v. Redesign: The redesign activity involves the act of rethinking the design of next generation products so they can use components, materials and resources recovered from the previous life-cycle (Jawahir & Bradley, 2016).
vi. Remanufacture: This principle involves the re-processing of already used products aiming the restoration to their original state or even a like-new form that still holds all functionalities through the reuse of as many parts as possible (Jawahir & Bradley, 2016).

A perfectly CE would be characterized by an entirely circular industry system where Stage 1 would encompass resource extraction within the planetary regenerative limits and Stage 3 would seize to exist, due to the inherent waste-free system. This is still a very idealistic formulation, but the work on CE emphasizes the necessary shift towards a more circular model. Adopting the 6Rs as tools for enforcing the main principles of CE is essential to achieve significative economic and social benefits with reduced adverse environmental issues. Table 2 explains where and why which 'Rs' are the most pertinent, in guaranteeing the viability of the three main circular economy principles:

*Table 2 - 6Rs application in the context of the three main principles of CE*

| Principles | Action / R(s) | Stage | Description | Literature |
|---|---|---|---|---|
| *i) Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows* | Reduce | 1,2,3 | Decrease resource extraction from biosphere to levels within the Earth's capacity in order to guarantee a sustainable future; Reduce energy consumption and harmful emissions; Decrease waste discharge in landfills. | (Ghisellini et al., 2016; Sauvé et al., 2016) |
| | Redesign | 1,2,3 | Redesign, restoratively and regeneratively, the entire supply chain process in order to achieve a balancing renewable resource flow and avoid imprudent resource and energy losses; Particularly redesign production activities; Introduce enhanced technologies to make processes more efficient; Renewable energy should be the main energy source;<br>Increase adaptability of the economic system towards fossil fuels negative effects (e.g. increase in oil prices, lack of supply, etc.); Redesign products for better compliance with other R-actions. | (Ellen MacArthur Foundation, 2012; Geissdoerfer et al., 2017; Ghisellini et al., 2016; Zhijun & Nailing, 2007) |
| *ii) Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles* | Recover | 2 | When 'nutrients' are no longer suitable for envisioned purpose, reintroduce materials into the biosphere at level within the planet's boundaries[1]; After the disposal, products should be recovered and assessed so other 'R' actions can take place.[2] | (Ellen MacArthur Foundation, 2012; Kalmykova et al., 2018) |
| | Reuse | 2 | If materials no longer serve their initial function, reuse them to fulfill different purposes (cascade procedure);[1] After being recovered, if the product as a whole is in good conditions, it should be sent to a commercial to be sold for the same initial purpose. If the product is not able to serve it original function, it should be disassembled so its working components can be reused.[2] | (Ellen MacArthur Foundation, 2012; Geissdoerfer et al., 2017; Mendoza et al., 2017) |
| | Remanufacture | 2 | Collect available used working components and remanufacture initial products.[2] | (Sihvonen & Partanen, 2017) |
| | Redesign | 2 | Redesign products to maximize the incorporation of reused components. | (Mendoza et al., 2017) |
| | Recycle | 2 | [2]The remaining products that cannot be either reused or remanufactured should be recycled and reincorporated into the cycle through a supplier. | (Ellen MacArthur Foundation, 2012) |
| *iii) Foster system effectiveness by revealing and designing out negative externalities* | Redesign | 1,2,3 | Redesign the entire supply chain in order to eliminate unnecessary negative externalities and redundancies; Also redesign so that other externalities that might arise are easily detected. | (Elia et al., 2017; Jawahir & Bradley, 2016) |
| | Reduce | 1,2,3 | When redesigning the SC, the main aim should be to reduce the excessive burdens and damaged caused by the negative externalities. | (Elia et al., 2017; Ellen MacArthur Foundation, 2012) |

[1]Applicable for biological 'nutrients' only
[2]Mainly applicable to technical 'nutrients'

While resource-efficient manufacturing and minimal generation of waste are the anticipated cornerstones of a closed-loop sustainable manufacturing, a comprehensive understanding of the 6R based approaches and their impact in value creation proves to be essential in achieving the economic and societal benefits with minimal adverse environmental impacts ambitioned by the three main principles of CE (Jawahir & Bradley, 2016). However, the implementation of CE is a multidimensional process. It depends on a range of factors, such as the type of approach, type of government, degree of implementation, and more. So, it is

essential to have an overview of which approaches, and tools support the actions and principles for an effective shift towards a circular model.

### 3.1.3. Activities and Implementation

According to Ghisellini et al. (2016) worldwide CE seems to follow two substantially different patterns. One pattern can be characterized as a top-down approach where CE is promoted or enforced via national programs that are embedded in some wider policy for economic transformation. The other pattern, as for the case of CE in Europe, follows a bottom-up approach, i.e. the initiatives of environmental organizations, other institutions and even civil society, actively push green initiatives and adequate legislation into national policies (Chertow, 2000).

The type of approach should dictate at which level the implementation of CE is analyzed (Ghisellini et al., 2016). Su et al. (2013) state that a successful implementation of the CE policies requires efforts at three different levels: micro-level, meso-level, and macro-level. The bottom-up approach implies that the analysis of CE implementation should focus on the micro level, whilst the top-down approach suggests a shift to the higher hierarchical levels – meso and macro (Ghisellini et al., 2016). The micro level refers to the individual firm level and the suite of corporate-level initiatives, whilst the CE actions in the meso level refer to the inter-firm level and is primarily related to symbiosis associations (Geng & Doberstein, 2008). It involves the development of productive network denominations, e.g. eco-industrial parks, and physical exchanges among several organizations (Chertow, 2000). Finally, the macro level is associated to CE implementation in cities, provinces or regions and involves the redesign of four main systems.

Within each level, CE literature identifies several actions and activities through which the CE principles are enforced. Although different taxonomies are adopted, it is possible find several similarities between the activities described. Leite (2018) analyzed those similarities and categorized the six main on-going practices in CE strategies implementation: i) Eco-design; ii) Green Procurement; iii) Cleaner Production; iv) Service Economy; v) Sustained Lifespan; vi) Recovery Economy (Leite, 2018).

<u>Eco-design</u>

Several definitions of eco-design arise from the literature and, in general, it is possible to identify a pattern. They all seem to refer that eco-design consists of proactively addressing the environmental characteristics of a product in the early stages of the development process with the aim of reducing the environmental implications throughout its entire life cycle (Plouffe et al., 2011; Su et al., 2013). In the CE context, eco-design should promote easiness in circularity while enhancing the environmental value of the whole SC by promoting the utilization of recyclable materials and renewable resources into new products and encourage long-lasting designs (Elia et al., 2017; Geissdoerfer et al., 2017).

<u>Green Procurement</u>

The main goal with this activity is to perform a holistic analysis in sourcing and procurement activities in order to safeguard environmental standards and an effectively ‘green’ supply chain (Ellen MacArthur

Foundation, 2012; Lieder & Rashid, 2016). CE literature already comprises several developments on the concept of Green Public Procurement (GPP) and it even has been adopted by several nations and included in government programs (Winans et al., 2017). However, as recognized by Leite (2016), the green procurement activity should also be extended to companies, especially those who sourcing activities have a large weight in the quality of the final product, and not only practice by the public sector.

Cleaner Production

The term 'cleaner production' was initially used in the CE context in the Cleaner Production Promotion Law implemented by the Chinese government (Winans et al., 2017). Cleaner production incorporates a number of practices that increase the environmental sustainability of a company's production activities (Severo et al., 2017) by promoting the use of cleaner energy, improved technologies, better resource consumption and other activities (Elia et al., 2017; Ghisellini et al., 2016). It has a predominant role in reducing externalities as it actively prevents unnecessary material and energy losses (Su et al., 2013).

Service Economy

This concept was introduced by Stahel (1997) to describe an economy where the majority of value is created by services and the majority of jobs have service-related activities. The underlying idea is to transfer product ownership to the manufacturers and providers to increase their search for longevity, reliability and reusability (Lacy & Rutqvist, 2015). It supported by leasing and renting strategies as the costumers receive the service related to the product without assuming the material liability, which is kept by the manufacturer (Braungart et al., 2007).

Several authors in CE literature suggest strategies that support a service economy and the changes in product ownership, such as 'renting systems' (Su et al., 2013), 'collaborative consumption' and 'consumer-to-consumer channels' (Stahel, 2013).

Sustained Lifespan

As recognized in the literature, one key challenge in CE is to maximize the products lifetime. There are two major ways of achieving better longevity: Enhancing the products robustness and quality and/or by ensuring effective repair (Ellen MacArthur Foundation, 2012; Ghisellini et al., 2016; Lieder & Rashid, 2016; Sauvé et al., 2016).

Recovery Economy

"The main focus of the circular economy, embedded in the original concept, has gradually been shifted from narrow waste recycling to broad efficient-oriented control were more areas have been covered: aside from resources and waste problems, energy efficiency and conservation, land management and soil protection, and integrated water resource management problems have also been considered as key issues." (Su et al., 2013). However, worldwide focus in CE continues to be the capitalization on material flow recycling (Winans et al., 2017), preceded by efficient recovery methods (Elia et al., 2017). The recovery economy can be said to have a bi-dimensional motivation. On one side, it is based on the need to minimize the use

of virgin resources in the production but it also plays the active role of minimizing the amount of waste discarded (Geissdoerfer et al., 2017; Su et al., 2013; Winans et al., 2017).

Still, some authors emphasize that, even though a recovery economy is pertinent, it should play the major role in an idealist CE model. As stated by Stahel (2013), “Although circular economy is often identified with the recycling principle, it must be underlined that this may be the least sustainable solution compared with the reuse principle in terms of resource efficiency and profitability“ (Stahel, 2013).

## 3.2. Stakeholder Analysis

### 3.2.1. Defining Stakeholder

The concept of *stakeholder*, initially coined by the Stanford Research Institute in 1963, referred to “those groups without whose support the organization would cease to exist”. The earliest lists of stakeholders originally included employees, customers, suppliers, lenders, shareowners and society (Mitchell et al. 1997). The concept was then broadened by the same Robert Edward Freeman (1984) in his landmark book - *Strategic Management: A Stakeholder Approach* - to “any group or individual who can affect, or is affected by, the achievement of a corporation’s purpose”. Even broader definitions were proposed in attempts to translate the empirical reality that virtually anyone can be affected by an organization’s actions, as well as narrower definitions, reflecting the damaged effectiveness in managers pursuing to attend all potential claims (Mitchell et al., 1997). Which makes clear that decision makers knowing who is affected (and how) by their decisions and corporate actions, as well as recognizing who has the power to influence their outcomes are extremely powerful management tools (Reed et al., 2009).

While the above-mentioned definitions prove to be useful in explaining the concept, the role that definitions play should not be overemphasized. By the words of Freeman (1983) “the stakeholder notion is indeed a deceptively simple one”. So, it is important not to get caught up in definitions but to understand the actual usefulness of stakeholder analysis (Hörisch et al., 2014).

### 3.2.2. Stakeholder Analysis Approaches

Although stakeholder analysis is recognized as a vital management task, stakeholders are often identified with no specific methodology and lacking proper planning. This can result in the demeaning of important focus groups and compromise the organization’s performance. Therefore, Ackerman and Eden (2011) identify three critical issues for the analysis and management of stakeholders:

- Identifying who the stakeholders are in the specific situation (rather than relying on generic stakeholder lists). It is crucial to recognize the uniqueness of each organization’s context.
- Acknowledge the importance of stakeholder dynamics: Analyze the multiple and interdependent interactions between stakeholders (and potential stakeholders).
- Develop context specific stakeholder management strategies, based on stakeholder significance, interest and power to influence the organization’s direction.

This growing realization of the potential impact stakeholders can have in an organization's objectives led to the development of approaches on how to analyze stakeholders, making possible to understand the level of interest, potential impact and how these can support or threaten businesses (Bryson, Patton, & Bowman, 2010). A review of stakeholder theory shows considerably different approaches have been developed. According to Donaldson and Preston (1995) it is possible to label three distinct types of approach to stakeholder analysis: descriptive/empirical stakeholder analysis, instrumental stakeholder analysis and normative stakeholder analysis. A fourth approach can be recognized as it aims to integrate descriptive, empirical and normative aspects, known as integrative stakeholder analysis (Hart & Sanjay, 2004). Table 3 describes the theory behind each approach and its main focus.

*Table 3 - Different types of stakeholder theory (Adapted from Donaldson & Preston 1995; Hörisch et al. 2014)*

| Theory | Focus |
|---|---|
| *Descriptive/Empirical stakeholder theory* | Describe and explain past, present and future states of affair and specific relationships between a particular phenomenon and its stakeholders |
| *Instrumental stakeholder theory* | Effects of stakeholder management on the achievement of desired outcomes; Connect stakeholder approaches and desired objectives |
| *Normative stakeholder theory* | Discussion of the purpose of business; moral justifications of stakeholder theory |

The descriptive approach is rarely conducted as an end itself, as its purpose is to only describe the relationships between the phenomenon and its stakeholders. However, the remaining two approaches require an understanding on current state of affairs, so a descriptive approach can be perceived as a precursor for both instrumental and normative approaches (Donaldson & Preston, 1995).

As stakeholder analysis is extended to policy, development and natural resource management the emphasis on the legitimacy of stakeholder involvement and empowerment in decision-making processes increases. Therefore, these areas favor normative approaches. Yet, instrumental stakeholder research is more pragmatic, and it has been argued to enable information to be sought from a wider range of sources, providing more robust knowledge bases from which improved resource management initiatives can be built. This can be particularly useful in the need to reach consensually agreed targets (Prell et al., 2009).

Both normative and instrumental approaches prove to be useful in different disciplines and contexts by applying a wide variety of methods. And these methods can be categorized as methods used for (Mathur et al., 2007; Prell et al., 2009).

i. Identifying stakeholders (section 3.2.4.)
ii. Mapping stakeholders (differentiating and categorizing stakeholders) (section 3.2.5.)
iii. Analyzing relationships between stakeholders (section 3.2.6.)

After a brief introduction to some interviewing techniques, the following sections will present relevant stakeholder analysis methodologies following the above typology, which has been adapted from Reed et al. (2009) and Mathur et al. (2007), while also having in consideration the critical issues presented by

Ackerman and Eden (2011). Each section will culminate with a table summarizing each of the approaches presented, as well as its main strengths and weaknesses.

### 3.2.3. Interviewing Techniques for Stakeholder Analysis

The majority of stakeholder analysis techniques require some type of interviewing to perform tasks such as selecting participants for research, gathering information about stakeholders and the surrounding environment, and using stakeholder participation as analysis input (Wilson, 2013). Three interviewing techniques that are commonly use to address stakeholder analysis problematics are presented during this section, and a summary of these techniques and their weaknesses and strengths is provided in Table 4.

Focus Groups

Also known as group interviews, it is a qualitative research method where a facilitator guides a group of five to twelve pre-selected participants with the aim of understanding their range of perspectives (Lazar et al., 2017). These participants are selected based on the premise that they share characteristics and knowledge that are relevant for the topic to be addressed (Wilson, 2013). It is usually associated with brainstorming and the use of facilitation materials, such as flip-charts and post-its to make the process more visual and easier to follow (Reed et al., 2009).

It can have some associated expenses, like renting a room, food and drinks, or an expert facilitator, but it is considered to be cost-effective as results are usually quickly obtained. However, depending on the dynamics of the participants, execution and analysis might be complicated (Lazar et al., 2017).

Structured Interviews

Structured interviews are verbal or written questionnaires in which responses are limited by a fixed set of questions and minimal deviation. Usually, the same set of questions, by the same order, is provided to the set of interviewees. Closed answers are particularly useful for standardizing responses (Wilson, 2013). It is especially useful when the objective is to collect standardized information from a large sample of participants and it is usually adopted to obtain information about demographics, behaviors and relationships (Wilson, 2013).

The flexibility of conducting these interviews either personally or at the distance (e.g. via web platforms), is one the major advantages of this type of interview. Another strength is the easiness of comparing standardized answers. However, the rigid nature of the interview might make the interviewer-respondent connection harder to achieve and, the more passive role of participants may lead to unreasonable answers and wrong judgements being transmitted (Wilson, 2013).

Semi-structured interviews

Semi-structured interviews are characterized by combining predefined questions with open-ended and unstructured questions. The goal is to gather systematic and in-depth data about a set of topics, while allowing some freedom towards addressing related issues (Wilson, 2013).

These interviews usually require the use of an interview guide, but are structured in a way that allows the interviewer to adapt the questions depending on the participant (Wilson, 2013). It is particularly useful when the interviewer already has some knowledge about the topic, but more in-depth knowledge or particular points of view are required.

The main strength of this technique is the ability to unveil previously unknown information about a certain topic, clarify complex scenarios and cross-check information gathered via other methodology. However, there is one major set back when compared, for example, with structured interviews, due to the considerable human and resource efforts that required for conducting all interviews personally. In addition, the mixture of quantitative and qualitative data is also time-consuming to analyze (Reed et al., 2009).

*Table 4 - Interviewing techniques for stakeholder analysis*

| Technique | Description | Resources | Advantages | Disadvantages |
|---|---|---|---|---|
| *Focus Groups* | A selected group of 5 to 12 participants brainstorms on relevant information on the stakeholders. Discussion is then leaded by a facilitator. | Room hire; Facilitation materials (e.g. flip-chart paper and post-its). | Quick and cost effective; Easily adaptable; Promotes group understanding in complex issues. | Not very well structured; Requires high level and effective facilitation for good results. |
| *Structured interviews* | Interviews based on a fixed set of (sometimes) standardized questions. | Interview time, platform for allowing respondents to file their answers | Allows to collect uniform data from large samples. Easy to compare answers, facilitating data analysis. Can be performed via network platforms. | Difficult to establish appropriate set of questions. Participants may adopt more passive roles. |
| *Semi-structured interviews* | Interviews composed of both predefined questions and open-ended questions. | Mobility resources for analyzer; voice recorder. | Provides in-depth insight on stakeholder relationships and judgements. | Time consuming and hence costly; Makes stakeholder categorization difficult. |

### 3.2.4. Identifying Stakeholders

Much of the stakeholder analysis literature suggests premeditated generic lists, followed by a categorization of the pre-identified stakeholders. However, as addressed by Ackerman an Eden (2011), a clear understanding of the context is indispensable. Only that way it is possible to properly delimitate the boundaries of the phenomenon under investigation – “Every situation is unique, shaped by the issues, the people, history, location, structures of organizations and institutions taking part, wider decision-making processes and systems, and so on” (INVOLVE, 2005). Yet, even if the boundaries are well defined, the extend of the project might turn stakeholder identification inviable and, if it is the case, a line must be drawn based on well-founded criteria (Clarke & Clegg, 1998). Taking this limitation into account, four distinct techniques for the identification of stakeholders have been recognized from the literature: i) list evaluation stakeholders, ii) radical transactiveness, iii) snowball sampling, and iv) baseline approach. This section will now expose each of these methods.

<u>List Evaluation Stakeholders</u>

This technique starts with a small evaluation planning group, might even be just one evaluator, brainstorming on the list of people or groups who care about or are affected by the subject matter. This first stage is typically discrete and restricted to the evaluating group. Further additional information inputs may come from targeted information gathering techniques such as interviews, questionnaires and focus groups (Bryson et al., 2011). Particular attention should be payed to establishing the right level of aggregation, meaning stakeholders should be identified at a level coherent with the system at stake (Ackermann & Eden, 2011) - Perhaps the best illustration of this concern is the involvement of government sponsored institutions, were the government itself is not a stakeholder, but sponsored environment agencies might be, or the police department, for example. Those involved in the brainstorming process should also be aware that other stakeholders may emerge further in the analysis process (Bryson et al., 2011).

Radical Transactiveness – RT

Most organizations still tend to protect their advantages in existing businesses focusing only on known, notable and authoritative stakeholders. By recognizing these challenges Hart and Sanjay (2004) developed the concept of RT. This is a dynamic approach seeking to systematically identify stakeholders in the periphery - 'fringe' – of the system and aims to manage potential disruptive change and build competitive information (Hart & Sanjay, 2004).

Stakeholders are then split into 'core' stakeholders – those readily identifiable by other methodologies due to its direct stake, power, legitimacy or urgency of their claims – and 'fringe' stakeholders that are usually remote, weak, poor, disinterested, isolated, non-legitimate or non-human becoming imperceptible to conventional approaches. Figure 7 illustrates the main differences between 'core' and 'fringe' stakeholders (Hart & Sanjay, 2004):

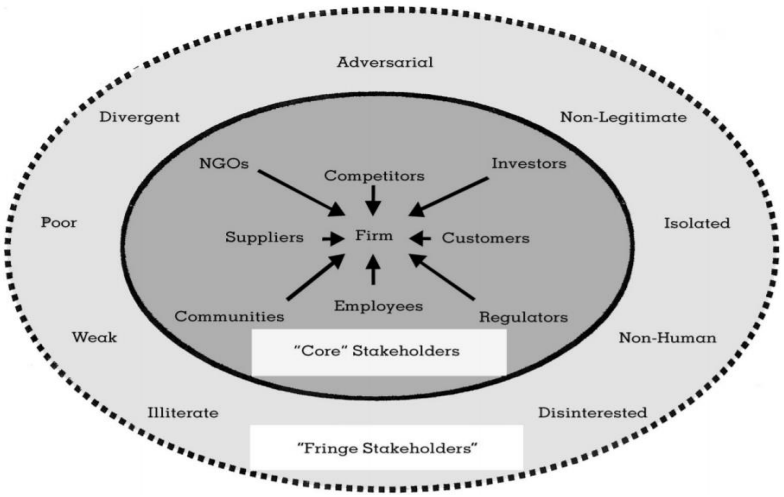


*Figure 7 - Illustration of core and fringe stakeholders (Hart & Sanjay, 2018)*

'Fringe' stakeholders become relevant as they may hold information and perspectives, not only on other 'fringe' stakeholders, but that are key to anticipate potential future sources of problems or innovative opportunities. Allowing to later open communication channels to these previously untapped sources of

knowledge might enable a dynamic alignment of strategies and changing environment. In this method the issue of drawing the border for ‘fringe’ stakeholders becomes a critical once. Considering that in practice, resources are limited, and to over extend the boundary can hamper the management process (Mitchell et al., 1997).

Snowball sampling

This is one of the most mentioned methods in literature for general actor identification. First, the analyst must develop a screening procedure for the initial group of participants, and these should then help the analyst identify additional people to be included in the study (Hair et al., 2014).

As for stakeholder application, it involves the practice of subjectively identifying and qualifying a set of initial prospective stakeholders, that then need to be questioned about whom they consider as stakeholders (Mathur et al., 2007). After identifying a new set of stakeholders, the process is then repeated until all relevant parts are identified (Kalton & Anderson, 1986). These opinions on who stakeholders perceive as also being stakeholders might be elicited through the array of interview approaches presented in Table 4.

Baseline approach

The following methodology was adapted from the approach developed by Sharp et al. (1999) for stakeholder identification in requirements engineering and it focuses on interactions between stakeholders rather than relationships between the system and stakeholder.

The starting point of the method is a set of stakeholders referred to as ‘baseline’ stakeholders. ‘Baseline’ stakeholders usually comprise four groups (Sharp et al., 1999):

- Users: Those who receive products from the system.
- Operators: Those who carry out the activities of the system.
- Legislators: Government agencies, trade unions, safety executives and other entities who may produce guidelines for operation affecting the system.
- Decision-makers: Stakeholders in decision-making structures directly associated with the user and/or operational organizations

From this four groups it is then possible to recognize two other groups: ‘supplier’ stakeholders and ‘client’ stakeholders. The former supplies some type of good or service to the baseline while the latter processes or inspects the products of the baseline. The final group of stakeholders is called ‘satellite’, as they interact with the baseline in ways of communication or research (Sharp et al., 1999). Figure 8 illustrates the main elements of this stakeholder identification process:

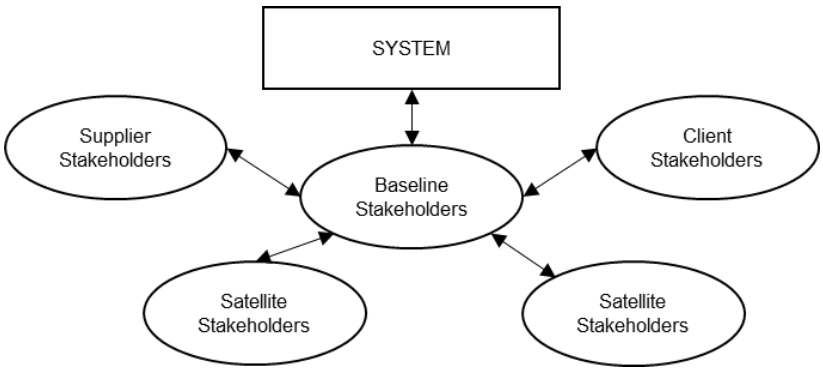


*Figure 8 - Main elements of the baseline approach (Adapted from Sharp et al. 1999)*

A summary of the stakeholder identification methods as well as a review on their particular strengths and weaknesses is provided in Table 5. The entities which are included and which are omitted may depend on the applied methodology for stakeholder identification. This is a critical stage on stakeholder analysis as it will decide "who and what really counts" and determine further work and approaches for stakeholder analysis (Mitchell et al., 1997). After properly applying the best suited identification method (or methods), the analysis should be followed by properly differentiating between and categorizing stakeholders (Reed et al., 2009).

*Table 5 - Methodologies for stakeholder identification (adapted from Reed et al. 2009; Abreu 2017)*

| Methodology | Description | Strengths | Weaknesses |
|---|---|---|---|
| *List evaluation stakeholders* | Small group (or individual) brainstorms a broad list of potential stakeholders. | Simple and cost-effective. Good starting point for other methodologies. | Might lead to a narrow perspective. High risk of not including relevant stakeholders |
| *Radical Transactiveness* | Identify 'fringe' stakeholders through information from other 'fringe' stakeholders – particular application of snowball sampling. | Identifies stakeholders usually left out that might provide relevant competitive information. | Drawing the boundary for 'fringe' stakeholders is critical. High risk of hampering effectiveness by overextending stakeholder dimension. Resource consuming. |
| *Snowball sampling* | Iterative process were individuals from an initial set of stakeholders are interviewed, identifying new stakeholders and contacts. | Easy to secure interviews without data protection issues; fewer interviews declined. | Sample may be biased by the social networks of the first group in the sample, not identifying less visible stakeholders. |
| *Baseline stakeholders* | Identify stakeholders according to a categorization of baseline, supplier, client or satellite. | Starts from a known core of stakeholders working outwards. Small chances of major stakeholders being left out. | Time demanding. Might lead to redundant data. |

### 3.2.5. Mapping Stakeholders

The methodologies involved in characterizing and classifying stakeholders tend to follow two broad approaches: i) top down 'analytical categorizations' and ii) bottom-up 'reconstructive methods' (Reed et al., 2009). In analytical categorizations the classification of stakeholders is performed by those conducting the analysis based on their perspective on the subject matter and theoretical knowledge on the surrounding

environment (Bryson, 2004; Mathur et al., 2007). These top down approaches often tend to focus on the 'usual suspects' leading to under-representation of marginalized or not so representative groups. Reconstructive categorizations try to answer to those limitations allowing categorizations and parameters to be defined by the stakeholders themselves, so their concerns have greater weight in the analysis process (Hare & Pahl-Wostl, 2003). Nevertheless, involving stakeholders in the mapping process can be difficult and extremely cost demanding. Given so, three analytical categorization processes will now be presented:

Two-dimensional matrices – 'Power versus Interest' matrix

Two-dimensional matrices are the most commonly used techniques for differentiating and categorizing stakeholders. These techniques suggest mapping stakeholders on a matrix/grid composed by two key attributes as its axes (Mathur et al., 2007). Stakeholders are then mapped in matrices such as the importance/influence matrix, power/interest matrix, readiness/power matrix, support/opposition grid, amongst others (Bryson, 2004; Mathur et al., 2007).

Although relatively more complex three-dimensional approaches can result in better conceptual understanding of stakeholders, it can be argued that simpler techniques can be universally adopted. From the several referred two-dimensional grids to map stakeholders, the power/interest matrix is widely used and of proved effectiveness (Ackermann & Eden, 2011) .

The definitions of power and interest fluctuate according to the context. The definition for power, particularly, is far from consensus in stakeholder literature. As Mitchel et al. (1997) point out "power may be tricky to define but it is not that difficult to recognize". Still, generalist and widely accepted definitions exist. Murray-Webster and Simon (2006) define power as the stakeholder potential to influence derived from their positional or resource power relative to the concept, or their actual influence due to their credibility as leaders or experts. Whilst interest is measured by the extent to which stakeholders will be active or passive (Murray-Webster & Simon, 2006).

The resulting two-by-two matrix, as illustrated in Figure 9, means stakeholders placement divides them into to four groups (Ackermann & Eden, 2011; Bryson, 2004):

- Players - Have both an interest and significant power
- Subjects - Have an interest but little power
- Crowd - consists of stakeholders with little interest or power
- Context Setters - Have power but little direct interest

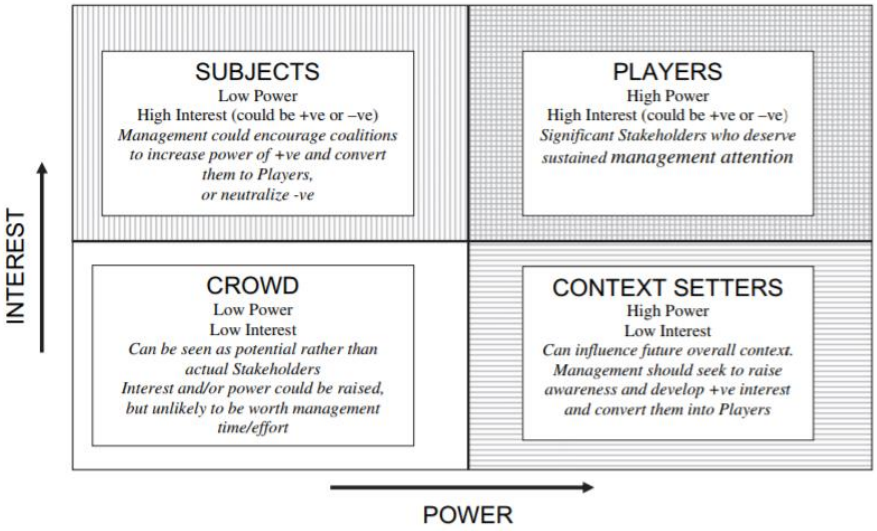


*Figure 9 - Stakeholder power-interest grid (Ackermann and Eden 2011)*

<u>Support versus Opposition Grid</u>

Most of the stakeholder categorization techniques tend to downplay the significance of opposition. There is no explicit and active approach to this subject. The support versus opposition grid is another two-dimensional matrix that was initially developed by Anderson et al. (1999) as an adaptation to Nutt and Backoff 's (1992) technique for planning purposes and actively accounts opposition, aiming to develop problems definitions likely to lead to a winning coalition (Bryson, 2004).

The method consists of grouping stakeholders in one of four cells according to their power and likeliness to support for or opposition towards the issue (Crosby & Bryson, 2005). The output of this method are four categories of stakeholders according to their position in the grid (see Figure 10).

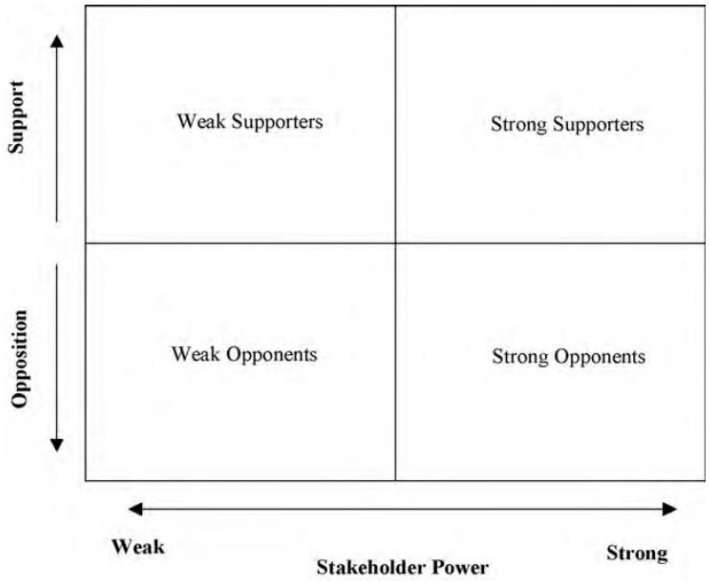


*Figure 10 - Stakeholder power-interest grid (Bryson et al., 2011)*

The resulting categories are: weak supporters, strong supporters, weak opponents and strong opponents (Bryson, 2004).

Power, Legitimacy and Urgency diagram

This categorization model by Mitchell et al. 1997, expanded the limited scope of the (Rawlins 2006) model by recognizing that power, legitimacy and urgency were not mutually exclusive variables but part of a mix that would help prioritize stakeholders (Rawlins, 2006).

Mitchel et al.'s 'power' definition is based on the idea that power is "the ability of those who possess power to bring about the outcomes they desire" (Salancik & Pfeffer, 1977). On the other hand, 'Legitimacy' holds for the generalized perception if the actions of an entity are desirable, proper or appropriate within the society's value system (Mitchell et al., 1997; Suchman, 1995). Ultimately 'urgency is defined as "the degree to which stakeholder claims call for immediate attention" (Mitchell et al., 1997).

A focal point of this dynamic methodology is the assumption that stakeholder attributes are variable, not steady state (Mitchell et al., 1997; Wagner Mainardes et al., 2012). From the various combinations of these attributes result the following stakeholder classes depicted in Figure 11:

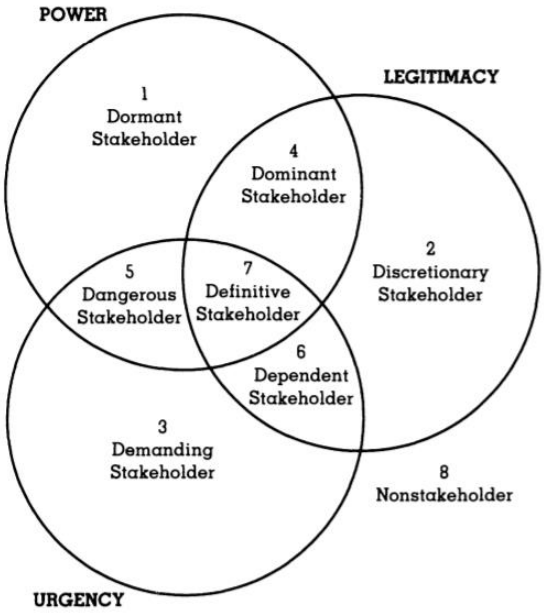


*Figure 11 - Stakeholder typology according to Power, Legitimacy and Urgency (Mitchell et al. 1997)*

Stakeholders can then be classified as: 1. Dormant stakeholders; 2. Discretionary stakeholders; 3. Demanding stakeholders; 4. Dominant stakeholders; 5. Dangerous stakeholders; 6. Dependent stakeholders; 7. Definitive stakeholders.

Table 6 presents a summary of the considered methodologies for mapping stakeholders as well as their major strengths and weaknesses:

*Table 6 - Methodologies for stakeholder mapping (adapted from Abreu 2017)*

| Methodology | Description | Strengths | Weaknesses |
|---|---|---|---|
| *Power-interest grid* | Stakeholders are placed on a matrix according to their relative power and interest in the subject and classified according to the combination of both dimensions. | Practical approach. Possible to prioritize stakeholders for inclusion. | Assumes power and interest as only relevant factors for categorization. May lead to marginalizing certain groups. |
| *Support versus opposition Grid* | Classify stakeholders as likely to support or oppose against the issue having into account their relative power. | Actively includes opposition and can be useful in developing winning coalitions. | Risk of stakeholder marginalization. Results may be biased by evaluation team. |
| *Power, legitimacy and urgency diagram* | Stakeholders are classified according to a combination of three attributes – power, legitimacy and urgency. | Considers the dynamic dimension of the attributes. Broader range of stakeholder categories. | Attributes dimensions can be overlapping and confusing. |

### 3.2.6. Analyzing Relationships Between Stakeholders

As important as identifying and disaggregating stakeholders is the need to acknowledge the existence of diverging interests between them and manage the potential conflicts that might arise (Frooman, 1999). As quoted by Ackermann and Eden (2011), “one stakeholder’s actions can generate a dynamic of responses across a range of others” and depicting those interactions can help surface the formal and informal relationships of the system that can be crucial in anticipating conflict or opportunities (Ackermann and Eden 2011). This section will bring to light the two of the major methodologies identified by Reed et al. (2009) - i) Actor-linkage matrices, ii) Social network analysis -, and a third approach by Bryson (2004) – iii) the Participation planning matrix.

<u>Actor-linkage matrices</u>

The actor-linkage matrix (ALM) provides a visual illustration of the key stakeholders involved in the context and allows monitoring of the changes in the research system over time (Biggs & Matsaert, 1999).

In the ALM, stakeholders are listed in both rows and columns within the same matrix. The resulting grid is then used to describe interrelationships between stakeholder groups. The input to each cell varies depending on literature. Biggs and Matsaert (1999) suggest describing the flow of information that passes from the row stakeholder to the column stakeholder (the cells in the diagonal of the matrix represent information that flows between stakeholders of the same group), whilst Reed et al. (2009) highlight the use of keywords to describe such relationships such as “conflict”, “complementary” or “cooperation”. Either can be useful in understanding the direct relationships between each group of stakeholders.

<u>Social network analysis (SNA)</u>

Similar to actor-linkage matrices, SNA also makes use of matrices to organize data on the direct linkages between stakeholders and it proofs to be useful considering that “instead of analyzing individual behaviors, attitudes and beliefs, social network analysis focuses its attention on how these interactions constitute a framework or structure that can be studied and analyzed in its own right” (Wasserman & Galaskiewicz,

1994). The main purpose is to examine relational systems in which stakeholders' dwell and understand how the nature of the relational ties structure impacts behaviors (Rowley, 1997).

As mentioned, similarly to ALM, SNA uses matrices as framework. Each matrix will reflect a particular relationship, for example: communication, advice, conflict, trust, etc. But in this method the ties are characterized by numbers (instead of keywords) to represent two dimensions: i) the presence/absence of a tie and ii) the relative strength of the tie. And the data is usually gathered through interview techniques such as the ones depicted in Table 4.

Stakeholder influence diagram

This technique for capturing the interactions between stakeholders grew naturally as an adjacent step to the power versus interest grid. One of the main drivers for this development is the often empirical observation of how stakeholder power/interest is dependent on both formal and informal relationships (Ackermann & Eden, 2011).

Stakeholder influence diagrams aim to surface these formal and informal ties that constitute the bases of the stakeholder network through a schematic representation that is similar to a sociogram (Ackermann & Eden, 2011). The relationships are depicted within the power versus interest diagram with linking arrows. The direction of the arrows dictates the nature of the relationship - the influence runs from tail to head (doubles arrows can be used when there is mutual influence) – whilst formal and informal relationships are distinguished through the use of solid and dotted arrows, respectively (Ackermann & Eden, 2011).

Table 7 provides a summary of the three methods for investigation stakeholder relationships and the associated weaknesses and strengths.

*Table 7 - Methodologies for investigating relationships between stakeholders (Adapted from Abreu 2017)*

| Methodology | Description | Strengths | Weaknesses |
|---|---|---|---|
| *Actor-linkage matrix* | Stakeholders are tabulated in a two-dimensional matrix and their relationships described by the use of keywords | Simple and flexible to use; Requires low resources. | Narrow focus on one-to-one relationships. Relevant multi-party relationships can be left out. |
| *Social network analysis* | Identify the stakeholder network and measure relational ties between stakeholders. | Gain insight on the stakeholder network and its boundaries. Easier to differ between influential stakeholders and peripheral ones. | Time consuming. Very demanding and complicated for complex cases as individual interview techniques can be time and resource consuming. |
| *Stakeholder influence network* | Adjacent step and based on the power-interest grid. Establishes influence connections and its direction between stakeholders within the grid. | Encourages discussion; Gives further insight on how power and interest interrelate in the system. | Time consuming; Analysis can be influenced by the evaluation team. |

## 3.3. Chapter Conclusions

Circular Economy practices have emerged as efficient solutions to boost environmental sustainability of value chains and major prerequisite for complying with planetary limitations. A truly circular economy still is no more than a theoretical conceptualization but the implementation of CE practices provides the guidelines for a future where products are consistently reused to the maximum extent possible.

The state-of-the-art review on CE unveiled that CE strategies rest on five major activities for effectiveness in its implementation – Eco-design, Green-Procurement, Cleaner Production, Sustained Lifespan, and Recovery Economy. Applying these practices into an already established system should be significantly efficient in promoting improved sustainability.

Despite the concept of recycling not being the sole tool for CE implementation, it comes as the most relevant in short-run applications and the most direct and active strategy for addressing the externalities from the rise in waste material quantity. However, if the aim is to really move out of the 'take, make, use, dispose' linear system, the remainder practices prove to be critical in a path to ultimate sustainability and correct resource management.

A CE approach to waste supply chains should require coordinated actions from a wide range of actors and organizations, particularly in the case of the complex Portuguese waste management system, as disclosed in Chapter 2. A well-established approach to the management of system's involving several entities is stakeholder analysis.

Stakeholder analysis literature is substantially complete, and seems to provide the proper tools for handling the problem at hand. During this chapter's state of the art review, several methodologies were presented for identifying, mapping and managing stakeholder relationships and their application is not mutually exclusive. Meaning several methodologies can be applied during each stage each stage, so that no relevant actor, organization or link is left unaccountable. A set of interviewing techniques was also provided as common approaches for efficiently obtaining the data that supports the presented methodologies.

In sum, stakeholder analysis seems to provide the tools for a holistic evaluation of complex plastic waste supply chains. Therefore, enabling a systemic implementation of CE practices as the best-fit solutions towards efficient valorization of the system. Thus, the next chapter will disclose the approach that was developed for combining the several theoretical concepts into a multimethodology for stakeholder analysis in the valorization of the Portuguese plastic waste supply chains.

# 4. Research Methodology

The following chapter presents the methodology that was adopted during the development of this dissertation. Based on the literature that was provided, section 4.1. introduces the employed multimethodology approach for an integrated stakeholders' analysis. Subsequently, in Section 4.2., an activity worksheet for the development of a SWOT analysis is presented, for improved systematization of the conclusions that were obtained from implementing the proposed methodology. The chapter culminates with the chapter conclusion in Section 4.3..

## 4.1. Stakeholder Analysis

The performed stakeholder analysis aimed to fulfill three different objectives of work:

a. Having an overall appraisal on the functioning of the current Portuguese plastic waste supply chains and assessing their performance quantitively and qualitatively – Which are the current stakeholders involved and/or affected by the SC and the associated material, financial and information flows?
b. Obtain internal insight on stakeholder positioning and the perception they have of the other stakeholders and categorizing them accordingly – How do stakeholders perceive each other and how does it affect their decisions and current businesses?
c. Understanding which directions provide the best opportunities for increasing the value capture - Which stages and entities are the most attractive in terms of valorization opportunities and how is it possible to achieve it?

As exposed in Chapter 3, the structure of the stakeholder analysis to be conducted for this dissertation is based on the frameworks presented by Reed et al. (2009) and Abreu (2017) and it consists of three major phases:

A. The first phase is to define the scope of the project. As mentioned by Ackermann and Eden (2011), a clear understanding of the concept is critical for properly delimitating the boundaries of the project.
B. The second phase is to identify the involved stakeholders and obtain a holistic understanding of the system. This phase comprises identifying the most significant stakeholders (step 1) and develop a complete description of the system's flows and performance (step 2) – Step 1 is based on a literature review on stakeholder analysis in waste management systems, where key generic stakeholder groups are defined and an initial stakeholders' list is developed. This list is then expanded by implementing a 'Snowball Sampling' procedure through semi-structured interviews (step 3) with the identified actors. Step 2 requires a web research based on official documents, scientific databases and other safe and related-to-topic online sources. In parallel to web researching, the performance topic is also addressed during the semi-structured interviews for non-online expert opinion.
C. The third phase comprises stakeholder categorization and relationship analysis. Stakeholders will be differentiated according to the following tools (step 4): 'Power vs. Interest' matrix and the

'Support vs. Opposition' grid, whilst stakeholder relationships will be analyzed through SNA (step 5). All three mentioned analysis tools are to be based on the stakeholders' own qualitative and quantitative judgements that are to be obtained through the interviews.

As above described, input data for steps 1, 2, 4 and 5 is to be collected via semi-structured interviews (step 3) with several organizations from the identified stakeholders' list. According to the state of the art that was presented in Chapter 3, semi-structured interviews are the best alternative for providing in-depth knowledge on stakeholders' opinion which should be extremely relevant for the chosen approach for this stakeholder analysis.

These semi-structured interviews were based on an interview guide comprising both open-ended questions – leading to spontaneous answers based on the interviewees' knowledge and opinion whilst leaving room for better understanding of the interviewees' judgement – and also closed objective questions in order to collect standardized information from the participants in order to make implicit knowledge more explicit.

A schematic representation of this multimethodology is presented in Figure 12 and more holistic description of the tools and methods to be implemented during each stages and steps is provided next.

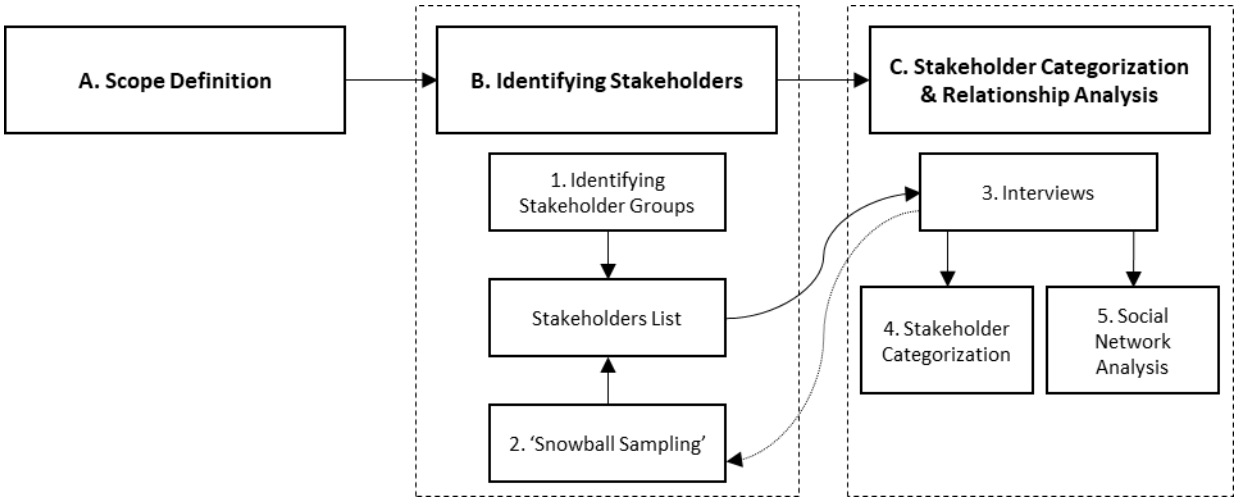


*Figure 12 - Dissertation's stakeholder analysis multimethodology*

### 4.1.1. Scope Definition

The purpose of this task is to define the scope of the study, by clearly establishing its boundaries. During Chapter 2 (see Section 2.2.3.) it was clarified that, in Portugal, plastic waste follows one of three streams, depending on capacity (i.e. urban or commercial/industrial) and the typology of plastic (i.e. packaging or non-packaging). It was acknowledged that, for this dissertation, assessing all three streams could lead to overwhelming information that could not comply with the limitations of a project such nature. As so, the decision was to focus on the most representative stream, narrowing down the scope for stakeholder analysis into an admissible level. The fact that, in Europe, about two thirds of total plastic waste are attributed to packaging material (Velis, 2015), led to the need of specifically addressing this type of waste

material. Additionally, web research provided early indicators that packaging waste had the most available data, which would allow a more complete and accurate research. For these reasons, it was decided that the scope of this dissertation's stakeholder analysis would be focused on the urban plastic packaging waste supply chain.

### 4.1.2. Identifying Stakeholders

*Step 1 – Identifying Stakeholder Groups*

After a literature review on stakeholder analysis in waste management systems and contextualization within the current Portuguese plastic waste supply chain, six broad groups of stakeholders were identified and selected for analysis, according to different sectors of intervention: i) Academia, ii) Civil society, iii) Funding/Financial Institutions, iv) Governmental authorities, v) NGOs and vi) Service Operators. These key stakeholders and referencing literature are summarized in Table 8 and their roles in waste management summarized in Table 9:

*Table 8 - Stakeholders in waste management systems*

| **Stakeholder Categories** | Delmas & Toffel (2004) | Joseph (2006) | Heidrich et al. (2009) | Lienert et al. (2013) | Wilson et al. (2013) | Caniato et al. (2014) | Xu et al. (2016) | Muchangos et al. (2017) |
|---|---|---|---|---|---|---|---|---|
| Academia | | ● | ● | | | ● | ● | ● |
| Civil Society | ● | ● | ● | ● | | ● | ● | ● |
| Financial Institutions / Agencies | | | | | ● | | ● | ● |
| Government/ Gov. Authorities | ● | ● | ● | | ● | ● | ● | ● |
| NGOs | ● | ● | ● | ● | ● | ● | ● | |
| Service Operators | | ● | ● | | ● | ● | ● | ● |

In this particular case, it was acknowledged that the 'Service Users' stakeholder group required a higher degree of discrimination. In that sense, the 'Service Users' were divided according to nature of activities, adding five more stakeholder groups:

- Producer Responsibility Organizations (PROs), which manage the supply chain;
- Packers and importers of packaging products, responsible for introducing plastic packaging products to the market;
- Urban waste management operators (UWMOs), responsible for the collection and sorting of the urban waste material;
- Other waste management operators (other WMOs), responsible for the collection non-urban plastic waste;
- Recyclers, which process the plastic waste material and produce recycled products that are reintroduced to the industry;

*Table 9 - Stakeholder description based on the literature from Table 8*

| Stakeholder Group | Who? | Role/Concern | Stakeholder effect on system |
|---|---|---|---|
| Academia | Universities, education and training institutions, research and development centers. | Research and innovation; Establish and share best practice in industry; Offer environmental related programs and subjects | Affect the system indirectly through the provision of R&D practices towards system improvement |
| Civil Society | (Small and big) MSW generators; Local communities. | Practice waste reduction and source segregation (awareness); "Pay" for waste management | Affect the system directly through product choices and primary waste management choices |
| Funding / Financial Institutions | Banks/ Financial and other resource providing institutions. | Provide financial, technical and capacity building support. | Provide support directly to local authorities and/or MSWM related projects |
| Government/ Governmental Authorities | Government; Policymakers, Local, national and international authorities | Setting environmental regulations, targets and standards; Monitoring and enforcement; Supporting environmentally sound developments. | Can affect the system directly via legislation, regulation and compliance; Are involved in planning (at local, national and international level); Provision of services and resources. |
| NGOs | Environmental institutions; Volunteering agencies; Cooperation agencies | Mobilizing community awareness and participation; Voicing different sectors of both public and private sectors | Possible indirect effects via lobbying on environmental or planning issues; Relevance can increase if any urgent claim or effect become prominent. |
| Service Users | Service suppliers, technology suppliers, Service operators; Service managers | Searching and implementing appropriate actions; Provide formal waste management services; Receive/buy waste material; Financial and economic performance; Support public awareness and participation | Directly affect system by determining and being responsible for waste management services and practices |

Based on the reports by SPV (2019), Novo Verde (2019) and the work by Pires et al. (2015) an initial characterization of the Portuguese plastic waste supply chains was developed. Figure 13 depicts the initial description of the quantitative flows – physical and monetary – of the current Portuguese supply chain for plastic packaging waste.

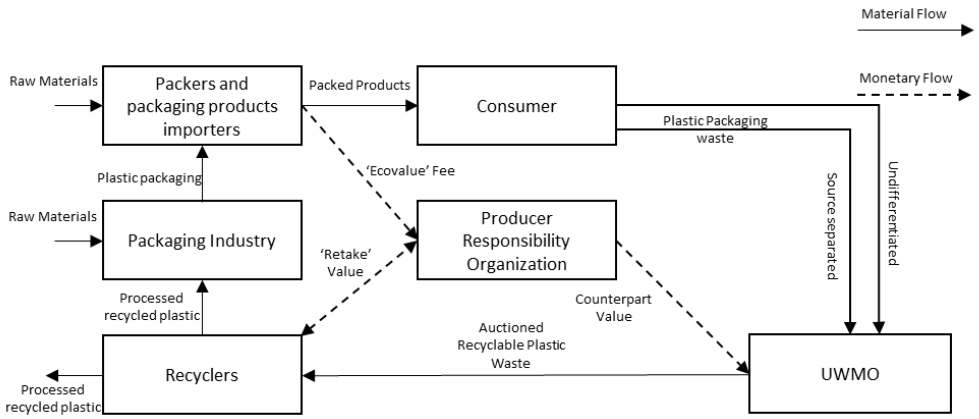


*Figure 13 - Plastic packaging waste supply chain material and monetary flows (Adapted from Pires et al., 2015)*

In order to better understand the degree of accuracy encompassing this illustration and assure there were no missing links or entities, it was decided to validate the system that is illustrated in Figure 13 with the interviewees. While proceeding with this validation, interviewees were also requested to engage in a 'snowball sampling' procedure, next presented as Step 2 of this multimethodology.

*Step 2 - Snowball Sampling*

This complementary task of stakeholder identification provides the necessary validation and complementation of the stakeholder list by deepening the knowledge on neglected entities and providing further insight on the current system. It is based on the methodology presented in Chapter 3 and is included in the interview guide as interviewees are solicitated to identify any casted-out stakeholders.

### 4.1.3. Stakeholder Prioritization and Relationship Analysis

The main objective of the third stage is to categorize stakeholder groups regarding their relevance on the valorization of plastic waste supply chains and analyze their relationships. As so, the theoretical basis of this stage are the following stakeholder analysis tools: Power vs. Interest matrix (Bryson, 2004; Ackermann & Eden 2011); Support vs. Opposition grid (Nutt & Backoff, 1987; Bryson 2004) and SNA.

The appraisal of such attributes - power, interest and support - requires the collection of qualitative and quantitative data, thus it is particularly important to have a clear and well-defined description of each addressed topic. The definitions of each attribute and the supporting literature are:

- Power: Stakeholder (perceived) capacity to bring about the outcomes they desire when affecting a policy or the case, in terms of access and availability to resources and the possibility of mobilizing and effectively using them (Mitchell et al., 1997; Schmeer, 1999; Caniato et al., 2014);
- Interest: Stakeholder's interest in the specific case to be analyzed according to the advantages and disadvantages that it may bring to the stakeholder (Ackermann and Eden, 2011; Schmeer, 1999);
- Support: Extent to which the stakeholder is actively interested and concerned with the success of particular recommendations, as opposed to providing resistance or dissent, expressing it through either actions or argument (Nutt & Backoff, 1987; Bryson et al., 2011).

*Step 3 - Interview guide*

From the three main work objectives and associated research questions an interview guide was elaborated. It was developed to be answered by the possible stakeholders for a stakeholder-led evaluation. The interview guide is divided into three main sections. Interview questions are directly related to the work objectives. As so, each objective and the adjacent questions are next exposed and explained:

Objective 1 - Having an overall appraisal on the functioning of the current Portuguese plastic waste supply chains and assessing their performance quantitively and qualitatively.

This objective regards a holistic understanding of the current fragmented system. To understand current flows – material and financial (including taxation and fees) –, and an internal appraisal of on how the system currently works. Interviewees are confronted with the schematic representation presented in Figure 13. The set of questions regarding Objective 1 is next presented, based on the work of Schmeer (1999), Bryson et al. (2011) and Caniato et al. (2014).

1. Are you familiar with the Portuguese plastic (packaging) waste supply chain / plastic waste management system?
2. If so, what do you know about it? How do you compare it to the schematic representation of Figure 13?
3. Is the system clear to you?
4. Is it hard for you to obtain information on the system?
5. Can you identify any particular strengths in the current Portuguese plastic waste supply chains? If so, which are they?
6. What about weaknesses? Which are they? Could you rank them?
7. Do you share your information with any other actors/stakeholders? Do you think it is important to do it? How do you do it?
8. With which actors from the stakeholder list are you in contact? Please try to list them and, for each one, state if you have:
    a. Null/Scarce information sharing
    b. Occasional sharing
    c. Frequent sharing

For interviewees representing categories directly involved in the plastic waste supply chain or handling plastic waste derived products:

i. Are you able to easily find market demand for your products?
ii. Do you think there is room for increasing demand for your products?

<u>Objective 2</u> - Obtain internal insight on stakeholder positioning and the perception they have of the other stakeholders and categorizing them accordingly.

This topic considers stakeholders' opinion on how they see themselves and others regarding the attributes 'Power', 'Interest', 'Urgency', and 'Support' towards this problem of study. It also comprises the snowball sampling procedure, where interviewees are solicitated to evaluate the current stakeholder categories list and identify any possible casted groups and/or actors. The set of questions is next presented supported by the work of Nutt & Backoff (1987), Suchman (1995), Mitchell et al. (1997), Schmeer (1999), Ackermann and Eden (2011), Bryson et al. (2011) and Caniato et al. (2014).

9. Do you agree with the presented stakeholder list? Is there any group you would add/remove? Why?
10. Could we ask you to name some companies, organizations or groups that you think to be relevant and would fit in each of the stakeholders' group? (This method is called snowball sampling and is useful in identifying any other casted-out stakeholders to be included in this study)

11. Could evaluate each stakeholder group according to the definitions and value scales presented in the table (see Table 10)?
12. From the already mentioned stakeholders is there any actor / organization you think is or could be a suitable leader in this valorization topic? – By leader we mean an actor (individual, group, organization, etc.) that could involve and actively mobilize the system as whole an bring such type of project into action.

*Table 10 - Attribute definitions and value scale for the interview guide*

| Attribute | Value Scale (1 to 5) |
|---|---|
| **Power**: Stakeholder (perceived) capacity to bring about the outcomes they desire when affecting a policy or the case, in terms of access and availability to resources and the possibility of mobilizing and effectively using them | 1 = Very little Power<br>3 = Medium Power<br>5 = Very significant Power |
| **Interest**: Stakeholder's interest in the specific case to be analyzed according to the advantages and disadvantages that it may bring to the stakeholder | 1 = Very little interest<br>3 = Medium interest<br>5 = Very significant interest |
| **Support**: Extent to which stakeholder is actively interested and concerned with the success of particular recommendations, as opposed to providing resistance or dissent, expressing it either actions or argument | 5 = Strongly support it<br>4 = Slight support<br>3 = Neither support it or oppose it<br>2 = Slightly oppose it<br>1 = Strongly oppose it |

Objective 3 - Understanding which stages/activities of the supply chain present the best opportunities for increasing the value capture.

This topic explores which are the main drivers and barriers towards the valorization of the system, attempts to provide a glimpse on which types of solutions could play an important role in the matter and which should be the magnitude of such solutions. The set of questions follows and is based on the work of Schmeer (1999), Caniato et al. (2014), Xu et al., (2016) and Ghisellini et al., (2016).

13. Do you think there is an overall interest (shared by the majority of the system's actors) on a project for the valorization of the plastic waste supply chain?
14. Would you be interested in a project for the valorization of the plastic waste supply chain?
15. What are the potential benefits that your organization would expect (for yourselves) from such type of project?
16. What are the benefits you would expect for the plastic waste management system as whole?
17. Are there any potential disadvantages to your organization that could come adjacent to a project of this type?
18. Do you think there are / could be any major barriers towards the valorization of the current system? If so, could you identify them?
19. Could you identify what you think to be the major drivers towards the valorization of the current system?
20. Are you familiar with the Circular Economy concept? Would you say CE implementation in Portugal follows a top-down approach – CE is promoted/enforced via national programs that are embedded in some wider policy for economic transformation -, or a bottom-up approach –

the initiatives of environmental organizations, other institutions and even civil society actively push greener ambitions and legislation into national policies?

21. At which level do you think there are better opportunities for the valorization of the plastic waste supply chain?
    a. Micro-level: Individual firm level and corporate-level initiatives.
    b. Meso-level: Inter-firm level and symbiosis associations.
    c. Macro-level: Cities, regions or national level requiring the redesign of major systems (industrial, infrastructure, cultural framework and social).

Closed-ended questions are ideal gateways to open ended probing. Meaning that for most closed questions there is a chance for the interviewer to follow up by asking “Why is that?” or “Why so?” and continue with additional probing as deemed necessary (Newcomer et al., 2015). The flexibility of the semi-structured interviews also allows to include other questions, if the interviewer deems them as relevant.

After conducting all the interviews, the answers were brought together to check general consistency. In case of evident inconsistency between inter and external judgement (e.g. stakeholders overestimating their knowledge of the system) the significance of such answers was adjusted by giving a greater weight to the overall opinion. Inconsistencies can be produced by stakeholders having different perceptions or scarce knowledge on designated topics (Caniato et al., 2014). This lack of knowledge can be either admitted or not by the interviewee, so, during the interview, the follow-up questions asking for clarifications can lead to a more consistent interview, with error recognition (Newcomer et al., 2015).

*Step 4 - Categorizing stakeholder groups / Attributes data processing and analysis*

After collecting the data on the attributes’ scores via interviews, these were used as input for constructing the stakeholder categorization tools – ‘Power vs. Interest’ matrix and ‘Support vs. Opposition’ grid.

*Step 5 - Social Network Analysis*

Social network analysis (SNA) is a sociological research method that can be modeled through specific software and provides indicators of network density, node degree, distance and centrality that are used for understanding the structure and the properties of the social network (Wasserman & Faust, 1994). After obtaining the data from the interviews, the data was processed, with the aid of UCINET software (version 6.685), a well-known statistical social network analysis software, to calculate the indicators and develop the graphic representations (Borgatti et al., 2002). The chosen analysis metrics were (Freeman, 1977; Wasserman & Faust 1994):

i. <u>Density ($D$)</u>, as an indicator of the level of connectedness of the network. Given as the relative value between the existing number of network connections and the maximum number of possible network connections, accounting the fact that the connection between two stakeholders can have two directions. Hence assuming values between 0 (fully disconnected) and 1 (all stakeholders in the network are directly connected to one another).

$$D = \frac{TC}{N \times (N-1)} \quad (1)$$

Where $TC$ is the total number of connections and $N$ is the number of stakeholders.

ii. Degree Centrality ($DC$), which directly shows the total number of connections that a stakeholder has with other stakeholders.

$$DC_i = \frac{\sum_{j=1}^{N} x_{ij}}{N-1} \quad , \quad i \neq j \quad (2)$$

Where $\sum_{j=1}^{N} x_{ij}$ is the number of links directly connected with stakeholder $i$ and $1/(N-1)$ serves as a standardization parameter.

As mentioned in Chapter 3, analyzing the mixture of quantitative and qualitative data from semi-structured interviews might be challenging. SWOT analysis is a commonly used tool as a precursor to strategic planning and should be considerable useful for systematizing the data from stakeholder analysis. Details on how this SWOT analysis is set to be conducted are presented in the next section

## 4.2. SWOT Analysis

After conducting the stakeholder analysis process, the purpose is to combine results and develop strategic action plans that target the supply chain valorization. Organizing the quantitative and qualitative results as internal and external factors, and capabilities of the involved stakeholders through SWOT analysis, should enable the development of best-suit strategies (Srivastava et al., 2005).

The methodology that was adopted for the SWOT analysis in this dissertation, was adapted from the work by Srivastava et al (2005) and consisted of systematizing the results from the stakeholder analysis steps through the worksheet that is presented in Table 11.

*Table 11 - Worksheet for SWOT analysis (adapted from Srivastava et al., 2005)*

| Factors | Questions |
|---|---|
| Strengths | What are the advantages / benefits?<br>What are the factors supporting the valorization topic?<br>Do the stakeholders show willingness for supporting the program?<br>Are the stakeholders well positioned within the system? |
| Weaknesses | What could be improved?<br>What is not done properly?<br>What should be avoided?<br>What are the barriers preventing valorization?<br>Where are the complaints coming from? |
| Opportunities | What are the interesting trends?<br>What benefits may occur from valorization?<br>What changes in governmental policies related to the Portuguese plastic waste supply chain may be possible? |
| Threats | What are the barriers could valorization face?<br>Are the required support and necessary resources for valorization available?<br>Are there any real weak links in the system? |

## 4.3. Chapter Conclusions

The presented chapter disclosed the methodology to be implemented during the development of the dissertation. In sum, it is possible to divide this methodology into to three major stages of analysis: i) stakeholder identification; ii) stakeholder categorization and iii) social network analysis, which are brought together through a SWOT directed worksheet.

As stated by Mingers and Brocklesby (1997), the combination of two or more scientific methodologies during the analysis process is likely to produce a richer picture for understanding complex relationships and connections, which is the case in the Portuguese waste management system. Hence the relevance of applying several analysis tools across each of the three stages of the stakeholder analysis when aiming for a holistic approach to the problem.

The novel for the stakeholder identification stage consists of literature review and web research, then including the 'snowball sampling' procedure in order to complement and validate research data. In the case of stakeholder categorization, the holistic approach emerges as two different categorization tools – 'Power vs. Interest' matrix and 'Support vs. Opposition' grid – are developed as complements to one another. Subsequentially, SNA should provide insight on the nature of the system's relations regarding information sharing. Ultimately, conclusions from each stage of the stakeholder analysis are paired with the worksheet for a SWOT analysis for posterior development of strategic suggestions for plastic waste supply chain valorization.

Data input for the above described stakeholder analysis methodologies is set to be obtained via semi-structured interviews, designed for a stakeholder led evaluation. For that, an interview guide was developed, comprising multimethodology oriented questions with the aim to acquire consistent and adequate data. A full description of the interview guide and its questions was also provided in this chapter.

# 5. Results and Discussion

This chapter presents the data and the analysis that was obtained by implementing the methodology that was disclosed in Chapter 4. Sections 5.1. to 5.4. cover steps 2, 4 and 5 of this methodology, followed by the development of suggestions for strategy directions in Section 5.5., culminating with Section 5.6., were chapter conclusions are presented.

## 5.1. Stakeholder Identification

Based on the stakeholder groups from the literature review, through web research on the Portuguese plastic packaging waste supply chain, it was possible to develop an initial stakeholder list comprising 40 entities/organizations. After the interviews, another 9 actors were identified through the 'snowball sampling' procedure, hence the final stakeholder list totaling 49 entities. It should be noticed that identifying all the organizations comprised by the packers and importers of packaging products would require an extensive effort that would not show relevant contributions within the scope of this dissertation. For this reason, it was decided to apply a general definition for the constituents of this stakeholder group. The stakeholder list is bellow presented through Tables 12 and 13, according to stakeholder group.

*Table 12 - Stakeholder list – part 1*

| ***Academia*** | **Role** |
|---|---|
| COTEC Portugal – Associação Empresarial para a Inovação | Promoting cross-business innovation and technological cooperation |
| CVR – Centro para a Valorização de Resíduos | Providing research, scientific analysis and solutions in the field of waste recovery |
| Universities | Provide technology and research development through specialized environmental departments |
| ***NGOs*** | **Role** |
| APESB – Associação Portuguesa de Engenharia Sanitária e Ambiental | Research, development and promotion of knowledge in the water and waste environmental sectors |
| APEMETA – Associação Portuguesa de Empresas de Tecnologias Ambientais | Support environmental related business activities |
| ZERO – Associação Sistema Terrestre Sustentável | Active participation in the defense of sustainability values within the Portuguese society (ZERO, 2019) |
| Smart Waste Portugal | Business development network whose mission is to create a national platform promoting innovation, research, development and implementation solutions |
| ***Government / Governmental Authorities*** | **Role** |
| APA – Agência Portuguesa do Ambiente | Governmental body for the monitoring, planning, evaluation, licensing and inspection of environment related policies |
| CAGER – Comissão de Acompanhamento de Gestão de Resíduos | Technical support, monitoring and evaluation of waste related policies (APA, 2019) |
| IGAMAOT – Inspecção-Geral da Agricultura, do Mar, do Ambiente e do Ordenamento do Território | Internal affairs regulatory agency for the responsible for the monitoring and inspection of waste management activities |
| ERSAR – Entidade Reguladora dos Serviços de Águas e Resíduos | Regulation and supervision of urban solid waste management activities (ERSAR, 2019) |

*Table 13 - Stakeholder list – part 2*

| ***Producer Responsibility Organizations*** | **Role** |
|---|---|
| SPV – Sociedade Ponto Verde | Financing the collection and treatment of the packaging waste; Guarantee the waste management of packaging products from the companies which have transferred their responsibility. |
| Novo Verde | |
| Electrão (former Amb3e) | |
| ***Urban Waste Managers Operators (SGRUs)*** | **Role** |
| 23 SGRUs (Sistemas de Gestão de Resíduos Urbanos) operating in Continental Portugal[1] | Collection, transport and treatment of urban waste |
| ***Recyclers*** | **Role** |
| Extruplás | Licensed companies which process the different types of plastic waste (depending on company) that was collected by the SGRUs, and produce new recycled products (e.g. new packaging material and urban furnishing) |
| Micronipol | |
| Ligeplás | |
| Ecoibéria | |
| Sirplaste | |
| ***Other Waste Management Operators*** | **Role** |
| EcoGestus | Provide waste management solutions from collection systems to urban design |
| Ambigroup | Provide services for the management, collection and valorization of waste |
| Eco-Modus | Provide services for the conditioning, cleaning and sorting of waste materials (Eco-Modus, 2019) |
| ***Funding / Financial Agencies*** | **Role** |
| FomentInvest | Holding company within the waste management sector (FomentInvest, 2019). |
| POSEUR | Program with the aim of contributing for sustainability related projects (). |
| ***Packers and packaging products importers*** | **Role** |
| Companies that introduce packaging products in the Portuguese markets | |
| ***Civil Society*** | **Role** |
| Small plastic waste generators (Small/medium size companies and population as waste producers) | Disposal of the plastic waste, which can be source segregated or undifferentiated |

[1]Full list provided in the annexes

From all 49 stakeholders from the disclosed stakeholder list, 32 were invited to participate in the interviews, as only the six bigger volume SGRUs were contacted. As new stakeholders were identified through the 'snowball sampling' procedure, these were also invited to participate. In total 8 interviews were conducted, including representatives from the following groups: Academia, Governmental Authorities, NGOs, Producer Responsibility Organizations, UWMOs, Recyclers, and Packers and importers of packaging products.

Having identified the system's stakeholders, the next step was to understand how stakeholders operate and how does the system function. As so, during the interviews, the system that was illustrated in Section 4.1.2. was complemented and validated. In addition, web research, based on official documents, scientific

databases and other safe and related-to topic online sources sustained the characterization of the system's flows, which were also complemented by the interviewees, whom then were requested to provide their judgements on the system's performance. This characterization of the supply chain flows and analysis on the system's performance is presented next.

## 5.2. System's Flows and Performance

This sub-chapter first provides a complete description of the system's functioning and a characterization of the existing monetary and financial flows, in the Section 5.2.1. and 5.2.2., respectively. Subsequently, in Section 5.2.3. the overall appraisal by the interviewees on the system's performance is presented.

The Portuguese plastic packaging waste supply chain is part of the Integrated System for the Management of Packaging Waste (SIGRE, in the Portuguese acronym), which was created to provide the legal obligation related to the extended producer responsibility policies. It is a collective management system financed by organizations in the packaging value chain. Figure 14 represents a scheme of the system's functioning, the main relationships amongst players and both material and monetary flows.

The producer responsibility organizations (PRO) work as the central organizations for the collective management of these systems. Until 2016, Sociedade Ponto Verde (SPV) had been the single active Portuguese private and non-profit organization responsible for managing the packaging waste system in Portugal, when Novo Verde acquired their license and became the second operating PRO (Novo Verde, 2018). In 2018, Electrão also joined and now has a share of the packaging waste business (Electrão, 2019). Still, in the year of 2018, SPV held a market share of over 85% for overall packaging and 77% for plastic packaging, making it the most representative of the three organizations (SPV, 2019a).

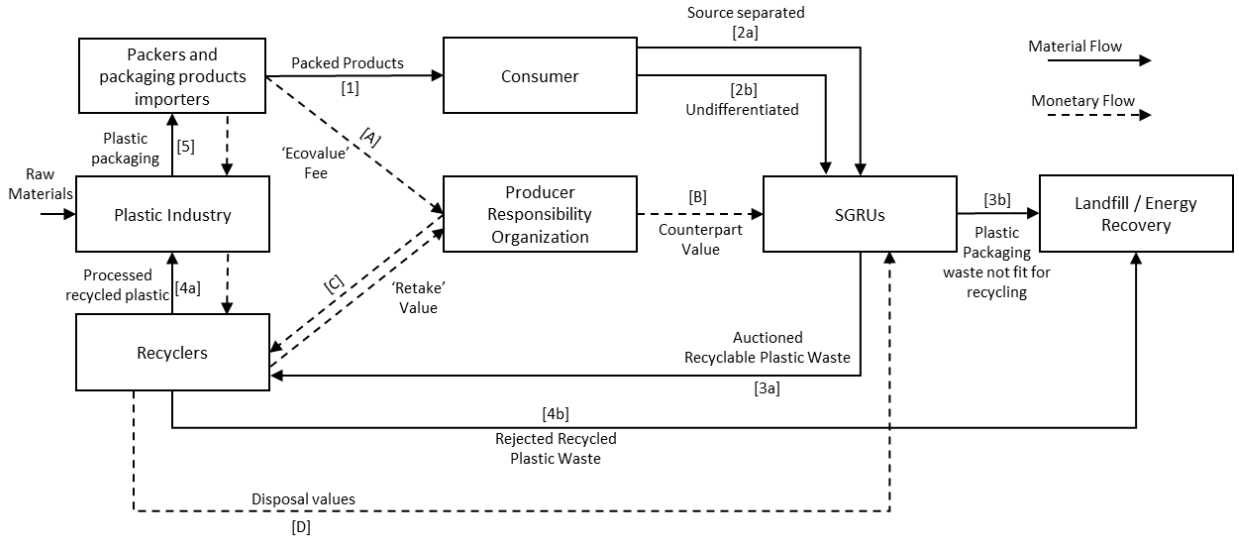


*Figure 14 - Plastic packaging waste supply chain*

In the SIGRE, companies transfer their responsibility to the PROs for recovering and treating the packaging waste according to Portuguese and European EPR legislation. On the other hand, the PROs receive a fee

– ‘Ecovalue’ fee – in exchange of becoming the responsible party for the collection and treatment of the packaging waste (Rubio et al., 2019).

The PROs do not treat the packaging waste directly. This work is carried out by the Portuguese Urban Waste Management Systems (SGRUs, in the Portuguese acronym) There are currently 23 SGRUs operating in Continental Portugal, from which almost half – 11 - are mainly controlled by private operators and the remaining 12 are intermunicipal systems.

The monetary and material flows depicted in Figure 14 also have an associated number and letter, respectively in order to facilitate the analysis process. Flow associated information derives from web research and is supported by the data that was gathered during the interviews. Both flows are explained in greater detail in the next sections.

### 5.2.1. Material Flow

The material flow starts with the raw materials that are used as input for the production of plastic packaging material, which is later sold to the packers and packaging products importers. Both packers and importers have the obligation to submit their packaging waste management to the Portuguese collective system, through one of the three licensed organizations – SPV, Novo Verde and Electrão. The quantity of plastic packaging declared to each PRO is provided in Table 14.

*Table 14 – Plastic packaging declared to PROs in 2018 (SPV, 2019a; Novo Verde, 2019; Electrão, 2019)*

| | Sociedade Ponto Verde | Novo Verde | Electrão |
|---|---|---|---|
| Amount of plastic packaging declared (in tons) | 125255 ton | 22469 ton | 15315 ton |
| Market Share (plastic packaging only) | 76.8% | 13.8% | 9.4% |

Once the consumer buys and uses a certain plastic packed product [1], the packaging waste is either selectively disposed through recycling containers – source segregated [2a] – or discarded through undifferentiated disposing methods [2b]. The collection of both source segregated and undifferentiated waste is carried out by the SGRUs.

After the collection, the waste material is transported to SGRU owned sorting facilities. The source separated plastic waste [2a] is sorted by type of plastic material. This sorting process allows an improved homogeneity and quality of the waste material. Plastic waste can be divided by the following types (SPV, 2019b; Testin & Vergano, 1997; SPV, 2015):

- PET (Polyethylene terephthalate), about 22% of total plastic waste: Mainly used in drinking bottles, although also used in domestic hygiene and thermoformed packaging;
- HDPE (High-density polyethylene): Essentially used in domestic use packaging (e.g. shampoo bottles);

- EPS (Expanded Polystyrene), about 1% of total plastic waste: Commonly none as Styrofoam, used in wide range of applications, including white foam packaging;
- Plastic Film, together with HDPE, amounts about 36% of total plastic waste: Flexible and thin plastic packaging. Mainly used for food packaging (e.g. in-store plastic bags for produce)
- Mixed Plastics, about 41% of total plastic waste: Comprises several diverse common use plastic packaging products and mainly derives from residual plastic material from the sorting of the previously mentioned plastic types.

Undifferentiated waste [2b] is subject to mechanical treatment in attempt to recover any recyclable material, including plastics, which then is also sorted by plastic material type (but with a lower quality of both separation and recycled material).

Ultimately, plastic waste that is not eligible for recycling or that was not possible to sort [3b] is sent to landfills or energy recovery. As for the plastic material that qualifies for recycling [3a], PROs are responsible for auctioning it to the recycling companies (referred as Recyclers in the schematic representation). After the auction, the successful bidding company has to carry out the transportation of the plastic waste from the SGRU establishment from which the batch was auctioned to their own installations (see Table 15).

*Table 15 - Quantities of plastic packaging waste that was sent for recycling per PRO (SPV, 2019a; Novo Verde, 2019; Electrão, 2019)*

| | SPV | | Novo Verde | | Electrão | | |
|---|---|---|---|---|---|---|---|
| | ***Quantity*** | ***Share*** | ***Quantity*** | ***Share*** | ***Quantity*** | ***Share*** | **SIGRE total** |
| Selective Collection | 46255 ton | 76% | 8653 ton | 14% | 5854 ton | 10% | 60762 ton |
| Undifferentiated subject to mechanical treatment | 8636 ton | 74% | 1940 ton | 17% | 1023 ton | 9% | 11599 ton |
| PRO Total | 54891 ton | 75.9% | 10593 ton | 14.6% | 6877 ton | 9.5% | 72361 ton |

Each recycling company then decides into which type of product they process the recycled plastic material. It can be shaped into pallets and reenter the plastic industry as production input in different market sectors [4a], packaging included. Or recyclers can develop their own plastic products, such as packaging material, outdoor equipment, 3D printing filament, etc. In addition, all recyclers have scrap rates which vary according to the quality of the purchased batch. The recycling companies then transport the rejected material to SGRUs [4b], as they have the resources for the disposal of this material via landfill or energy recovery.

Performance wise, according to official data, Portugal shows similar numbers when compared to the EU-28 average regarding packaging waste recycling rates (APA, 2019). After a steady growing stage, in 2009, packaging waste generation took a downturn that lasted until 2012, probably due to the deep impact of the

economic crisis effect in the country. That trend was again reversed, and after another steady growth, in 2017, total packaging waste amounted for 1,709,941 tons (APA, 2019). In Figure 15 it is possible to visualize the evolution of Portuguese recycling rates for plastic packaging waste over the past years, as well as the target set for 2020.

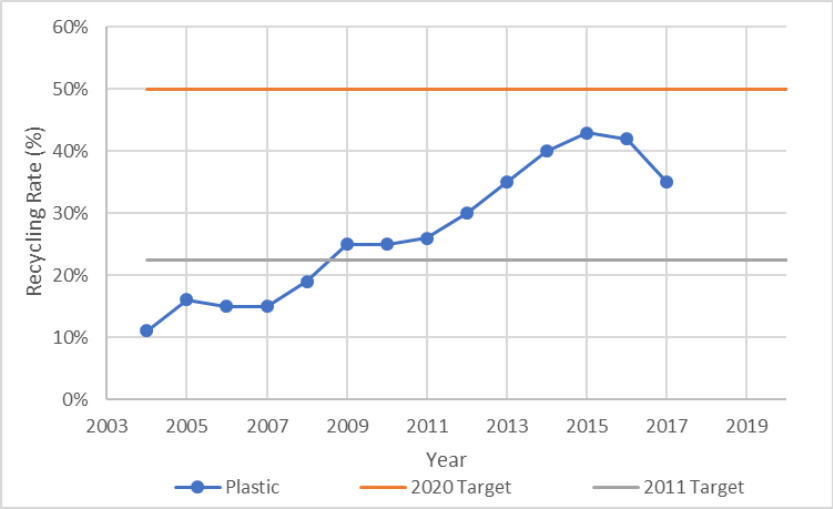


*Figure 15 – Portuguese plastic packaging recycling rates and 2020 target (APA, 2019)*

It is possible to highlight the significant decrease in recycling rates that the system has experienced starting in 2016, after a solid improvement during the previous years with an average growth of 3.6% since 2010 (see Figure 16).

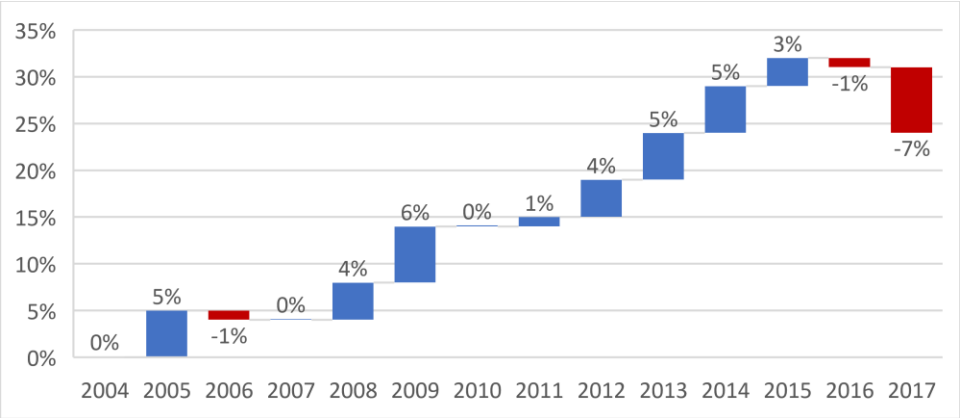


*Figure 16 –Packaging plastic waste recycling rate growth from 2005 to 2017 (APA, 2019)*

Interviewees were questioned about the system's performance, and particularly the ones behind the downturn in plastic recycling rates. The results from their responses is presented in Section 5.2.5.

### 5.2.2. Financial Flow

Most companies do not provide full details on their financial results. Although the chain's cost structure was validated as accurate through the interviews, some values remain as a generalization of individual results (e.g. the weight of ecovalue fees and retake values on the cost structure are generalizations of SPV results,

as the most representative PRO). A description of each financial flow is presented next (in Figure 14 each financial flow is characterized by a letter, for better comprehension).

[A] - Financial flow from Packers & Importers to PROs

Regarding the management of packaging waste, Portugal has adopted the Green Dot System, a widely disseminated EPR program in Europe (Pires et al., 2015). Successful implementation of EPR requires an economic instrument to finance the system. In Portugal, this instrument emerges as the 'ecovalue' fee, paid by the companies – packers and importers of packaging products – for transferring their responsibility for the recovery and treatment of the packaging waste to the PROs. For plastic packaging, the fee would vary according to packaging type until last year, now it assumes the same value for all types, as provided in Table 16.

*Table 16 - 'Ecovalue' fees per PRO for the year of 2019 (SPV, 2019; Novo Verde, 2019; Electrão, 2019)*

| *PRO* | Ecovalue fee |
|---|---|
| *SPV* | *0.2009 €/Kg* |
| *Novo Verde* | 0.2236 *€/Kg* |
| *Electrão* | *0.1863 €/Kg* |

[B] - Financial flow from PROs to SGRUs (UWMOs)

The PROs are then responsible for financing all the system's activities. The majority of the costs – about 90% in the case of SPV – arises from the reimbursements that PROs pay to the SGRUs for the collection, treatment and sorting of packaging waste – 'Counterpart value'. These reimbursements are implemented by the Portuguese Environment Agency and vary according to the waste material, type of disposal – undifferentiated or source separated -, and the SGRU cluster. There are currently four different clusters which reflect the nature of the population served, the relative amounts of waste and ultimately the associated collection efforts (see Table 17).

*Table 17 - SGRU cluster counterpart values per type of disposal for the year of 2019 (Novo Verde, 2019)*

| | SGRU Cluster | | | |
|---|---|---|---|---|
| | ***A*** | **B** | **C** | **D** |
| *Source Separated* | *686 €/ton* | 641 €/ton | 545 €/ton | 531 €/ton |
| Undifferentiated subject to mechanical treatment | 136 €/ton | | | |

[C] - Financial flow from Recyclers to PROs

The plastic packaging waste is held by the SGRUs whilst the PROs are responsible for selling it to licensed waste treatment operators – Recyclers. It is sold through a public bid occurring in PRO owned online platforms and the exchange value for the waste derived material can be designated as 'Retake value' (*valor de retoma*, in Portuguese) and it represents the remainder of PRO revenue. The value for which the material

is sold is directly related to the materials market and, depending on prevailing demand and batch quality, it can assume negative values. Meaning PROs pay to the recyclers so they take the plastic waste material.

[D] - Financial flow from Recyclers to SGRUs

Recyclers must pay to the SGRUs for the disposal of the material. Choosing SGRUs is usually a matter of proximity, as recyclers must cover the transportation costs.

The Portuguese packaging waste system is a full cost coverage system where PROs are responsible for financing all system's activities related to the collection and sorting the packaging waste from the urban flow. The system's main financial input is the above previously mentioned 'ecovalue' fee paid by packers and importers of packaging products to the PROs. The fees from all packaging materials represent over 80% of PRO revenue, of which half derives from plastic packaging alone. Which means 38% of total PRO revenue is assured by 'ecovalue' fees from this material (SPV, 2019; Novo Verde, 2019, Electrão, 2019). As already described, 90% of total PRO costs arise from the counterpart values. The remainder is divided by internal costs, sensibilization and R&D, where the last two have minimum percentual values inflicted by the Portuguese environment agency.

The 'ecovalue' fees are defined by each PRO and have to be approved by the Portuguese Environment Agency. As depicted in Figure 17, the fees remained constant since 2012 with major oscillations starting with the licensing of new entities and the introduction of a competitive model.

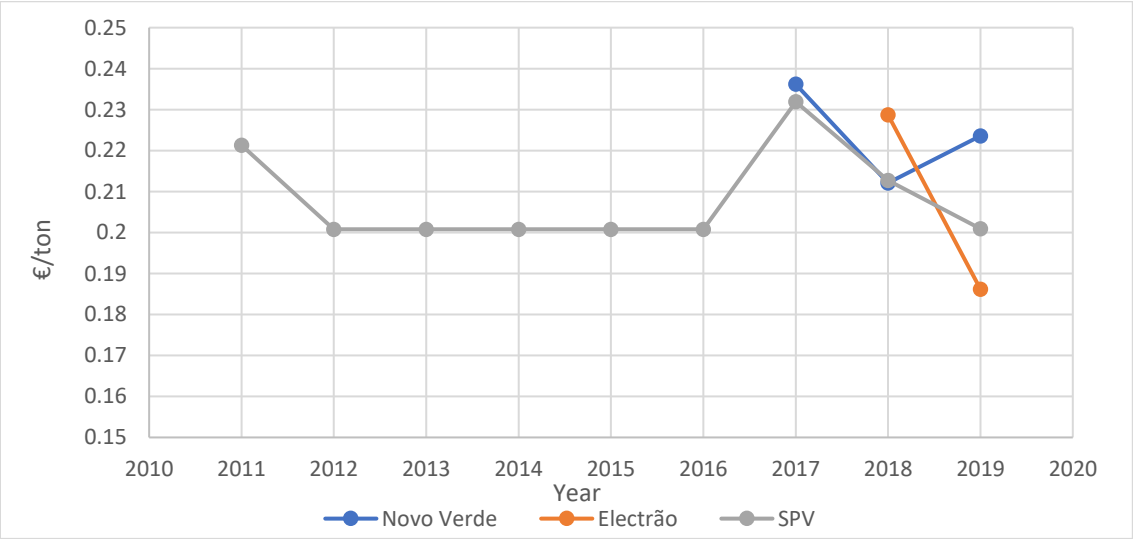


*Figure 17 - Plastic packaging ecovalue fee since 2011 (SPV 2019a; Novo Verde 2019; Electrão 2019)*

As mentioned, the remainder of PRO income is assured by the retake values, which represent about 20% of total revenue, depending on PRO. Public auctions for the batches collected by the several UWMO are held every quarter (or semesters in previous years) with recycler participation. SPV average monthly retake values for each type of plastic material is depicted in Figures 18 to 22. Data on the graphs corresponds to the starting auction values per plastic type. Although the actual auction results and final bid prices are not

available, base values can also reflect market behavior as these are calculated having into account the results from previous auction results.

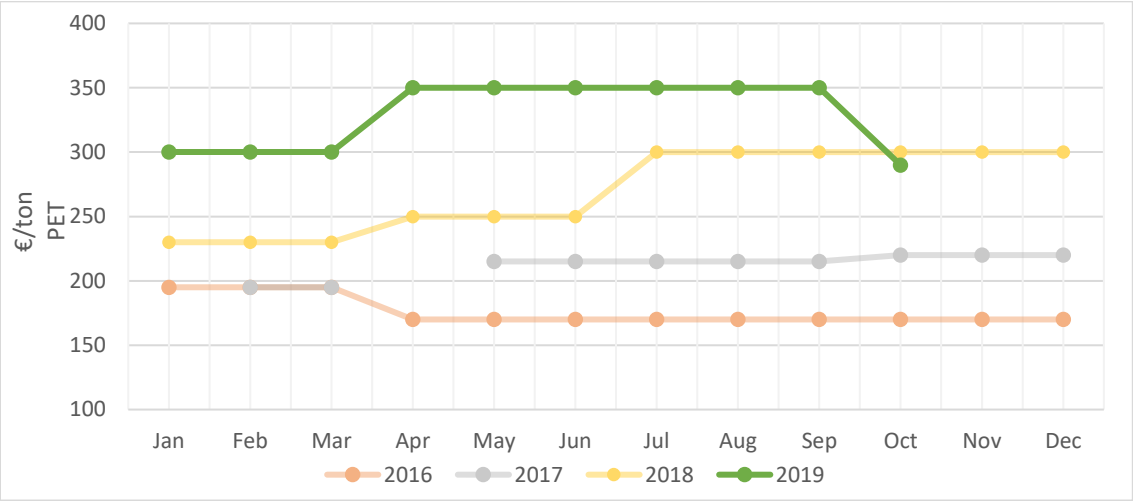


*Figure 18 – PET auction monthly average values (SPV, 2019)*

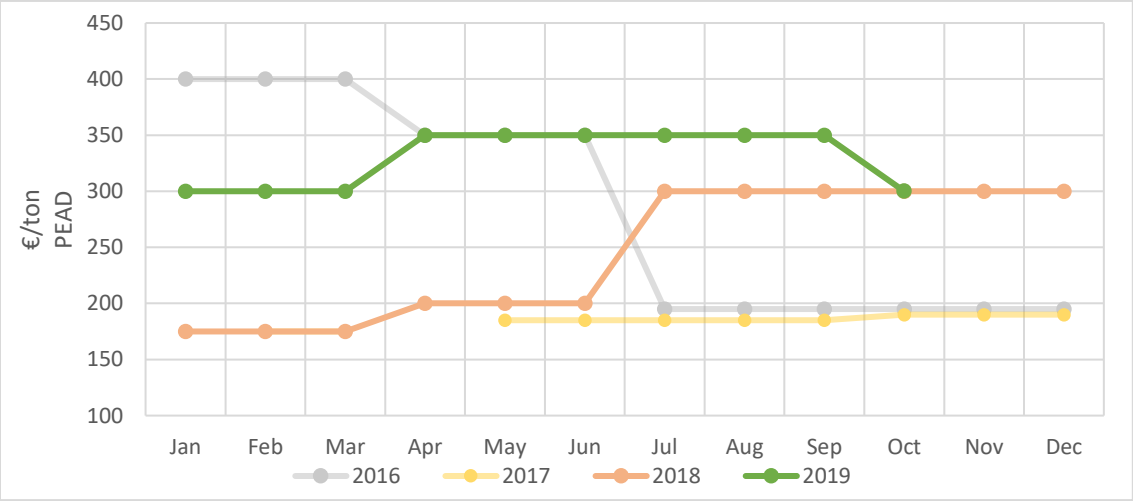


*Figure 19 - HDPE auction monthly average values (SPV, 2019)*

Both PET and HDPE portray an increasing trend since 2017. Average values for these two plastic types (represented in green) currently sit in the 300€ range.

Mixed plastics and EPS are the two plastic materials which assume negative retake values. Whilst mixed plastics values have remained constant for the past three years, EPS has experienced substantial a substantial valuation with base prices now approaching positive values (see Figure 21).

Other than EPS, plastic film is the other plastic type which has experienced the greater price fluctuations. But opposingly to EPS, there has been a considerable devaluation of this waste material, as Figure 22 depicts that 2019 values dropped over 80% in relation to the year of 2016.

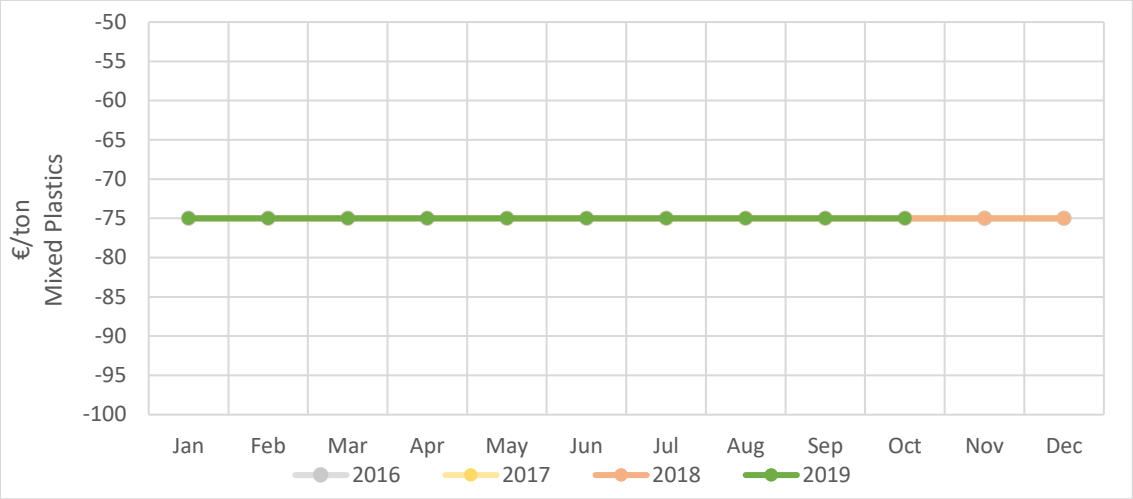


*Figure 20 – Mixed Plastics auction monthly average values (SPV, 2019)*

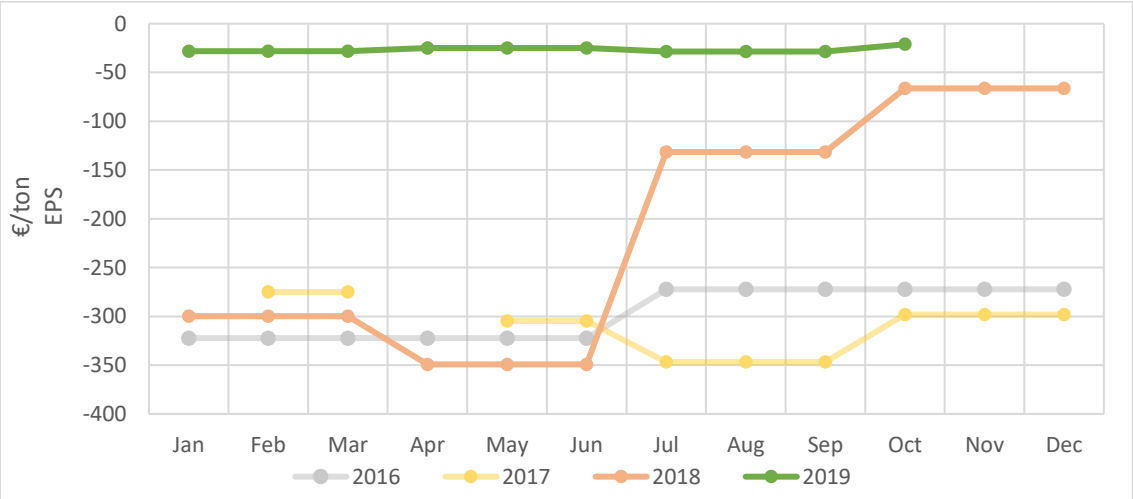


*Figure 21 – EPS auction monthly average values (SPV, 2019)*

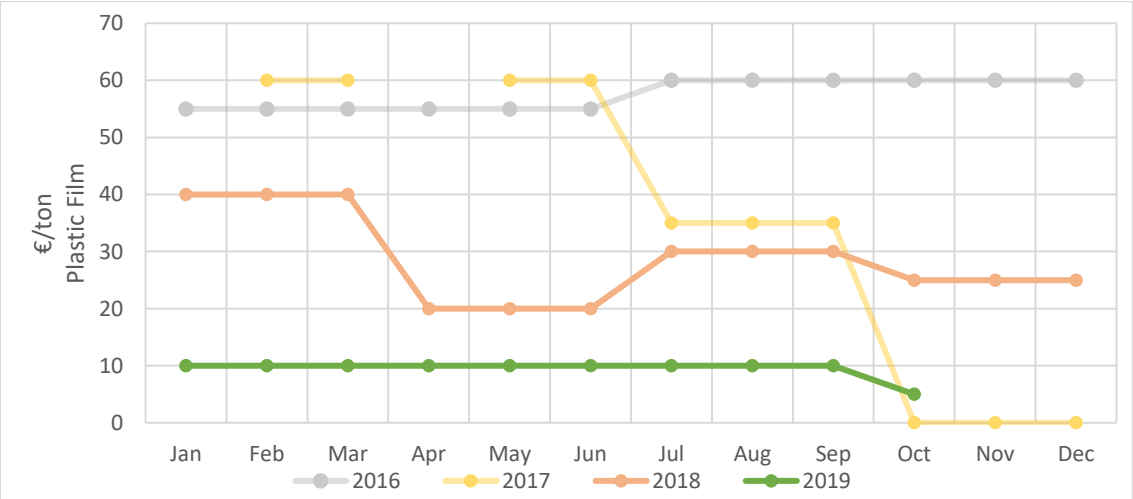


*Figure 22 – Plastic film auction monthly average values*

### 5.2.3. Interviewees View on System's Performance

One main topic that was addressed during the interviews was the 2017 downturn in recycling rates (see Figure 15 and 16). Although official reports do not provide an explanation for this decrease, while interviewees were subject to several questions on the evaluation of the current system's performance, there were two major subjects which were pointed out:

- The introduction of a competitive model for the Portuguese extended producer responsibility scheme for packaging waste in 2017 (year of the major downturn) with the entry of a newly licensed PRO. Later, in 2018, another PRO entered the system, meaning the current Portuguese packaging waste supply chain is now managed by three entities.
- In April of 2017, the Chinese government approved a ban on imported "recyclable" solid wastes. The ban included 24 kinds of solid wastes, amongst which non-industrial plastic wastes is the most prominent. Prior to this ban, China and other developing countries in East Asia were the destinations of a substantial share of plastic waste exports by higher-income countries, Portugal included (Wang et al., 2019).

In regard to the new PRO competitive model, the majority of the interviewees shared a skeptical opinion on the efficiency of this model. There seemed to be three major reasons supporting this opinion:

i. The first was that the dimension of the Portuguese packaging waste system does not justify the implementation of a competitive model. Overall opinion is that the added bureaucracies are hampering the efficiency of a previously well-functioning system. In addition, it was also mentioned that the aimed improvements that would derive from competition are still yet to match the economies of scale associated with a single PRO - "*At the end of each working year, it is necessary to manage the financial compensations between PROs for the discrepancies between allocated shares and the actual each PRO managed. This requires both human and financial resources and has associated costs".*
ii. The second reason is that competition could be incentivizing lower recycling rates. As already mentioned, the majority of PRO costs derive from the counterpart values they must pay to the SGRUs for the collection of the waste material. As so, in order to reduce costs for coping with the competition, lower declared collection rates would lead to costs reductions for the PROs.
iii. The third reason is that, for some interviewees this model "*(…) actually introduces a fake sense of competition."* As previously disclosed, about 90% of PROs total cost derive from the counterpart values they must pay to the SGRUs. As these values are defined by the Portuguese environment agency and enforced to all PROs, there is no margin for competitive strategies. On the revenue side, the 20% from retake values also does not provide competition margin, as it is highly dependent on recycler bidding power. In this way, some interviewees believe "*PROs are only competing for the remainder 10% of the system's costs and for market share of packers and*

*importers of packaging products. Meaning PROs are competing in a highly regulated a standardized market, which can be somehow controversial*".

On the other hand, after the Chinese import ban, Europe was flooded with plastic waste material that could no longer be recycled via the previous transoceanic solution. Still, data shows the resulting excessive supply was mainly reflected on the flow of recycled plastic film, which was the main target for exports, with other flows displaying only slight variations.

When questioned about the price fluctuations the several plastic waste types, interviewees highlighted that retake values vary depending on the nature of the plastic material and the disposal method. While PET and HDPE recycling is considerably efficient, mixed plastics and EPS require greater effort and financial commitment, reflecting a less attractive market. That is why retake values for these two are usually negative, although latest trends might point to an inversion in a near future.

Looking into each plastic type in a more detailed, it is also possible to highlight:

- Both PET and HDPE were not affected by the "China ban", as they were not a substantial target for exports. In addition, they are highly recyclable when compared to other plastic types and have extended applications in the packaging industry. Which also plays a relevant part in their valorization, as packaging companies are more and more actively engaging in sustainable practices, including the incorporation of recycled material. A clear example of this industry commitment that had a positive impact in the demand for these materials is the implementation of the 'Circular Plastics Alliance' in 2019, where over 100 public and private partners covering the whole plastics value chain, including major corporations of the packaging industry, committed to increasing the use of recycled plastic material.
- Mixed plastics & EPS negative values are a reflection of the greater resource effort that is demanded to the recycling companies for processing these materials. As consequence, the only way of currently sustaining mixed plastics and EPS recycling businesses is through subsidization. In addition, the recycled product derived from these types of plastic waste still has substantially low quality (i.e. when compared to PET and HDPE), and much more limited applications, therefore downsizing the overall valuation of these materials. This is the main reason behind mixed plastics' constant behavior throughout the past four years, as the demand for these products is still assured by the two same, experienced, recycling companies with no major changes to the industry. On the other hand, EPS is the least significant material (about 1% of total recycled plastic waste), so changes in material supply result in substantial price oscillations, making the analysis processes more difficult. Still, the improved valuation of EPS was awarded, by interviewees, to the entry of a new player in the recyclers stakeholder group, extending the applications for recycled products from this material.

- Interviewees stated the plastic film was the main target of Portuguese plastic exports. After the 2017 Chinese ban, the excessive supply led to severe price drops of the material in order to guarantee 100% demand for this plastic type.

Also, worth noticing is the fact that Portugal can be completely independent for the recycling of the material recovered by the SGRUs. As stated by a PRO representative, "*Portugal has the capability for recycling 100% of the recovered plastic material, although that could lead to variations in the prices of some plastic types*", because there still is a substantial share of plastic material that is sold to Spain. There was also mention to the substantial scarp rates that recyclers still experience (e.g. over 20% for PET and 10% for mixed plastics) and the high costs associated with its disposal.

Overall, performance analysis suggests there is substantial room for improvement in the Portuguese plastic packaging waste supply chain. Interviewees shared overall concern on the high possibility of not coping with the set-out targets for the coming years. From Figure 16 it is possible to infer that, even in a scenario of restoring the 3% to 4% growth pattern, the 2020 target of 50% would remain unattainable.

In parallel to obtaining the stakeholders view on the system's performance it is also essential determine which and how are the stakeholders influencing this performance. In order to promote the valorization of the plastic waste supply chain, it is necessary to understand which stakeholders have the biggest role in this valorization context. Given so, this analysis was complemented by the categorization of the stakeholder groups, which is presented next.

## 5.3. Stakeholder Categorization

*Table 18 - Interview scores in regard to the 'Power' attribute*

| Stakeholder Group | Interviewee A (Packers) | Interviewee B (PRO) | Interviewee C (Recycler) | Interviewee D (Academia) | Interviewee E (NGOs) | Interviewee F (Government) | Interviewee G (SGRU) | Interviewee H (Recycler) | Power Average score |
|---|---|---|---|---|---|---|---|---|---|
| Gov. Authorities | 5 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | **4.88** |
| Recyclers | 4 | 4 | 4 | 5 | 5 | 4 | 5 | 4 | **4.38** |
| PROs | 5 | 4 | 4 | 2 | 4 | 5 | 4 | 5 | **4.13** |
| Packers | 4 | 4 | 4 | 4 | 5 | 4 | 3 | 4 | **4.00** |
| Civil society | 4 | 4 | 4 | 5 | 3 | 5 | 3 | 3 | **3.88** |
| UWMO (SGRUs) | 4 | 4 | 3 | 4 | 4 | 3 | 3 | 4 | **3.63** |
| Academia | 3 | 4 | 3 | 5 | 4 | 3 | 3 | 3 | **3.50** |
| NGOs | 3 | 3 | 5 | 4 | 2 | 1 | 3 | 4 | **3.13** |
| Financial Institutions | 2 | 4 | 3 | 4 | 3 | 3 | 3 | 3 | **3.13** |
| Other WMO | 3 | 3 | 1 | 3 | 3 | 3 | 1 | 3 | **2.50** |

The evaluation and categorization of stakeholder groups was performed considering three main attributes – Power, Interest and Support. The data supporting this evaluation was provided by Group II of the interview

guide (see step 3 of Section 4.3.1.) when interviewees were asked to evaluate the mentioned attributes using a score system from 1 to 5 points, where 1 is the lowest score (e.g. very little power/interest and strong opposition) and 5 is the highest (e.g. very strong power/interest and strong support). Individual and average interview results are presented in Tables 18 to 20:

Interviewees justifications supporting the scores for the 'Power' attribute for the higher power stakeholder groups were the following (by decreasing order of power degree):

- Government / Governmental Authorities (score 4,88): This stakeholder group was recognized as holding the most power regarding the valorization of the plastic waste supply chain. As main regulators, enforcers and direct respondents to the European Commission, they set most of the norms and legislation surrounding the entities that are directly involved in the plastic waste supply chain, making them "*(…) the culmination of power in the valorization context*". The main outputs of their power can be perceived in the following affairs:
    - APA is responsible for giving out the licenses to both PROs and the recyclers operating within national ground.
    - They are responsible for determining the counterpart values for all PRO organizations and, despite not directly determining the 'ecovalue' fees (these are proposed by each PRO) individually, governmental authorities must approve these values for the start of each working year.
    - Batches of recycled material that were collected by the SGRUs must meet government set specifications in order to be eligible for the PRO conducted auctions.
    - There are government specific bodies for the supervision and inspection of the companies that are operate waste material. This includes PROs, UWMOs, other WMOs and recyclers.
    - Governmental authorities restrict the utilization of PRO revenue, setting minimum investments in the R&D and awareness departments for all PROs.
    - The Portuguese environment agency is responsible for establishing the values and criteria supporting the waste management fee (in Portuguese, TGR - *Taxa de Gestão de Resíduos*)
- Recyclers (score 4,38): Recyclers were also considered to have great power in the valorization topic. Although this group's score differs in just half score unit from the governmental authorities, the rationale supporting interviewees evaluation is of a considerably different nature.
    - "*The system is extremely conditioned by the performance and the willingness that this stakeholder group has for recycling the materials*". General opinion of interviewees states that the number of plastic recycling companies in national territory is still relatively low - in 2015 there were under 20 recycling companies approved by the Portuguese governmental authorities. Analyzing the allocation of type of plastic material per recycling company in that same year it is possible to highlight (SPV, 2016):

- Mixed plastics (41% of total recycled plastic): Over 70% (71%) of mixed plastics was allocated to a single company, while the reminder 29% was acquired by just one other company;
- HDPE and plastic film (26% of total recycled plastic): Almost 50% (46%) was allocated to a single company.
- PET (22% of total recycled plastic): 99% was allocated to two companies, with shares of 55% and 44%

Which shows most recycled plastic material is constantly allocated to the same companies. This can suggest that, despite the auctioning system, demand for recycled plastic material comprises a weak competitive environment than can be translated into a high bargaining power from the main recycling companies.

- Producer Responsibility Organizations (score 4,13): PROs were also perceived to have great power on the valorization topic. This group of stakeholders has direct contact with all other major stakeholder groups in the supply chain. Direct contact with packers and importers of packaging products comes in the form of receiving the 'ecovalue' fee, they are also responsible for the payment of counterpart values to the SGRUs and they are accountable for fixing retake values with the recycling companies. One interviewee stated that "*Currently, power seems to sit with the organizations with greater financial input. As so, PROs definitely have the power to influence the system, as they receive the most financial support for doing so*". So, although not managing the material itself and despite some of their actions being relatively limited by governmental legislation, PROs manage the processes of collecting the plastic packaging waste all the way to its final disposal destination and treatment.
- Packers and importer of packaging products (score 4,00): The following reasons emerged as the main justifications for the perceived high power of the packers' group:
    - The financial input of this group of stakeholders represents major financial support of the entire system's cost structure. In 2018, for plastic packaging alone, 'ecovalue' fees paid by this group of stakeholders to the PROs ascended over 30 million euros. In PRO cost structure, plastic is also the most representative of packaging materials. Plastic 'ecovalue' fees alone, represented 50% of the total fees that were paid to the system and amounted to 38% of PROs revenue (SPV, 2019; Novo Verde, 2019, Electrão, 2019).
    - In addition, the composition and arrangement of materials in packaging products have an extensive impact on waste recyclability. "*Packers have very high power; recyclability is extremely dependent of the information that the packers possess.*". Bundling different plastic types (like HDPE, PET, plastic film or EPS) can lead to incompatibilities where the mix of plastic types is lower valued than those same materials recycled separately. Therefore, friendlier, more recyclable packaging products can lead to higher quality recycled material which in turn can lead to a greater valorization of the system as a whole.

- Civil Society (score 3,88): Despite having slight less power than the above mentioned, there was consensus on the important part that plastic waste producers have in the valorization of recycled material. SGRU income comes essentially from the counterpart values paid by the PROs. These values differ from selective to undifferentiated collection for each SGRU cluster. Counterpart value for plastic material that was recovered from undifferentiated waste subject to mechanical treatment represents a devaluation that ranges from 74% to 80% (depending on SGRU cluster) when compared to plastic waste from selective collection (Novo Verde, 2019). In addition, counterpart values for selective collection is still limited by the quality of the collected material. If selective disposal by waste producers is not performed in adequately, the higher the contamination levels of the plastic material. Interview results claim there is still considerable margin for improving the quality of collected plastic material only considering consumer actions. Which in turn can translate into to higher financial compensation for waste recovery. A substantial number of interviewees shared the opinion that "*Civil society is the major barrier towards improved valorization of the waste material*".

*Table 19 - Interview scores in regard to the 'Interest' attribute*

| Stakeholder Group | Interviewee A (Packers) | Interviewee B (PRO) | Interviewee C (Recycler) | Interviewee D (Academia) | Interviewee E (NGOs) | Interviewee F (Government) | Interviewee G (SGRU) | Interviewee H (Recycler) | Interest Average score |
|---|---|---|---|---|---|---|---|---|---|
| PROs | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | **4.88** |
| Recyclers | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 3 | **4.50** |
| UWMO (SGRUs) | 4 | 5 | 3 | 4 | 5 | 4 | 5 | 5 | **4.38** |
| NGOs | 4 | 5 | 4 | 5 | 3 | 4 | 4 | 5 | **4.25** |
| Gov. Authorities | 4 | 5 | 3 | 4 | 4 | 5 | 5 | 3 | **4.13** |
| Packers | 4 | 4 | 3 | 5 | 5 | 3 | 4 | 5 | **4.13** |
| Academia | 4 | 4 | 4 | 4 | 3 | 3 | 4 | 3 | **3.63** |
| Other WMO | 3 | 5 | 2 | 3 | 4 | 4 | 4 | 3 | **3.50** |
| Civil society | 3 | 4 | 4 | 4 | 3 | 2 | 4 | 3 | **3.38** |
| Financial Institutions | 3 | 4 | 3 | 3 | 3 | 2 | 4 | 3 | **3.13** |

Preliminary analysis on the data concerning the interest of stakeholders towards the valorization of the plastic waste supply chain show as a generally positive picture. According to interview results, all stakeholders share, at least, a moderate level of interest (score higher than 3) in the context of better valorizing the plastic waste supply chain. The groups with higher perceived 'interest', and the justifications provided by interviewees are:

- Producer Responsibility Organizations (score 4,88): In the way the current system is organized, PROs seem to be tasked with the greatest effort in streamlining plastic material back into the

industry. The existence of plastic types (e.g. mixed plastics and EPS) that constantly take negative retake values suggest that recyclers demand and competitiveness for recycled material are still encompassed by a reasonably unattractive market. Better valorization of these materials could lead to a more competitive industry in the recyclers group, facilitating the flow of the unprocessed plastic waste material. In addition, PROs are under direct pressure of governmental authorities for achieving the ambitioning set targets of recycling rates. Not accomplishing the imposed rates results in penalty fees for the PRO organizations, which last year ascended over 300.000 € for SPV alone.

- Recyclers (score 4,50): This stakeholder group also has a substantially high perceived interest in the valorization of the plastic waste supply chain. Two main reasons were attributed to this perceived high interest of the stakeholder group.
    - An enhanced market offer and increased material quality. If outcomes of the supply chain valorization are to go by an increase of the material offer, this would lead to higher potential production inputs for the recycling companies. In addition, better quality material can also augment production and final product quality.
    - Increasingly competitive market. With the achievement of this valorization, demand for plastic waste material could increase, leading to a larger and more competitive market of recycling products. Such aspects associated with greater competition should also draw interest from this stakeholder group.
- Urban Waste Management Operators (SGRUs) (score 4.38): The main driver for SGRU interest is associated with financial compensation. These companies have their counterpart values determined by governmental authorities. As already mentioned, these values vary according to the type of collection (and SGRU cluster, not relevant at this point). As so, SGRU strategies for improved financial performance are still substantially attached to educating waste producers towards selective disposal, which has a greater associated counterpart value. Better valorization of the plastic waste material could translate into increased counterpart values which in turn captures the financial interest of the SGRUs.
- Packers and importers of packaging companies (score 4,13): Over the past years, sustainability has become a topic of increasing importance for all organizations, regardless of the industry and operating markets. Companies that are directly associated with waste production are target of extensive pressure on decreasing the negative externalities of their products. As so, there is a substantial shared interest across the packaging industry on an improved post-life valorization of their products, and this interest is well perceived across the remaining stakeholders.
- Government and Governmental Authorities (score 4,13): "*Governmental authorities do show high levels of interest, but sometimes this is interest is very narrow. In the sense that they are extremely concerned with the EC's directives and complying with the targets, but they do not express the same interest on defining the appropriate solutions for that compliance. They are mostly interested*

*in seeing the remainder of the system deliver those goals.*". - Some interviewees stated that governmental authorities show an active concern on the valorization topic as a mean towards complying with the EU standards, but less interest in solutions and the means towards achieving those goals.

*Table 20 - Interview scores in regard to the 'Support' attribute*

| Stakeholder Group | Interviewee A (Packers) | Interviewee B (PRO) | Interviewee C (Recycler) | Interviewee D (Academia) | Interviewee E (NGOs) | Interviewee F (Government) | Interviewee G (SGRU) | Interviewee H (Recycler) | Support Average score |
|---|---|---|---|---|---|---|---|---|---|
| PROs | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | **4.88** |
| Recyclers | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | **4.88** |
| UWMO (SGRUs) | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | **4.75** |
| Gov. Authorities | 5 | 5 | 3 | 5 | 4 | 4 | 4 | 3 | **4.13** |
| Packers | 4 | 4 | 4 | 3 | 5 | 4 | 4 | 3 | **3.88** |
| NGOs | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | **3.63** |
| Financial Institutions | 3 | 3 | 4 | 3 | 4 | 4 | 3 | 3 | **3.38** |
| Academia | 3 | 4 | 3 | 3 | 3 | 4 | 3 | 3 | **3.25** |
| Other WMO | 3 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | **3.25** |
| Civil society | 3 | 3 | 2 | 2 | 4 | 3 | 3 | 3 | **2.88** |

The results obtained for the 'Support' attribute seem to reinforce the current positive overall picture on the perspectives for future supply chain valorization, already mentioned in the analysis of the 'Interest' attribute.

This can be justified by the overall recognition that the valorization of the plastic waste supply chain, at least at this stage, would not compromise nor damage any of the activities of the identified stakeholders. In fact, an overall valorization was seen as a boost for all system's businesses. In addition, the opinion that valorization is one major performance measure of the system was a predominant thought shared by most interviewees.

An aggregated of stakeholder groups average scores in the three attributes is presented in Table 21:

*Table 21 - Stakeholders' average score for each attribute*

| | Academia | NGOs | Government | PROs | UWMO (SGRUs) | Other WMO | Packers and importers | Civil Society | Financial Agencies | Recyclers |
|---|---|---|---|---|---|---|---|---|---|---|
| Power | 3.50 | 3.13 | 4.88 | 4.13 | 3.63 | 2.50 | 4.00 | 3.88 | 3.13 | 4.38 |
| Interest | 3.63 | 4.25 | 4.13 | 4.88 | 4.38 | 3.50 | 4.13 | 3.38 | 3.13 | 4.50 |
| Support | 3.25 | 3.63 | 4.13 | 4.88 | 4.75 | 3.25 | 3.88 | 2.88 | 3.38 | 4.88 |

Other than just analyzing each attribute separately, the combination of attributes through stakeholder analysis' tools can complement the categorization procedure and provide particular strategies for coping with each stakeholder group. For those reasons, the analysis during the next two sections explores this combination by matching attribute scores with the 'Power vs. Interest' matrix and the 'Support vs. Opposition' grid.

### 5.3.4. Power vs. Interest Matrix

The power versus interest matrix is a commonly applied method for stakeholder categorization which can support the assessment of the relevance of the stakeholders perceived power and interest, allowing to categorize them accordingly. The matrix that resulted from the data in Table 21 is shown in Figure 23.

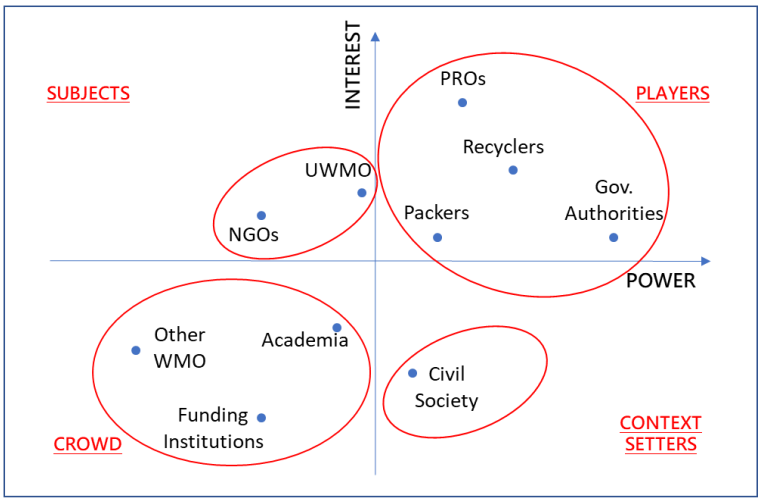


*Figure 23 - Power vs. Interest matrix*

From Chapter 2 it is known that this two-by-two matrix is supposed to divide stakeholders into four major categories:

- Players – Who have both high interest and high power;
- Subjects – Who have high interest but less power;
- Context Setters – Who have high power but less immediate interest.
- Crowd – Which consists of stakeholders with less power and less interest;

Analyzing the results from the 'Power vs. Interest' matrix in Figure 23 and introducing the above-mentioned categories, the following stakeholders' categories were derived:

i. The first quadrant, that was categorized as the 'Players' category, comprises stakeholders which were perceived to have the greater power and substantially high interest in the plastic waste supply chain valorization subject. Within this category it is still possible establish a differentiation between two stakeholder types:
    a. Stakeholders directly involved in the material flow of the plastic waste supply chain – packers (and importers of packaging products) and the Recyclers. Packers hold high

interest as they are constantly targeted by national and European directives and the main subjects of packaging legislation. In addition, as already observed, 'ecovalue' fees not only represent substantial expenditures for the packers, as they are the major financial input of the system, suggesting its sustainability is highly dependent on the monetary compensation that derives from the packaging industry. A clear manifestation of this group holds so much interest and power. Likewise, if valorization is to come by improved quality of recovered plastic waste, packers can play an important part in improving the recyclability of their products (e.g. through the combination of more compatible material types). On the side of the recyclers, power and interest come from the fact that they are the most responsible for expanding the demand for the final recycled material. So higher valorization of the supply chain, could lead to improved performance of the recycling companies. Interviews also showed that some of this group's power derives from the relatively small number of recycling companies that are currently licensed to operate in national ground. Nevertheless, although better valorization could lead to a more competitive demand for collected plastic waste, interviewees from the recyclers group did not show any resistance nor concern regarding a possibly more competitive industry.

b. Stakeholders involved in the regulation and management of the system – Government (and Governmental Authorities) and Producer Responsibility Organizations. Government interest derives not only from the fact that recyclability is globally recognized as a common good, but as they are the main national respondents to EC legislation and directives. Portuguese environment related governmental authorities are under constant pressure from the EC for achieving the ambitiously set targets that are constantly updated. Their maximum power comes mainly from the fact that they impose the legislation under most of the system's organizations operate, especially the ones that also had high perceived power. If governmental authorities are the main respondent to the EC, PROs are the main respondents to the governmental authorities. And they are considerably powerful as they are the central entity that assures the flow of material along the supply chain. The nature of the interest of these two groups on the valorization topic is rather similar, as it could be a main boost to recycling rates and allow the compliance of set out targets.

ii. The second quadrant, categorized as 'Subjects', comprises the stakeholder's groups that are also perceived to have relatively high interest yet considerably less power than the 'Players'. These stakeholders, if empowered, can easily move to the latter category. Its composition comprises the Urban Waste Management Operators (SGRUs) and the NGOs. UWMO's high interest comes from the direct relation between supply chain valorization and the improvement of their performance. Still, they are limited by the government standards, operating area, and the disposal culture of the population they cover. NGOs scored a perceived high interest as many of the organizations from

these organizations are usually sponsored by, or partners of the already mentioned high interest stakeholder groups, but also showed considerably less power according to respondents.

iii. Third quadrant, categorized as the 'Context Setters', comprises the entities holding high power while not demonstrating the same high levels of interest as other stakeholder groups. Civil Society is the solo representor of this category, as their behavior was widely referred to as a major limitation towards better valorization of the waste material. This shows their considerable power, deriving from the high margin for improving material quality by simply adjusting their consumer behavior and disposal habits. But their significantly smaller interest, as the majority of the system acknowledges waste producers show some hesitance in accepting those corrective measures.

iv. Fourth quadrant, categorized as 'Crowd', is comprised by Other Waste Management Operators, Academia and Funding/Financial Institutions. Although other WMO, academia, and funding/financial institutions show some interest, they are not as actively involved nor concerned as other stakeholder groups. In addition, the representative entities of these groups are still rather small in number and unable to have a significant impact in the system, which justifies the lower levels of power.

The 'Power vs. Interest' matrix has a more evaluative component, in a sense that it helps to identify the interests of individual stakeholders in the valorization topic. and determines which players' interest and power issues must be considered. After coming fairly close to deciding who the 'key' stakeholders are, the next step is to generate healthy discussion and reveal the stakeholders that should be included in the more public beginning of the valorization effort. The 'Support vs. Opposition' grid is one way of tackling this issue and is presented next.

### 5.3.5. Support vs. Opposition Grid

'Support vs. Opposition' grids pay a major part in discretizing the fact that stakeholder's interest might not always have a positive nature. In that sense, this stakeholder analysis tool complements the 'Power vs. Interest' matrix by attempting to differentiate between the positive and negative interests and provide further insight on which stakeholder groups would be efficient mobilizers in the beginning of the valorization effort. The resulting two-by-two grid, labels stakeholders as weak supporters, strong supporters, weak opponents or strong opponents. In this particular supply chain valorization context, it is important to highlight that no stakeholder group was attributed a final score significantly below 3 score points in the 'Support' attribute. Where, in the value scale, 3 is equal to a 'neutral attitude' (neither support it nor oppose it), it shows that only the civil society group is perceived to have a slightly opposing attitude towards the valorization topic.

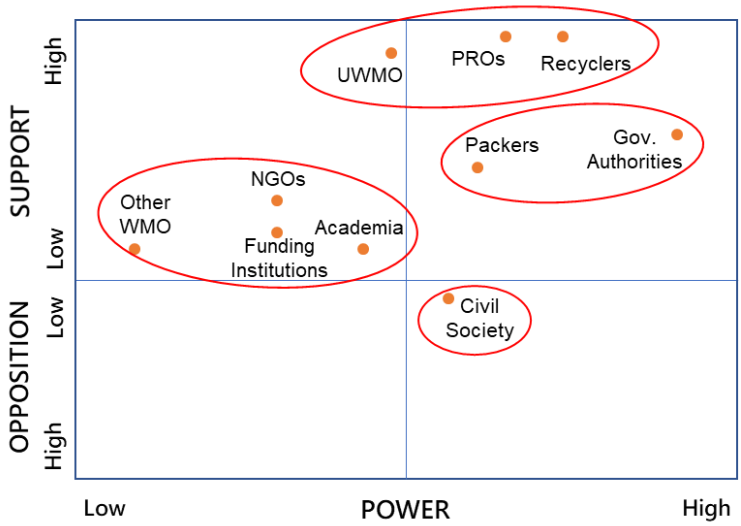


*Figure 24 - Support vs. Opposition Grid*

Still, it is important to distinguish between 'Interest' and 'Support', as a stakeholder might show considerable interest, yet not be willing to actively mobilize resources towards the subject. Given so, slight adaptions were made to the categorizations that are presented in this methodology's literature. Namely the work by Nutt & Backoff (1987) and Bryson et al. (2011). The grid that resulted from Table 21 is shown in Figure 24.

From Chapter 2 it is known that this grid is supposed to classify stakeholders according to four major labels:

- Strong Supporters – Who have both high power and show strong support
- Weak Supporters – Who show strong support, but have less power;
- Strong Opponents – Who have high power and show strong opposition;
- Weak Opponents – Which consists of stakeholders that show opposition but have less power.

Regarding the results from the 'Support vs. Opposition' grid, it is possible to highlight the fact that, with the exception of civil society, no stakeholders have a perceived opposing attitude in the valorization topic. Which shows a substantially positive picture towards effectively making this transition. For this reason, a slight adaptation was made to the literature with the introduction of a more specific nomenclature. Based on interviewee responses, stakeholders were classified according to the following labels:

- 'Key Supporters' - Comprising the Recyclers, the PROs and the UWMO (SGRUs). This label was added to the original literature and encompasses stakeholders who have the most power and are likely to be the most supportive in terms of actively mobilizing their resources and the remaining stakeholder groups towards a successful supply chain valorization, making their participation highly critical.
    - Recyclers are likely to be key supporters as they would have "(*…) major financial motivation deriving from the particular valorization of the plastic material.*" Meaning

recyclers would be attracted not only by the valorization of the system as whole, but by the adjacent valorization of the material.

    - PRO ultimate goal is to pursue the best recycling rates as possible. Interviewees shared an opinion that PROs would be willing to actively mobilize any valorization project.
    - Despite UWMO having slightly less power than the first two stakeholder groups, a better valorization of the system is likely to ultimately increase financial compensations and the performance of the SGRUs.

- 'Strong Supporters' - includes Packers, Civil Society and Governmental Authorities. It is meant to distinguish those stakeholders which have high power but are likely mobilize reduced resources and show less commitment when compared to their full capabilities. In the sense that they support the valorization topic but it does not pose an immediate priority.
    - Packers and importers have increasingly demonstrated greater commitment to adopting 'greener' practices, the 'Circular Plastics Alliance' is a clear example. Nonetheless, sustainability issues such as recyclability of their products is yet to be the main focus of their businesses.
    - Despite being supportive, governmental authorities are perceived as being rather "slow" in actually mobilizing their resources. So, even though they are likely to support the valorization topic, it should be slightly difficult to have their commitment during the early stages of the valorization process.
- 'Weak Supporters' - this label comprehends Other WMO, NGOs, Funding / Financial Institutions and Academia, and intends to represent the stakeholders which show minor support or adopt a neutral position, and have little power when compared to other stakeholders. Even though interviewees considered them to show substantial support towards a valorization effort, the smaller power they hold within the system means that, individually, their commitment is not likely to produce significant improvements.
- 'Strong (Moderate) Opponents' - solely represented by the civil society. It was adapted from the original literature as civil society's 2.88 average score is considerably close to a neutral position but still suggests some probability of a reluctant stakeholder group in regard to a valorization effort. The common opinion is that "*Civil Society can, on one hand, be the main promotor of sustainability measures. We are experiencing an increased commitment to proper recycling by the population, yet there is a vast majority not willing to collaborate. Most people still seem lack a direct motivation or greater compensation for their effort.*"

Other than just categorizing stakeholders, a holistic approach to stakeholder analysis requires an in-depth view on how stakeholders interact with each other, for improved management of their relationships. Social network analysis provides insights into patterns of communication, trust, and influence between the actors within a system. For those reasons, during the interviews, interviewees were questioned about the level of

information sharing that their stakeholder group had with the remainder, enabling to build a SNA model that was latter analyzed with the use of UCINET software. The results are presented in the next section.

## 5.4. Social Network Analysis

The interactions and degree of information exchange amongst stakeholders that were obtained through the interviews were mapped and are presented in Figure 25. By capturing the nature of stakeholder relationships and the strengths of those relational ties, SNA is an efficient method for recording this information in a quantitative form, easing summarization and analysis (Reed et al., 2009). By doing so, SNA complements stakeholder categorization in the sense that it can be used to ensure key stakeholder groups are not marginalized, identify conflicts between stakeholders and select representatives based on the way that the network is structured.

In this particular network, it is important to highlight that these are “directed” graphs, which have the convention of connecting actors with arrows, that indicate who is directing the tie towards whom. Self-ties – information sharing within the same stakeholder group – were also accounted, although they are indistinguishable in the graphical representations.

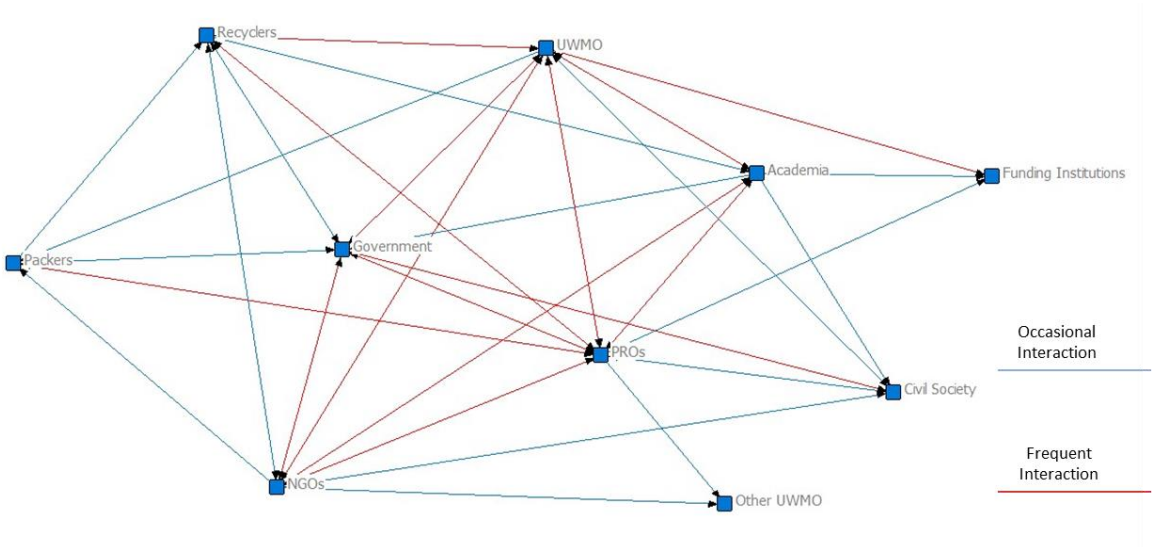


*Figure 25 - Social Network Diagram*

Each node represents one stakeholder group and information exchange is not homogeneous throughout the network. This feature is illustrated through the line coloring system, as the color of the lines (connections) vary according to how strong the connection in the analysis is. Stakeholder pairs can either have null/scarce information sharing – no connection -, occasional information sharing – blue line – or frequent information sharing – which is represented by the red lines.

Overall assessment shows that few stakeholder groups are either disconnected or only partially connected to others. In addition, during the interviews, no respondents stated to be really cut off from information flows.

In-depth analysis of this social network was developed by analyzing two major network parameters – Density and Degree of Centrality. The results and associated discussion are presented next.

### 5.4.1. Network Density and Degree of Centrality

Network Density $D = 0.42$

Network density describes the portion of the potential connections in a network and the actual connections, providing a degree of overall connectiveness of the system. Scores closer to zero, such as the resultant from the mapped network, point towards a certain lever of overall disconnection. As so, preliminary SNA results do not suggest an overall picture as promising as the categorization tools. It can also be observed that the stronger ties tend to occur mostly between the most powerful stakeholders, which can negatively affect the system. For instance, it might mean some actors, which could have potential impact within the valorization subject (such Academia through R&D), especially if empowered, are being left aside and 'shut down' from the decision-making process. Furthermore, if information and knowledge is constantly shared only within the same restrict group of stakeholders, it might become outdated and inefficient.

Stakeholder groups with the highest perceived power and interest, namely governmental authorities and PROs, present greater engagement in information sharing. This rather strong connectivity of high power/interest stakeholder groups should factor as a positive characteristic of the existing system. Nonetheless, the fact that recyclers, packers and civil society, which were classified as 'Players' and 'Context Setters' in the 'Power vs. Interest' matrix, appear to be considerably more disconnected than the remaining high power and high interest stakeholder groups, raises some alarm, specially due to the fact that if they are excluded from critical decision making processes, this could be leading to inherent, and unnecessary material losses. This disconnection can be better distinguished in the results for the actor degree centrality that are presented in Table 22.

Degree of Centrality

Since the data in this network involves directed ties, it is possible to distinguish between ties being sent and ties being received. The sum of connections from the actor to others is denominated as *out-degree* whilst the sum of connections coming from others to the actor is called *in-degree*. The funding institutions and other WMO stakeholder groups have no out-degree performances as it was not possible to interview any representative members. Still, interviewees were asked to reflect on how these two stakeholders share information with the remainder of the system and general opinion leads to think they have very poor out-degree performance. On the other hand, out-degree performance for the civil society did not derive directly from one interview, but from the expert opinion of the remainder interviewees on how waste producers actively communicate with the system.

*Table 22 - Degree of Centrality results*

| | Out-degree | In-degree | Normalized Out-degree | Normalized In-degree | Overall degree of centrality |
|---|---|---|---|---|---|
| PROs | 17.0 | 15.0 | 0.94 | 0.83 | 0.89 |
| UWMO | 15.0 | 12.0 | 0.83 | 0.67 | 0.75 |
| Gov. / Gov. Authorities | 13.0 | 11.0 | 0.72 | 0.61 | 0.67 |
| NGOs | 14.0 | 8.0 | 0.78 | 0.44 | 0.61 |
| Academia | 9.0 | 9.0 | 0.50 | 0.50 | 0.50 |
| Recyclers | 8.0 | 8.0 | 0.44 | 0.44 | 0.44 |
| Packers | 5.0 | 7.0 | 0.28 | 0.39 | 0.33 |
| Civil Society | 3.0 | 8.0 | 0.17 | 0.44 | 0.31 |
| Funding Institutions | - | 4.0 | 0.00 | 0.22 | 0.11 |
| Other UWMO | - | 2.0 | 0.00 | 0.11 | 0.06 |

*Out-degrees* provide data about the role that each actor plays as a “source” of information. Regarding this parameter it possible to split the stakeholder groups into three major sets:

- First set, comprises PROs, UWMO, NGOs and government/governmental authorities. Actors in this set may have higher potential to be influential. Good out-degree performance can reflect specialized and efficient departments for public relations;
- Second set, comprises academia and recyclers. These stakeholder groups “in the middle” have the potential to be influential if they are connected to the “right” other groups, otherwise they might have very little influence;
- Third set, comprises packers, other WMO, civil society and funding institutions. These stakeholder groups present the weakest out-degree performances and for that they may have lower potential to influence the remainder of the network.

On the other hand, *in-degrees* reflect how actors work as information receivers. Regarding in-degree results it is possible to state:

- UWMO, governmental authorities and PROs have highest in-degree performances. Actors which receive information from most sources may either be perceived as the most powerful, or they me considered as prestigious – other stakeholders may intent to have their activities and results recognized by these entities, so they send information;
- Civil society, recyclers and packers have relatively low in-degree performances., despite their high power;
- Lower power stakeholder groups, namely funding institutions, NGOs and other WMO have the worst in-degree performance, which may reinforce the fact that there is a relation between power and the role of information receiver.

When matching these results with the literature from SNA, overall analysis points out to the following subjects:

- The fact the majority of strong ties occur between the main high-power stakeholders might reflect a considerably centralized network. Although centralized networks are helpful for initial stages of building support for collective action, research suggests that centralized networks are also a disadvantage for long-term planning and problem solving (Olson et. al., 2004). Long-term goals in fact require more decentralized structures, with more ties between all stakeholders.
- Perhaps the most important conclusions to derive from SNA results is the different outcomes that 'strong' and 'weak' ties might produce:
    - Reed et. al (2009) state that there are several advantages deriving from strong ties, particularly in the environmental context. Stakeholder groups who share strong ties are more likely to influence one another, thus maintaining and promoting strong ties amongst diverse stakeholders can enhance mutual learning, and the sharing of resources and advice (Newman & Dale, 2005). In this supply chain valorization topic this is exceptionally relevant for the recyclers, PROs and UWMOs. The fact the first two stakeholder groups are classified as 'Players' and all three are the most directly involved in the operation and management of plastic waste material, might enable efficient information and resource sharing for adequate mobilization of the entire system towards improved valorization.
      However, as already mentioned, the benefits of these strong ties may be countered by the redundancy of information that is constantly shared between them.
    - In contrast, diverse information and new ideas have been shown to travel best through weak ties (Reed et al., 2009). Research shows that weak ties tend to occur mostly between dissimilar groups, and as such, offer stakeholders access to diverse pools of information and resources by engaging otherwise disconnected segments of the network. In this particular valorization topic, the intermediate results for the NGOs and Academia could actually be an advantage when effectively transmitting new technological developments and promoting new partnerships. Nonetheless, the potential drawback to weak ties is that they are easier to break.

Sections 5.1. to 5.4. presented substantial and extremely relevant data in regard to the valorization of plastic waste supply chains. Although each section presented methods and tools that complemented each other, allowing to translate interviewee knowledge and opinion into analysis prone explicit parameters, this same inter-connectiveness between the analysis methodology makes difficult to draw particular strategies from each of the analysis methods. For this reason, Section 5.5. will highlight the most important conclusions from each of the previous sections, and combine them for the development of strategic suggestions towards effective valorization of the plastic supply chain.

## 5.5. Developing Suggestions for Strategy Directions

So far, the results from web research and interview data were presented and a connection between each step of the methodology was made. Still, the complexity and amount of information from each of the analysis stage has not yet allowed to draw an overall picture for strategy development in this valorization context. One way of combining the main points that were drawn from the previous analysis is to perform a stakeholder-based SWOT analysis.

### 5.5.1. SWOT Analysis

SWOT analysis was applied to develop the strategic action plans for successful implementation of new initiatives for the valorization of the Portuguese plastic packaging waste supply chain, by systemically culminating the results for the previous sections on stakeholder analysis. The positioning of each of the relevant analysis factors was achieved by applying the worksheet from Chapter 4 to each of the categories that were identified by the 'Power vs. Interest' matrix.

The resulting SWOT analysis are presented through Tables 23 to 26.

The general goals of a SWOT analysis aim to maximize both strengths and opportunities, minimize the external threats, transform the identified weaknesses into strengths and to take advantage of opportunities along with minimizing both internal weaknesses and external threats (Saaty, 1987). When developing strategic plans within the sustainability subject, such as the case of this dissertation, including the already known Circular Economy tools and activities should enable a more holistic approach to the issues. Given so, during the next section, stakeholder categorization generic strategies are combined with suitable CE activities with the aim of pursuing the guidelines form the SWOT analysis.

*Table 23 - SWOT analysis for the Subjects category*

| | **Subjects** |
|---|---|
| Strengths | - UWMOs were classified as 'Key Supporters' in the valorization topic;<br>- Both UWMOs and NGOs had good SNA results, meaning they can have an important role as initial promoters; |
| Weaknesses | - UWMOs can reach 100% of the population. UWMOs have the most direct contact with civil society which means they could be the major promoters of improved disposal habits; |
| Opportunities | - UWMOs may not be able to improver material quality due to budgetary constraints;<br>- Some interviewees stated that disposal values payed to UWMO are still too low. Which means disposal via landfill or energy recovery is still very accessible, and even attractive in some cases; |
| Threats | - The introduction of reverse vending machines could compromise the financial sustainability of the SGRUs; |

*Table 24 - SWOT analysis for the Context Setters category*

| | **Context Setters** |
|---|---|
| Strengths | - There more and more initiatives from civil society niches towards improved practices in waste valorization; |
| Weaknesses | - Civil society was identified as a 'Strong (Moderate) Opponent'. Which means there is a very low possibility seeing this stakeholder group (as whole) actively mobilizing efforts towards the valorization topic, |
| Opportunities | - Increasing interest from the population in more sustainable habits. Including a trend of greater engagement in the source segregated disposal;<br>- Substantial margin from improving recycled material quality by only changing consumer habits; |
| Threats | - Civil society could show active opposition towards a valorization initiative that would require a greater effort from their side; |

*Table 25 - SWOT analysis for the Players category*

| | Players |
|---|---|
| Strengths | - There is increased pressure towards the packaging industry for introducing recycled materials during their production process;<br>- Recyclers have major financial motivation in the valorization topic;<br>- Both packers and recyclers were categorized as 'Key supporters' of the valorization topic;<br>- PROs SNA results suggested this stakeholder group could be highly influent amongst the system. |
| Weaknesses | - Recyclers claim the batches of material they acquire from the SGRUs do not have the best quality. Leading to high scarp rates with substantial costs associated;<br>- Some types of plastic waste material still require considerable resource effort and expertise. Which why they have negative bidding prices;<br>- The calculations supporting many of the values that are imposed by governmental authorities are not clear and lead to some dissent; |
| Opportunities | - Constant EU pressure on the packaging companies for implementing more sustainable measures. Including the use of recycled products in their production (e.g. Circular Plastics Alliance);<br>- Reverse vending machines are set to be introduced in 2021, which will enhance the quality of the recycled material;<br>- The fact that many of context setters- stakeholder groups have good SNA results could be helpful for initial stages of building support for collective action; |
| Threats | - The system is substantially conditioned by the recyclers. A relatively small number of licensed companies means less competition and higher bargaining power in the PRO auctions, which could be devaluating the prices of recycled plastic;<br>- Governmental authorities could be rather 'slow' in mobilizing resources towards improved valorization;<br>- Recycled products are still more expensive than the equivalent virgin material products;<br>- There is considerable hesitance regarding the introduction of a competitive PRO model. Several claims that it could be damaging the system; |

*Table 26 - SWOT analysis for the Crowd category*

| | Crowd |
|---|---|
| Strengths | - NGOs had good SNA results because they could act as effective mediators between these more peripheral stakeholder groups and the most centralized ones; |
| Weaknesses | - Many interviewees pointed to the fact that the unattractiveness of the recycling is mainly due to poor economic returns. The fact that funding institutions do not seem eager to actively mobilize resources towards valorization systems could be hampering potential-filled initiatives.<br>- It was not possible to identify any substantial benefits that a valorization of the system could bring to some of these stakeholder groups |
| Opportunities | - The majority of these stakeholder groups (other than NGOs) had poor SNA results. Still, SNA points out that the 'Crowd' stakeholders could be efficient promoters of new ideas. Which is particularly interesting in the case of the academia group has they have the potential of introducing new disruptive technology. |
| Threats | - Poor SNA results could be leading to these stakeholder groups not being included in critical decision-making processes |

### 5.5.2. Combining Generic Strategies with Circular Economy Activities

This section will present strategy suggestions for the valorization of the Portuguese plastic waste supply chain. It follows a cross-check of the generic strategies that derived from the already implemented stakeholder analysis with the benchmark solutions from CE activities that were presented during Chapter 3. The strategies regarding each stakeholder category are:

<u>Players</u> (Governmental Authorities; Packers; Recyclers; PROs)

Generic strategies state that there should be close collaboration with and amongst Players, as it is very likely for them to be the primary intended users of such valorization. Meaning they are often key stakeholders in prime position to affect or compromise this use, whether by using it themselves or affecting

how others use it. In this particular case, it might be an encouraging aspect that most of the stakeholders with higher power also hold great interest. Successful valorization is highly dependent on the existence of a coordinated work environment, in which Players work together to establish common objectives, prioritize the actions and effectively mobilize the needed resources. As so, proper supply chain valorization has to come by a coordinated approach that must involve governmental authorities, PROs, recyclers and packers. In addition, legislation and financial flow related measures to be enforced by governmental authorities should be developed next to each of the other stakeholder groups. This would erase the current 'black box' perception that many interviewees shared in regard to government policy developments.

Subjects (NGOs; UWMO)

Generic strategies mention it might be important to support and enhance Subject's capacity to be involved. Especially in cases when they are considerably vulnerable to changes in the subject of matter. In the case of UWMOs and NGOs, but UWMO particularly, since they already have a direct impact in the system, it is necessary that these stakeholders fully recognize their potential to increase their power and rightfully take part in the decision-making process. UWMO actions are still rather restricted by the actions of the PROs and the legislation from governmental authorities. Counterpart values, which are their main source of income, are inflicted by the government and the computations supporting these values seems to remain rather fuzzy. Also contributing to that constraining is the fact that outflow of their materials is fully assured by the PROs. Increasing UWMO can be achieved through greater symbioses / alliances with other, more powerful stakeholders. Thus, greater involvement of the SGRUs in the decisions process could lead to improvements in the system.

Context Setters (Civil Society)

Generic strategies on Context Setters highlight the importance of possibly increasing the interest of the stakeholders in this category, especially if they are likely to pose barriers through their disinterest. In the case of civil society, here as the main plastic waste producers, it is imperative to implement strategies that can increase this group's participation. UWMO and PROs could be the main promotors of this interest boost, due to the first being the stakeholder group with most direct contact with civil society and the latter having awareness-raising obligations.

Crowd (Academia; Other WMO; Funding / Financial Institutions)

Generic strategies state that these stakeholders may need to be informed about the related developments and findings. However, in case of poorly managed communication, controversy may quickly turn the more amorphous "crowd" into fierce opponents of the system. In this particular case, inner alliances and cooperation between 'Crowd' members could foresee the displacement of some stakeholder groups to other categories. The academia group, through research and development, could be responsible for technology enhancements in the recycling business. And, if supported by the resources of funding / financial institutions (or other, more powerful, stakeholder groups), could be able to effectively introduce their findings into the system.

The CE activities that could be implemented for sustaining these strategies are:

- Eco-design: there are some eco-design related policies already being implemented within the Portuguese waste management system. One clear example are the discount fees applied to packaging that complies with certain measures regarding the recyclability of the material. Still, eco-design policies could be extended and articulated between recyclers and packers to improve this recyclability. The fact that these two stakeholder groups do not share strong ties means PROs could be an effective mobilizer of this partnership. The associated advantages could be reduced scrap rates for the recyclers, improved material quality, ultimately resulting in extended applications for the recycled material and better overall valorization.
- Green Procurement: There should be active promotion within the whole system for the adoption of measures which improve their environmental sustainability. Green procurement should be particularly promoted within civil society, encouraging the use of recycling prone packaging and products made out of recycled materials.
- Recovery Economy: This could be the most important CE concept to be applicated to the Portuguese plastic packaging waste supply chain. One major practice to be implemented in relation to this concept would be the establishment of partnerships within the recovery system. The system still seems to move upon individual ambitions, with little regard to overall performance. For example, UWMOs demand higher financial compensation for improved performance, not bearing the potential additional costs to packers and consumers, which could ultimately have negative consequences in these groups' motivations to engage in greener practices. Other major aspect is to increase cross-sharing within the same stakeholder group. If PRO competition is considered to damage the system's performance, other collaborative alternatives should be considered. This is also applicable to recyclers, as there are already some recycling companies that engage in direct exchanges of unwanted scraps from the waste batches they acquire, but that can still be recycled by other recycling companies. Still, this could be performed in a larger scale through specific exchanging platforms that could even be associated to the existing PRO bidding system. The final practice associated with this CE activity would be to encourage better product recovery. Although reverse vending systems are already pending implementation, interviewees highlighted that these systems would only be applicable to some packaging types. In case of plastic material, the main target would be PET bottles. Given so, strategies should be developed to encourage the recovery of the remainder plastic types in order to boost consumer's responsibility and commitment towards proper return of products for the recovery process and superior material quality.

Finally, there is one other strategy direction that is not answered by CE practices, which is a reform in legislation. There were some aspects of legislation that interviewees pointed out to be hampering a better valorization of the system, including:

- Low competition between recycling companies. In order to participate in PRO auction, recycling companies must be licensed by the Portuguese environment agency. The relatively small number of current recyclers could suggest excessive legislation, complicating market penetration, or the need for subsidization policies in order to increase market attractiveness.
- Many interviewees stated that the majority of the government inflicted policies are conceived within 'black box' conditions. It seems that stakeholder groups are not being actively included in the policy developments that will affect them. This could have a dual-hampering effect in the valorization topic. The first is the fact that, not taking into account the opinion and expertise of the stakeholders affected by the policy, might damage their performance. On the other hand, this could lead to rather supportive stakeholders' groups manifesting resistance, disturbing relations and hindering the system as a whole.

## 5.6. Chapter Conclusions

This chapter presented the results that were obtained by implementing the proposed methodology for stakeholder analysis in the valorization of plastic waste supply chains. The results were analyzed according to three major stakeholder analysis procedures, each directed to different goals – stakeholder identification and analysis of the system's performance, stakeholder categorization, and relationship analysis. After presenting the results from each step of the stakeholder analysis, the results were combined through a SWOT worksheet and strategic plans were suggested with the help of CE practices.

Data input that sustained the results was collected through semi-structured interviews with some of the identified stakeholders. Although 32 identified stakeholders from all groups were invited to take part in the interviews, a relatively low response rate was obtained (25%). Still, the results were sufficient to conduct the entire analysis and the diversity of the samples enriched the study by providing considerably different points of view.

When analyzing the system's performance, the decrease in plastic waste recycling rates – 7% in 2017 (APA, 2019) – draw particular interest, and, although there is still no official data on the reasons behind the fall, it reinforced the pertinence of the supply chain valorization topic. Two major factors were accounted as the major performance disruptors throughout the system. The first being the introduction of a competitive PRO model in 2017, which brought significant changes to monetary and financial flows. And the second factor were the changes in Chinese import legislation on recycled waste, resulting in excess supply of some types of plastic waste throughout European countries. Both monetary and financial flows were characterized, and analysis also indicated that market values for the majority of recycled plastic waste have remained stable with the only significant changes happening for EPS and plastic film. In order to gain insight on how each stakeholder is and could affect the system's performance, it is imperative to understand how stakeholder groups perceive each other within this valorization context. For these reasons, a stakeholder categorization followed. The categorization process was achieved by inputting interview data in to a 'Power vs. Interest' matrix and a 'Support vs. Opposition' grid. The first is perhaps the most common stakeholder

analysis' tool and has proved to be extremely relevant in aggregating stakeholder groups into four major categories - 'Players', 'Subjects', 'Context Setters' or 'Crowd. The decision of complementing stakeholder categorization with the 'Support vs. Opposition' grid aimed to distinguish stakeholders which show interest on the subject and the ones who are actually likely to actively provide and mobilize resources towards successful valorization.

In addition to stakeholder categorization, adequate strategic formulation requires knowledge on the existing interactions within the system. Given so, this stakeholder analysis multimethodology was complemented by SNA. SNA results, in some way, downgraded the positive feedback from the stakeholder categorization, unveiling a more fragmented system as analysis unveiled the relatively poor results for network density. Although disclosing a rather more negative picture, SNA results were consistent with the ones from the categorization procedure, as most powerful stakeholder groups also displayed the best in and out-degree performances. PROs and UWMO were classified as probably the most influential amongst the network, and the more likely to be the best suited leaders in the valorization topic, while 'mid-table' stakeholders should be supplied of a transparent communication channel and included in the decision making process, as they could also play a relevant part in promoting new developments and technologies.

This multitude of results culminated with the need of connecting conclusions from each step of the analysis process through a SWOT worksheet. The analysis results were broken into strengths, weaknesses, opportunities and threats, with the aid of this worksheet. By matching outcomes of the SWOT analysis with the CE activities that were presented during Chapter 3 of this dissertation, it was possible to develop suggestions for the strategic directions that could promote the valorization of the plastic waste supply chain.

Ultimate results point towards the importance of stakeholders engaging in three major CE activities – Eco-design, Green Procurement and Recovery Economy – for achieving effective valorization of the plastic waste supply chain, which would include:

- Improved quality of the recycled material by addressing material sustainability across all stages of the supply chain, leading to a decrease in the system's inherent losses, wider applications for recycled material and better overall valuation of plastic waste;
- More efficient legislation, achieved by actively including more stakeholders during policy and regulation development;
- Better recycling rates and less plastic material being disposed via landfills or energy recovery.

It should be noticed that a significant part of these results derives from the interviewees' qualitative judgements that were collected throughout the interviews. With this, comes an associated risk of interviewees emphasizing and overestimating the weight and the magnitude of the facts that most affect their company's performance and its surrounding environment. The next and final chapter will shed some light over these limitations, providing some suggestions to overcome them, as well as some closing and concluding remarks.

# 6. Conclusions and Future Work

Plastics have become an integral part of contemporary societies. The unique mechanical properties of this material mean it is used in a wide range of applications, from the transportation sector to food packaging. Plastic production has grown exponentially over the last century, driving plastic waste generation to levels that no longer comply with planetary limitations. This has had significant environmental implications and led to numerous waste management initiatives and policy implementation with the aim of containing and reducing the damage of the associated negative externalities. Establishing ‘sustainability‘ and ‘sustainable development’ as some of the main topics of discussion and research during the twenty first century (Velis, 2015).

Waste management in Europe and Portugal, particularly, has involved complex and multi-faceted trade-offs among a plethora of technological alternatives, economic instruments and regulatory frameworks (Pires et al, 2015). One topic that prominently stands out, is how to improve the post-life product valorization, as the most direct way of coping with excessive waste material. But despite the efforts that have been mobilized and several potential-filled initiatives, plastic recycling rates in Portugal have experienced a significant downturn during the past couple of years. Which points to the fact that, in order to significantly improve the performance of the system, a more holistic approach to the issue is necessary.

This dissertation aims precisely to provide a complete and integrated analysis of plastic waste supply chains, in order to properly address a better valorization of the system as whole. After a comprehensive investigation, it was perceived that combining circular economy activities and stakeholder analysis tools would be an effective and valuable approach towards pursuing the abovementioned goals. The first, due the acknowledgement that it provides the benchmark solutions within the sustainability topic, and the latter due to the fact that waste management in Portugal comprises a multitude of actors, processes and policies.

Bearing a state-of-the-art review of the aforementioned concepts, a multimethodology stakeholder analysis was conducted for the plastic packaging waste supply chain. Initial analysis brought to light an overall decrease in performance that was attributed to two major factors – the introduction of a PRO competitive model and the Chinese import ban of nonindustrial plastic waste, which only reinforced the importance of the importance of proper valorization of the current system.

Stakeholder categorization tools pointed towards an overall positive picture, with most of the system’s ‘Players’ showing high levels of perceived support. One major aspect that stood out, was the considerable margin for improving plastic waste quality through actions across the several stages of the supply chain, emphasizing changes in the consumer and disposal habits for the civil society. On the other hand, SNA exposed a more fragilized system with relatively centralized information sharing, showing substantial room for improvement.

In order to better connect all the results from the mentioned analysis tools, results were arranged through a SWOT analysis that provided a much clearer and holistic perspective of the system and surrounding environment. Ultimately, it was possible to match the standardized results from the SWOT analysis with the CE activities that were reviewed during Chapter 3, to produce strategic suggestions that would promote better valorization across the supply chain. Of which, it is possible to highlight:

- Eco-design as one major tool for improving the quality of the waste material, reducing system losses, improving system performance, and expanding the market for recycled products:
- Green Procurement in all stages of the supply chain, with particular importance within the civil society stakeholder group. Which would also boost material recyclability and improved material quality across the several flows of the supply chain.
- Recovery economy practices with the aim of expanding partnerships and promoting material and information cross sharing.
- Legislation reform. Despite not being directly associated with any CE practice, actively involving more stakeholders during policy developments could lead to overall better functioning and avoid interest conflicts and resistance between stakeholder groups.

The suitability of these activities within the formulated strategy action plans, only reinforced the degree of significance that the CE concept endures when aiming effective approaches in sustainability contexts, especially in this particular case of the valorization of plastic waste supply chains.

Overall appraisal on the work that was developed during this dissertation, is that the project was able to deliver the initially proposed objectives with success. If a more critical point of view is adopted, the main highlight goes to the fact that a substantial share of results derives from individual opinions from interviews with relatively few system experts. Which means some judgements might be given an inadequate weight of accuracy and reliance. Still, with the aim of best mitigating that risk and carrying out an impartial investigation, a great effort was put in to achieving the best possible variety of interviewees. Additionally, responses were crossed-checked for overall consistency. Still, despite the effort, it should be highlighted that these results should not be taken as the absolute pillars surrounding the Portuguese plastic packaging waste supply chain, but as strong, plausible and supported evaluations of the system and the strategic plans that were drawn from these results which should point towards.

It is suggested that future work on the subject should have three major dimensions. The first dimension is to target the limitations of the current dissertation, that are mainly associated with the relatively small sample of interviewees. Conducting interviews of the same nature as the ones conducted during this dissertation with all identified might demand excessive resources and effort, so other approaches such as questionnaires should be considered as viable options for the stakeholder categorization stage. The second dimension is to possibly consider this dissertation as a framework for investigating in greater detail some of the factors that were pointed out, such as the efficiency of a PRO competitive model in Portugal,

strategies for engaging packers and civil society in recycling practices or evaluating the impact in performance of the implementation of reverse vending systems. Finally, it would be interesting to test this multimethodology for stakeholder analysis in other contexts.

Ultimately, regarding stakeholder analysis in plastic waste supply chains, recommendations are of complementing this work with the remainder of tools and methods that were presented during the literature review, with the aim of a more holistic analysis that can provide better specific strategies for the valorization, while uncovering any misjudgments or inadequate recommendations of this work.

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# Annexes

*Annex 1 - Table with SGRU list (Novo Verde, 2019)*

| SGRU | Population Served |
|---|---|
| ALGAR | 441699 |
| AMAESUL | 782246 |
| AMBILITAL | 111082 |
| AMBISOUSA | 333860 |
| AMCAL | 24184 |
| BRAVAL | 287278 |
| ECOLEZÍRIA | 124241 |
| ERSUC | 926772 |
| GESAMB | 145628 |
| LIPOR | 956359 |
| ECOBEIRÃO | 334924 |
| RESIALENTEJO | 90242 |
| RESÍDUOS DO NORDESTE | 134021 |
| RESIESTRELA | 189228 |
| RESINORTE | 924435 |
| RESITEJO | 200340 |
| RESULIMA | 313141 |
| SULDOURO | 439759 |
| TRATOLIXO | 849924 |
| VALORNOR | 252919 |
| VALORLIS | 301942 |
| VALORMINHO | 74039 |
| VALORSUL | 1586020 |

*Annex 2 - Interview timetable*

| | Group | Interview Date | Interview method | Duration |
|---|---|---|---|---|
| Interviewee A | Packers | 18/10 | Presential | 45 min. |
| Interviewee B | PRO | 24/10 | Presential | 1h15 min |
| Interviewee C | Recycler | 22/10 | Skype | 1h15 min |
| Interviewee D | Academia | 02/10 | Presential | 43 min |
| Interviewee E | NGOs | 08/10 | Skype | 55 min |
| Interviewee F | Government | 03/10 | Presential | 1h10 min |
| Interviewee G | SGRU | 07/10 | Skype | 1h10 |
| Interviewee H | Recycler | 10/10-22/10 | Email | *12 days |