Louvain School of Management

The implementation of a Deposit Return System (DRS) for refillable plastic bottles in Belgium – General guidelines

Author(s): Neige Mertens
Supervisor(s): Philippe Chevalier
The academic year 2022-2023
Dissertation for the Master 120 credit in Business Engineering with specialisation in International Business
Master subject and focus: supply chain

I would like to start by thanking my Master's thesis supervisor, Professor Philippe Chevalier, for taking me under his wing and giving me the freedom to work at my own pace, however long it might have taken.

I express my profound gratitude to the LSM coaching program, for their support.

I also want to thank Mr Santos for his time and privileged visit of his company.

Last but not least, I am also grateful for the support of my family and friends. Especially my mother, for helping me when I lacked inspiration and my friend Nicolas Thirion, for knowing exactly when to push me, encourage me, or give me space. I could not have had a better ally in this last year of university.

Abstract

This study investigates the complexities surrounding sustainable beverage packaging, with a focus on the entire life cycle of packaging materials. It explores the potential of Ref-PET (refillable plastic) bottles, and the environmental impact of reusable packaging production, considering its durability and proper management. By analysing the performance of reusable bottles in comparison to single-use options, the research highlights the need for exploring new materials and collection systems, given the prevalence of PET bottles in the beverage industry. The European Union's (EU) commitment to plastic reduction through recycling quotas and reusing packaging is examined, with Deposit Return Schemes (DRS) emerging as an efficient approach to achieving these goals. This study proposes the implementation of a Ref-PET DRS in Belgium as a viable means of reducing plastic waste. While acknowledging the challenges, such as high investments and consumer behaviour, this research suggests that Belgium's Eco-tax can serve as an incentive for investment in waste management. Drawing insights from successful Ref-PET strategies and DRS implementations in other countries, this study provides recommendations for overcoming country-specific obstacles and fostering stakeholder cooperation. Ultimately, this research aims to pave the way for the effective and sustainable integration of a Ref-PET DRS in Belgium's soft drinks packaging portfolio.

Table of Contents

1. List of abbreviations

CCEP: Coca-Cola Europacific Partners

DPG: Deutsche Pfandsystem GmbH

DRS: Deposit Return System, Deposit Refund System, Deposit Refund Scheme

LCA: Life Cycle Assessment

EU: European Union

EPR: Extended Producer Responsibility

PET: polyethylene terephthalate

Ref-PET: Reusable/Returnable/Refillable PET, refillable plastic bottle

rPET: Recyclable PET

SUP: Single-Use Plastic

TCCC: The Coca-Cola Company

WFD: Waste Framework Directive

2. Introduction

In the past, it was customary to use refillable bottles with a deposit. Once you finished the contents, you would return the empty bottles, which were then cleaned, refilled, and labelled anew before being put back on the market. However, starting from the 1970s, these refillable bottles started to be gradually replaced by PET bottles, which were intended for single use only (Plastic Soup Foundation, 2022). From there on, overconsumption of products in single-use packaging led to large amounts of waste, especially of packaging materials such as plastics, metal and glass (Görgun et al., 2021) and improper waste disposal of these materials poses environmental risks (Abejón et al., 2020).

Plastic waste is becoming a growing concern due to the annual world plastic production exceeding 380 million tonnes and increasing at a rate of 4% (Malindzakova et al., 2022). Among all sectors in the EU, the packaging industry consumes the highest percentage of plastics, amounting to 40.5% of total plastic consumption (Zhu et al., 2022) and 1,292 billion litres of packaged drinks consumed in 2020 (Görgun et al., 2021). These numbers translate the strong urgency to improve waste management systems.

To move away from waste generation, linear business models are being replaced by approaches that prioritize resource reuse, encouraging reverse logistics and closed-loop supply chains (Malindzakova et al., 2022). Implementing sustainable waste managements for all types of packaging is crucial to reduce the environmental impact and conserve raw materials in the production stage of packaging, but it also offers an opportunity to recover resources and energy from packaging waste in the final stage (Abejón et al., 2020).

However, plastic waste management is hindered by the complex global plastic material flow, diverse national waste management systems, and the absence of international recycling standards (Shamsuyeva & Endres, 2021). To address this, there is a growing shift towards adopting a circular plastic economy through Deposit Return Systems (DRS) within the European Union (Malindzakova et al., 2022). In fact, to increase the efficiency of waste management systems and facilitate recycling or reusing, many countries have decided to collect beverage packaging separately from other wastes (Görgun et al., 2021). In addition, the European Union has implemented various regulations and policies in waste management. The Waste Framework Directive 2018/851 sets targets for waste recycling, aiming for 55%, 60%, and 65% of municipal waste to be reused and recycled by 2025, 2030, and 2035, respectively (EU, 2018). Despite recycling efforts, 65% of PET bottles are still discarded after single-use, with only about 35% being recovered in Europe (Malindzakova et al., 2022).

Furthermore, considering that environmentally responsible actions are driven by principles rooted in personal values and a sense of social responsibility (Puigvert et al., 2020) and that Life Cycle Assessment (LCA) of packaging plays a critical role in determining its sustainability, as it influences around 80% of environmental impacts (Zhu et al., 2022), there are opportunities to look into new types of plastic packaging for beverages and their management system.

3. Methodology

This thesis is structured into four sections. The first section begins with a personal reflection on current packaging innovations. It explains the motivations behind selecting this subject and outlines the overall questions structuring this study.

The second section provides a critical review of the existing literature on beverage packaging Life Cycle Assessment (LCA), European Regulations on packaging, and Deposit Return Schemes (DRS) in Europe. While the review is nonexhaustive, it focuses on information relevant to the third section.

The third section aims to contribute to the societal and managerial development of beverage packaging in Belgium. We start by presenting Coca-Cola's latest innovation in packaging: the refillable plastic bottle and its implementation recommendation compared to other beverage packaging. We then dive into Germany's DRS to detect the success criterion of its DRS implementation. After that, we engage in analysing Belgium's waste management system for single-use PET beverage packaging and returnable glass bottle. Finally, we assess the learnings from these 3 analyses and provide last recommendations for a potential refillable plastic bottle DRS in Belgium.

Lastly, the fourth section concludes the thesis by reporting the key learnings and limitations encountered throughout this research.

(PART I: Research questions)

4. Problem and research questions

The European Union (EU) has placed increasing pressure on countries to improve the management of single-use plastic beverage packaging. This includes raising quotas for recycled plastic in new bottles, demanding higher collection rates for single-use plastic beverage packaging, and encouraging the adoption of reusable (also called refillable) alternatives when feasible. However, both companies and countries are facing challenges in meeting these sustainability targets.

Beverage companies are actively working on creating innovative solutions to meet the EU's requirements, in their product and their management. One of the new product innovations to reduce plastic waste is called the refillable plastic bottle, developed by The Coca-Cola Company (TCCC). While this packaging concept has found successful implementation in Germany, it is yet to be adopted in Belgium. Here are the Research Questions driving this study:

1. Which beverage packaging can be considered sustainable based on the whole life cycle? Understanding the environmental impact of different packaging types is essential to make informed decisions about sustainable alternatives.

2. Are Deposit Return Schemes (DRS) effective waste management solutions to meet the EU's requirements? What challenges do they pose in terms of management? Investigating the success and difficulties of implementing DRS will provide insights into their viability as a solution for sustainable packaging.

3. Would implementing a DRS model for refillable plastic bottles in Belgium be an appropriate improvement of the current waste management system? Exploring the potential for adopting a successful DRS model such as the German model will shed light on its adaptability to Belgium.

4. What are the main challenges associated with implementing a DRS for refillable plastic bottles in Belgium? Examining the specific obstacles in the Belgian context will provide crucial insights for a smooth and effective implementation process.

(PART II: Literature Review)

In this section, our main objective is to gain a deeper understanding of the environmental impact associated with various types of packaging and to explore the concept of a Deposit Return Scheme (DRS) through an extensive literature review.

5. Concept definitions

5.1 Waste management systems

Waste management systems have been developed to minimize the environmental consequences of waste and to reduce the consumption of natural resources (Malek et al., 2023). These systems are regulated by policies and follow a waste hierarchy, from the lower level of disposal to the higher level.

Linear waste managements like landfill and incineration represent the lower levels of this hierarchy (Malek et al., 2023). Before human recognition that natural resources are not infinite, they were the predominant methods used to dispose of waste and have had severe consequences on the environment.

Sustainable waste management systems aim to recover, treat, and recycle or reuse materials to reduce the environmental impact of waste and create value from the used materials, thereby avoiding landfilling or incineration (Puigvert et al., 2020). The higher levels of the waste management hierarchy have the ambition to move away from the linear disposal of waste toward a more circular approach. These higher levels are more environmentally friendly as they try to find ways for waste to have a good final impact.

5.2 The concept of circular economy

The circular economy is described as an economic system that emphasizes maintaining the value of products, materials, and resources within the economy for as long as possible, while minimizing waste generation (Malindzakova et al., 2022). It aims to transition from the traditional linear economic model of 'take-make-use-dispose' to create a closed loop where resources are used, reused, and recycled, generating additional value across multiple lifecycles (Abejón et al., 2020).

Waste management, materials and overall supply chain are elements to consider in achieving the circularity of a product. It must be supported by proper packaging design, production, and commercialization (Zhu et al., 2022).

5.3 Reverse logistics

Reverse logistics, or reverse supply chain, is a concept developed to transform used materials to regain value rather than disposing of them as waste, moving away from end-of-life products (Malindzakova et al., 2022). The materials are sorted into three categories; reuse, recycle, or dispose of adequately. It is a good instrument to reach economic and environmental goals (Agnusdei et al., 2022).

5.4 Types of bottles

Single-use plastic Bottle: Article 3 of the Directive (EU, 2019) provides the following definition for a single-use plastic product: “A product that is made wholly or partly from plastic and that is not conceived, designed or placed on the market to accomplish, within its life span, multiple trips or rotations by being returned to a producer for refill or re-used for the same purpose for which it was conceived”. In this work, single-use packaging and one-way packaging are used as synonyms.

Recyclable plastic Bottle (rPET): Single-use PET bottles that can be recycled if collected and sorted properly after use. The recycling process involves transforming PET material into new products, either partially or entirely made of recycled PET (Simon et al., 2016). There are different recycling approaches:

- Closed-loop recycling: The PET material is recycled into the same type of product without any loss of quality. This ensures a sustainable and continuous cycle of PET reuse.
- Open-loop recycling: The PET material is recycled into different types of products, expanding its usability, and reducing the demand for new raw materials.

- Down-cycling: The PET material is transformed into higher-value items, even though the resulting products might not be of the same quality as the original PET bottles.
- Up-cycling: Recycling PET results in the creation of lower-quality products but still offers a valuable way to repurpose the material and reduce waste.

Reusable/Returnable/Refillable plastic bottle: "A product that is made wholly or partly from plastic and that is conceived, designed or placed on the market to accomplish, within its life span, multiple trips or rotations by being returned to a producer for refill or re-used for the same purpose for which it was conceived" (EU, 2019). In the context of this work, reusable and refillable are used as synonyms. The same definition can be extended to glass bottles.

In this work, refillable plastic bottles, reusable plastic bottles, returnable plastic bottles, universal plastic bottles and Ref-PET bottles are considered synonyms.

6. Comparison of popular bottle packaging and their LCA

The objective of this section is to determine the advantages and limitations of recyclable and reusable beverage packaging based on the existing literature so that their characteristics could potentially be extended to refillable plastic bottles (ref-PET), under hypotheses, as there is little to no literature available on the latter. To do so, the focus is set on recyclable plastic bottles (rPET) and reusable glass bottles.

6.1 Implications of beverage packaging LCA

Life Cycle Assessments (LCA) can be used to assess the complete supply chain of beverage packaging, considering their entire life cycle from production to disposal. Indeed, when analysing packaging, it is crucial to consider it as part of a broader system rather than focusing solely on the product itself (Coelho et al., 2020). By evaluating the entire life cycle, including materials used, production processes, waste management, energy consumption, and water usage, LCA enables the identification of opportunities and threats, leading to solutions that reduce environmental impacts effectively (Agnusdei et al., 2022).

The environmental performance of packaging depends on various factors, such as the type of packaging (bottles, cups, crates, etc.) and the type of materials (plastic, glass, carton, etc.), but also process parameters (product design, transportation methods, types of materials used, the product's use phase, and its integration within the system) (Coelho et al., 2020). Depending on these factors, certain parameters may hold greater or lesser significance in determining the overall environmental impact of the packaging. While these factors serve as general guidelines to compare different types of beverage packaging, it is not possible to determine an overall "winner" material through a general LCA due to the numerous variables involved. Indeed, specific case studies are usually necessary to make informed decisions and design environmentally friendly beverage packaging systems (Simon et al., 2016).

Simon et al. (2016) has identified the four primary factors that play a significant role in determining the environmental impact of beverage packaging:

- The weight-to-volume ratio: the size of the packaging and its weight.
- The recyclability of materials: The recycled material content in new bottles.
- The collection ratio: the percentage of collected bottles in the case of one-way bottles influences the recycling ratio of used packaging.
- The type of reverse logistics: closed-loop recycling, open-loop recycling, down-cycling, or up-cycling.

And three additional factors specific to reusable/refillable bottles:

- The frequency of refills.
- The distance the bottles travel from the filler to the point-of-sale.
- The energy and water efficiency involved in the cleaning process of both the bottle and the crate.

6.2 Recyclables

In this section, recyclable glass and PET packaging are often compared to highlight the characteristics of PET bottles, to the extent that the knowledge can be associated or compared with ref-PET bottles further on.

Production

Studies have indicated that one-way PET bottles show the most favourable environmental performance in terms of production and usage than one-way glass bottles (Simon et al., 2016), primarily because the production of PET bottles typically requires less energy compared to the production of glass bottles.

Transportation

PET bottles are lighter than glass bottles, which results in reduced transportation-related energy consumption and lower greenhouse gas emissions during distribution. Additionally, PET bottles are less fragile than glass bottles, leading to lower breakage rates during transportation and handling (Simon et al., 2016).

Number of cycles

In this section, since single-use bottles cannot be reused or refilled, but instead must be recycled and remade into new products, we focus on the collection of packaging.

Regarding the collection ratio, a significant portion of PET plastic bottles is still discarded after a single use, with only about 35% being recovered in Europe despite recycling efforts (Malindzakova et al., 2022). While production is known to have the most significant environmental impact for beverage packaging (Simon et al., 2016), the importance of post-consumer bottle collection is crucial to affect positively the environmental performance of PET packaging.

The recycling rate of PET bottles is progressively increasing. In the EU, PET bottles used to contain around 10% recycled PET content (Simon et al., 2016). However, since 2018, the European Parliament has taken significant steps towards promoting recycling. The Waste Framework Directive 2018/851 has established ambitious targets for waste recycling, aiming to achieve 55%, 60%, and 65% recycling rates for municipal waste by 2025, 2030, and 2035, respectively (EU, 2018).

Product end of life

Among beverage packaging materials, glass and aluminium show the most promising performance in terms of recycling, followed by PET and carton. Glass is the material that can be recycled with the highest quality because the high-temperature recycling process sterilizes the materials, offering long-term advantages in closed-loop recycling. Indeed, PET's main disadvantage lies in the potential decline in the quality of secondary granulates after multiple recycling, although advanced technology can enable the production of excellent quality secondary PET (Simon et al., 2016).

In conclusion, one-way glass bottles are considered less environmentally beneficial than one-way PET beverage packaging option due to higher specific weight (material mass per packed volume) and increased energy consumption throughout their entire life cycle (Simon et al., 2016).

The literature confirms that, considering all factors, PET bottles are more environmentally friendly than recyclable glass in their production and transportation phases, though the importance of high collection rate of good quality post-consumer bottles and the percentage of rPET in new bottles both play important roles in the environmental performance of PET packaging.

6.3 Reusables/Refillables

In this section, reusables are limited to glass bottles which can be brought back to retail shops following a DRS. According to Coelho et al. (2020), production, transportation, maximum number of cycles, and product end-of-life are the four key parameters in assessing the environmental performance of reusable glass packaging.

Production

In the majority of cases, but especially for reusable packaging, the production phase was identified as the most negatively environmentally impactful stage in a package's life cycle. Indeed, glass packaging has higher greenhouse gas emissions compared to plastic packaging, because the process of extracting and processing the raw materials to make glass bottles has a considerable environmental impact, primarily due to the energy-intensive nature of glass production (Agnusdei et al., 2022). However, the higher quality and durability required for reusable packaging to withstand multiple cycles throughout its lifetime (Coelho et al., 2020), if properly managed, are able to compensate for this disadvantage if we look at emissions per packaging unit.

Transportation

Regarding transportation emissions, the use phase of the product was identified as the most impactful stage in the life cycle, with transportation distances, backhauling, weight, volume of the packaging, and mode of transport all playing interconnected roles in influencing the environmental impacts of transportation (Coelho et al., 2020).

Number of cycles

The number of refills creates a significant reduction in the environmental impact of this packaging type. Indeed, reusable glass bottles (Appendix 1), of any shape and volume, when reused at least five times, lead to over a third reduction in overall CO_2 emissions compared to single-use glass bottles (Coelho et al., 2020). In fact, refillable glass packaging can be reused up to fifty times, depending on market demands (Agnusdei et al., 2022). Therefore, increasing the number of cycles further decreases the environmental impact, reaching a gradual stabilization at a plateau.

The breakeven point, when reusable packaging becomes more efficient than other packaging, generally occurs after two or three cycles. In comparison with recyclable PET, and considering all other parameters, the reusable glass bottle becomes more environmentally preferable to the 0.5L single-use PET bottle after only three cycles, and the same happens after 25 cycles for the 2L format bottle (Coelho et al., 2020). During each cycle of the package, transportation and sanitization impacts remain constant, while the effects of production vary and influence the overall environmental impact.

Product end of life

If improperly discarded, the slow degradation of glass packaging poses significant environmental concerns. Indeed, discarded glass bottles contribute significantly to municipal waste in Europe and pose a major concern as only a few effective management channels for glass recycling and disposal are currently identified (Agnusdei et al., 2022).

6.4 Assessment

The production, collection methods and packaging material influence the bottle's life cycle environmental performance. LCA of packaging (Appendix 2) consistently indicate that reusable glass bottles outperform single-use bottles made of glass, PET, or aluminium when considering a certain number of cycles (Coelho et al., 2020). In addition, the prevalence of PET bottles as beverage packaging highlights the importance of exploring new packaging materials beyond PET bottles but also better collection systems. Indeed, encouraging consumers to engage in more selective collection is crucial. Various collection methods can facilitate consumer participation in selective waste disposal, leading to reduce environmental impacts (Simon et al., 2016). Further research into innovative packaging materials and effective collection strategies can contribute to more sustainable waste management practices.

The efficiency of the reverse logistics system also plays a role. Identifying the best bottle material or collecting procedure is challenging due to the numerous variables involved. However, it appears that the production phase of packaging has the most significant impact on a product life cycle, and recycling and reusing can significantly reduce this impact (Simon et al., 2016). Nevertheless, for the majority of reusable packaging, the production emissions become less relevant since the overall environmental impact is divided throughout the number of cycles in order to reflect the emissions per functional unit (Coelho et al., 2020). This highlights the importance of implementing Deposit Return Systems to encourage the collection and refilling or recycling of bottles.

7. European regulations on packaging

Plastic consumption is expected to double in the next two decades (Hailstone, 2023), urging the European Commission to take targeted actions to address sustainability challenges posed by plastic and to promote global efforts to combat plastic pollution. To achieve these goals, the EU is implementing various measures against single-use plastic products. These regulations focus on three aspects: usage reduction through consumer awareness campaigns and Extended Producer Responsibility (EPR), design requirements, and recycling quotas. Belgium, as a member state of the EU, is subject to these regulations and directives.

7.1 Main European Regulations

The main European regulations tackling those issues are:

- The Directive 94/62/EC of the European Parliament and of the Council of 20 December 1994 on packaging and packaging waste.
- The Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.
- The Directive 2018/851/EU of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.
- The Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.

Directive 94/62/EC (Packaging and Packaging Waste Directive):
(EU, 2008)
Directive 94/62/EC has been amended and revised over the years to strengthen its provisions and align them with new environmental goals. It was later replaced by Directive (EU) 2018/851-852, which sets higher recycling targets and aims to reduce the impact of packaging on the environment even further.

The Waste Framework Directive (WFD) (Directive 2008/98/EC and Directive 2018/851/EU, 2018/852/EU)
(EU, 2018)
The WFD has contributed to waste management by establishing the now standard waste hierarchy and by developing the concept of Extended Producer Responsibility.

- The waste hierarchy prioritizes waste prevention, reuse, and recycling over disposal methods such as incineration and landfilling. This means that it encourages the development and promotion of more sustainable alternatives to single-use plastic products, such as reusable products and materials that have a reduced environmental impact.
- The concept of Extended Producer Responsibility holds producers accountable for the environmental impact of their products throughout their life cycle, including after they

become waste. Beverage producers are responsible for collecting, recycling, and managing the waste generated from their packaging.

In addition, the Waste Framework Directive 2018/851 has established ambitious targets for waste recycling, aiming to achieve 55%, 60%, and 65% recycling rates for municipal waste by 2025, 2030, and 2035, respectively.

The Single-Use Plastics (SUP) Directive (Directive (EU) 2019/904)
(EU, 2019)
This legislation addresses the 10 most frequently found single-use plastic products polluting Europe. The primary goal is to achieve a reduction of over 50% in plastic waste across the EU for 10 common single-use items, including plastic bags, cups, and beverage bottles. Specifically, regarding beverage packaging, this directive imposes:

- Separate Collection Targets: The directive sets a collection target of 90% recycling for single-use plastic bottles by 2029 (with an intermediate target of 77% by 2025).
- Recycling Content Requirements: These bottles should contain at least 25% recycled plastic in their manufacturing by 2025 (for PET bottles), and 30% of recycled material by 2030 for all bottles.
- Design Requirements: To avoid separate waste of beverage packaging, plastic beverage bottles with caps and lids must be designed in a way that ensures that they remain attached to the packaging.

7.2 Emerging Regulations and other actions

Other actions plans and regulations also emerged such as

- The Circular Economy Action Plan (CEAP)
- The European Plastic Pact (2020)
- The latest European Commission's proposal for Regulation on Packaging and Packaging Waste
- The Union of European Soft Drinks Associations Vision

Circular Economy Action Plan (CEAP)

(EU, 2020)

The CEAP which is part of the broader European Green Deal has been adopted in March 2020 by the European Commission. This plan restates the goal of ensuring that all packaging becomes reusable or recyclable by 2030 in a financially feasible manner, reducing net greenhouse gas emissions by 55% by 2030 compared to 1990 levels. It urges the Commission to introduce a legislative proposal that incorporates waste reduction measures and targets. Additionally, it emphasizes the importance of implementing ambitious essential requirements within the Packaging and Packaging Waste Directive. These requirements aim to reduce excessive packaging, particularly in e-commerce, enhance recyclability, simplify packaging design, boost the use of recycled materials, eliminate hazardous substances, and encourage re-use practices.

European Plastic Pact (2020)

The European Plastic Pact, established in 2020, is a voluntary agreement signed by governments, businesses, and NGOs to promote a circular economy for plastics. It sets four main targets to achieve by 2025:

- Design 100% recyclable and reusable products where possible
- Used 20% less virgin plastic (by weight) with a 10% absolute reduction in plastic.
- Increase the collection, sorting and recycling capacity by at least 25%
- Use at least 30% of recycled plastics in new plastics.

New proposal (March 2023): Proposal for a regulation of the European Parliament and of the Council on packaging and packaging waste, amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and repealing Directive 94/62/EC

(EU, 2023)

If this new proposal is accepted, Member States of the EU will be asked to take new measures related to packaging waste and the reduction of single-use plastic products:

- Set Reuse and Refill Targets: By January 1, 2030, at least 10% of plastic packaging should be available in reusable packaging or by enabling refill. By January 1, 2040, this target should increase to 25%.
- Implement EPR: Member States must ensure that producers comply with the extended producer responsibility obligations, which includes covering the costs of waste

collection and litter cleanup. Members states must also encourage producer to educate consumer about the impacts of inappropriate disposal of single-use plastic waste.

- Establish Collection Systems: Member States should implement a DRS by 1st January 2029 for all single-use plastic and metal beverage containers up to 3 litres (excluding wine, spirits, and milk packaging). However, Member States can be exempted from this requirement if they can demonstrate recycling rates of at least 90% for the relevant materials in the two years before the regulation takes effect.
- Promote Recycling: Alongside collection efforts, Member States are required to promote the recycling of packaging waste that meets the quality standards for using recycled materials.
- Consumer Awareness: Member States must inform and educate consumers to reduce litter from single-use plastics and promote the use of reusable alternatives.

Union of European Soft Drinks Associations

(Unesda, 2022)

Unesda introduced its 2030 Vision for Circular Packaging, focusing on achieving full circularity of beverage packaging (plastic, aluminium, and glass) by 2030. Unesda's approach includes three pillars:

- Collect: Establish closed-loop beverage packaging collection and recycling systems to achieve at least 90% collection of all packaging by 2030 via DRS.
- Recycle: Use circular design packaging and increase the adoption of recycled PET to create PET bottles made from 100% recycled and/or renewable PET by 2030, whenever technically and economically feasible.
- Reduce: Reduce the amount of single-use packaging by increasing the use of refillable packaging by 2030 compared to 2020

Unesda’s vision is encouraged nationally by associated organisations. In Belgium, the national associate to this organisation is the Fédération des Industries des Eaux et des Boissons Rafraîchissantes (F.I.E.B), and companies such as Coca-Cola, Nestle, PepsiCo are members of this organisation.

8. Theoretical Analysis of Deposit Return Systems (DRS)

8.1 Introduction

The Deposit-Return System, also known as Deposit-Refund System or Deposit-Return Scheme is an effective management method for collecting recyclable or refillable packaging. This concept, developed by Bohm in 1981, is one of the predominant methods for packaging collection in the beverage sector and can be understood as a tax on potentially polluting packaging and a subsidy on its separate collection after consumption (Agnusdei et al., 2022). In other words, DRS requires consumers to pay a deposit value (fee) on beverage packaging, which is refunded upon returning the empty packaging to designated collection points (Görgun et al., 2021).

This system has received widespread public support as an effective tool for collecting large quantities of beverage packaging, promoting reuse, and achieving higher rates of quality recycling and recovery compared to other recycling programs, particularly when the deposit amount is set at an optimal level (Agnusdei et al., 2022). Naturally, DRS is not the only business model favouring circular economy, nor the only one respecting the EPR policies. Other systems such as refill on the go (in-store dispensing systems), return from home (service for packaging collection at home), return on the go (deposit return machines), and refill at home (refills delivered through a subscription service) also work towards packaging waste reduction and recycling (Shamsuyeva & Endres, 2021).

However, implementing a DRS requires significant resources, and its effectiveness in increasing recycling rates largely depends on public involvement and participation. The success of the DRS has been evident in countries like Finland, Denmark, Germany, and Norway, where recycling rates have increased (Roca i Puigvert & al, 2020). Once properly implemented, a DRS can reach up to 98% of collection rate (Görgun & al, 2021).

8.2 Benefits of DRS Implementation

The adoption of a DRS for recyclable or reusable bottle packaging creates many social, environmental, and economic benefits, and effectively promotes a more sustainable approach to packaging and waste management, benefiting both the environment and society.

First, DRS proves to be effective in increasing packaging collection and preventing it from ending up in the environment (Malindzakova et al., 2022), showing a decrease in landfill waste by 0.838 million tonnes of all kinds of material, on average, since the implementation of the DRS (Malek et al., 2023). However, it does not influence consumption frequency or subsequent waste generation (Agnusdei et al., 2022).

Consequently, on the long term it will reduce the need for mining activities to obtain virgin materials, as the required materials can be collected through the system without the necessity to import virgin materials (Görgun et al., 2021). Furthermore, the import rate of recyclable materials is expected to decrease due to the system's high return rates for used beverage containers (Görgun et al., 2021).

Secondly, it ensures more control over the quality of the collected bottles (Malindzakova et al., 2022). This system enables separate collection of beverage containers without mixing them with other waste. This prevents contamination, preserving their economic value for sale and reducing waste management service fees (Görgun et al., 2021).

Thirdly, it stimulates environmental awareness by inciting consumers to be more involved in the process as they have the responsibility of sorting recyclable materials (Malindzakova et al., 2022).

Furthermore, the adoption of EPR regulations, which hold producers accountable for all steps of their product's life cycle, is instrumental in addressing environmental concerns associated with end-of-life consumer goods (Özdemir-Akyıldırım, 2015). DRS, by operating as a reverse logistic system within the framework of EPR policies, holds producers responsible not only for the design, production, and marketing of their products but also for the post-consumer stage, including collection, recycling, and proper disposal (Malindzakova et al., 2022). Indeed, this system has gained global recognition for its effectiveness in achieving high recycling rates in over 40 countries worldwide (Görgun et al., 2021).

Finally, adopting a DRS is in line with six Sustainable Development Goals (SDGs) including Decent Work and Economic Growth (Goal 8), Industry, Innovation, and Infrastructure (Goal 9), Responsible Consumption and Production (Goal 12), Climate Action (Goal 13), Life Below Water (Goal 14), and Life on Land (Goal 15) (Görgun et al., 2021).

For these reasons, there has been a significant global growth of DRS in the last decade, with several new programs implemented or announced in various countries, including some in Europe (Agnusdei et al., 2022).

8.3 Types of DRS implemented across Europe

The standardization of DRS models is a relatively recent area of research in the literature. It is difficult to standardise as DRS can be implemented with different scopes, rules, stakeholders, deposit rates, and levels of flexibility and efficiency, depending on the specific context and objectives of the system (Malindzakova et al., 2022). To facilitate the understanding of a DRS implementation, here are some general characteristics or guidelines shaping this system.
Calabrese et al. (2021) is one of the pioneering researchers who have attempted to structure DRS models, which now serve as guidelines for implementing DRS systems in countries.

Throughout the analyses of implemented European DRS models for returned or recycled packaging, four DRS archetypes have been developed by Calabrese et al. (2021):

- the operator-closing mode,
- the retailer-closing mode,
- the producer-closing mode,
- and the consumer-closing mode.

These models (Figure 1) provide a clear view of how money and resources flow among the various stakeholders involved in this system, as well as the specific costs that they each bear, giving valuable insights into the economic dynamics of the DRS implementation.

By comparing the efficiency and effectiveness of these models with Belgium's current waste management methods, the study aims to identify the most suitable model for implementing a refillable plastic bottles DRS in Belgium, while also providing country-specific guidelines.

A. Operator-closing mode

The operator-closing mode is the most common model and appears to be an efficient and widely adopted DRS model in various European countries for managing glass packaging and promoting recycling, such as Denmark and Sweden.

Phases

In the initial phase, the retailer purchases the product and pays a deposit to the beverage producer. Subsequently, during the second phase, the client buys the beverage and includes the deposit as an added price paid to the retailer. Once the beverage is consumed, in the third phase, the client returns the empty bottle to the retailer and receives a refund of the deposit. Finally, in the fourth phase, the operator takes over and collects the empty packaging from the retailers, assuming responsibility for their resale or recycling. During this phase, the retailer receives the deposit reimbursement. The operator then handles the transportation of the empty packaging to the collection centres, completing the loop by properly disposing of them.
The DRS operator manages the empty packaging and deposits, while the producers finance the system. The DRS operator takes charge of transporting the empty packages to collection centres, where they are sorted and either resold, recycled, or disposed of properly, closing the loop of the process.

Financial Aspects

The financing of the DRS operator's collection and disposal of empty packaging comes from three sources:

- Handling revenues from producers based on the cost of managing the empty packages flow.
- Revenue generated from packaging sales.
- Unredeemed deposits.

Producers, who lack a direct revenue source, are required to cover the system's cost by paying a fee to the DRS operator. This fee encompasses the collection and disposal activities for each unit of marketed packaging and the management of deposits. Additionally, some countries impose an environmental tax (Eco-Tax) on producers, in addition to the handling fee, which fluctuates depending on the percentage of empty packaging collected.

Retailers bear the responsibility for collecting empty packaging, thus incurring related costs. These costs include activities like collecting empty packaging and preparing stores and personnel. However, part of these costs is offset by the handling revenue paid to retailers by the DRS operator.

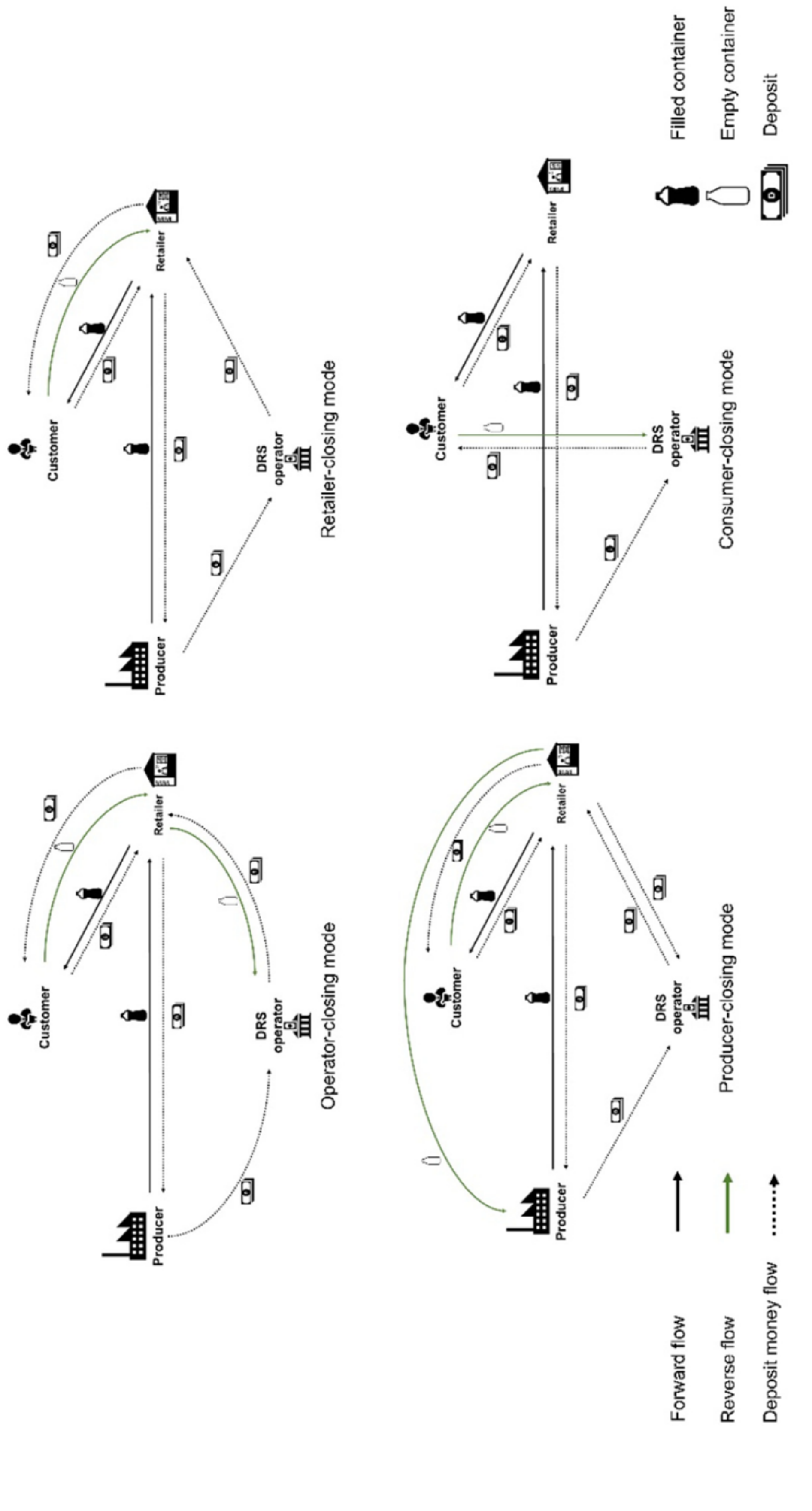


Figure 1: Schematisation of the four DRS archetypes (Agnusdei et al., 2022)

B. Retailer-closing mode

The retailer-closing mode is the adopted DRS model in Germany. It presents differences compared to the operator-closing mode in its process and in the cost and revenue distribution between stakeholders.

Phases

The phases are the same as the operator-closing mode, except for the last phase. Indeed, in operator-closing mode, empty packaging are taken by the DRS operator, while in the retailer-closing mode, they are managed by the retailers, who take on the responsibility for the transportation and disposal or resale.

Financial Aspects

The DRS operator is responsible for system design, while producers and retailers manage the deposits, which they can assign to an authorized firm by paying a fee.

Both retailers and producers actively participate in the collection, storage, transportation, disposal, and sale of empty bottles and both actors must pay an administrative fee to the DRS operator.

However, producers retain the unredeemed deposits and are exempt from paying a handling fee for managing empty packaging. Therefore, the majority of the costs are handled by the retailers, who have the responsibility of collecting and disposing or reselling the empty packaging. They face the risk of being unable to sell them. Retailers do not receive funds from the DRS operator to cover storage and disposal costs as they did in the previous model. To compensate for these expenses, retailers keep the revenues from selling the empty packaging.

C. Producer-closing mode

The producer-closing mode is the DRS model implemented in the Netherlands.

Phases

In the last phase, the producers retain ownership of the empty packaging instead of leaving them with the DRS operator or retailers. Therefore, in the final phase, it becomes the producers' responsibility to manage the collection, disposal, and resale of these packaging or to delegate these tasks to third parties.

Financial Aspects

In this model, retailers face the risk of losing this additional deposit if consumers fail to return the empty packaging. Indeed, retailers have to pay an additional deposit upon purchasing the product, which is not refunded to consumers during the purchase of a new beverage. This deposit is only reimbursed to retailers in the fourth phase when they return the empty packaging to the producers.
Consequently, retailers face the risk of losing this additional deposit if consumers fail to return the empty packaging. To compensate for the non-retrieved empty packaging, the producers get to keep the unredeemed deposit and the unredeemed surplus deposit.

The total costs for the retailer are the investments in collection systems and the storage area, as well as the personnel dedicated to handling the recovered packaging. and the Regarding the cost of collection, disposal, and resale, both producers and retailers share the burden.

D. Consumer-closing mode

The consumer-closing mode is the DRS model implemented in Iceland. The unique consumer-centric approach of the consumer-closing mode simplifies and optimizes the recycling system by directly involving consumers in the return of empty packaging. It reduces the steps and intermediaries involved in the process, making it more efficient and straightforward.

Phases

In this mode, customers directly return empty packaging to the collection and disposal departments of the DRS operator. Retailers are not involved in these operations, likely due to the country's geographical structure and population concentration.

Financial Aspects

The DRS operator manages deposit logistics and the disposal or resale of empty packaging and retains the revenue from selling empty packaging and unredeemed deposits. However, the DRS operator is relieved of the burden of transporting empty packaging from retailers to disposal or resale centres since consumers take care of this aspect.
The producers, on the other hand, pay a fee for the marketed packaging to cover its disposal or selling activities.
As for retailers, since they are not involved in the collection and disposal process, they have no costs or revenues associated with these aspects.

E. Overall performance of these models

These models were developed for increasing the packaging recycling and return rates in Europe and can inspire the structure of the Ref-PET bottle DRS in Belgium. In fact, the data analysed by Calabrese et al. (2021) reveals significant differences between countries with and without Deposit-Return Systems (DRS) regarding the percentage of returned and recycled packaging. Countries with DRS average 89.8% (operator-closing mode), 98% (retailer-closing mode), 95% (producer-closing mode), and 83% (consumer-closing mode) percentage of returned and recycled packaging, whereas countries using other waste management systems average 64%.

When comparing the systems, we observe that higher return rates are performed in systems where producers and retailers jointly bear the responsibility for empty packaging collection and disposal. However, when comparing the convenience of implementing DRS in different countries, researchers should also consider differences in shopping behaviour, population distribution, and commercial structures (Roca i Puigvert et al., 2020). Furthermore, to ensure a sustainable DRS, system efficiency plays a crucial role. Factors influencing system efficiency include the time required for DRS implementation, the balance between revenues and costs, and the technologies used during the investment and operation periods (Malindzakova et al., 2022).

8.4 Roles of stakeholders

Over time, many DRS systems have transitioned from voluntary to mandatory to increase recycling rates. Initially, voluntary systems were implemented due to lower production costs for new materials compared to collection and recycling costs. However, mandatory systems have been shown to achieve higher collection rates, especially for single-use beverage packaging (Malindzakova et al., 2022).

For the DRS to function optimally, a well-constituted governance structure is essential, with clearly defined responsibilities shared among stakeholders (Görgun et al., 2021). The monitoring and data recording of material and deposits (Figure 2) enable the tracking of transactions between participants, ensuring a fair distribution of costs and benefits based on each party's contribution to the system. (Malindzakova & Al, 2022). While management institutions or operators may vary across different countries or regions, The beverage packaging deposit-refund system is regulated either by the government, the beverage industry, or a combination of both (Zhou, 2020). Within the operator-closing mode, three actors play crucial roles in the return and recycling of beverage packaging:

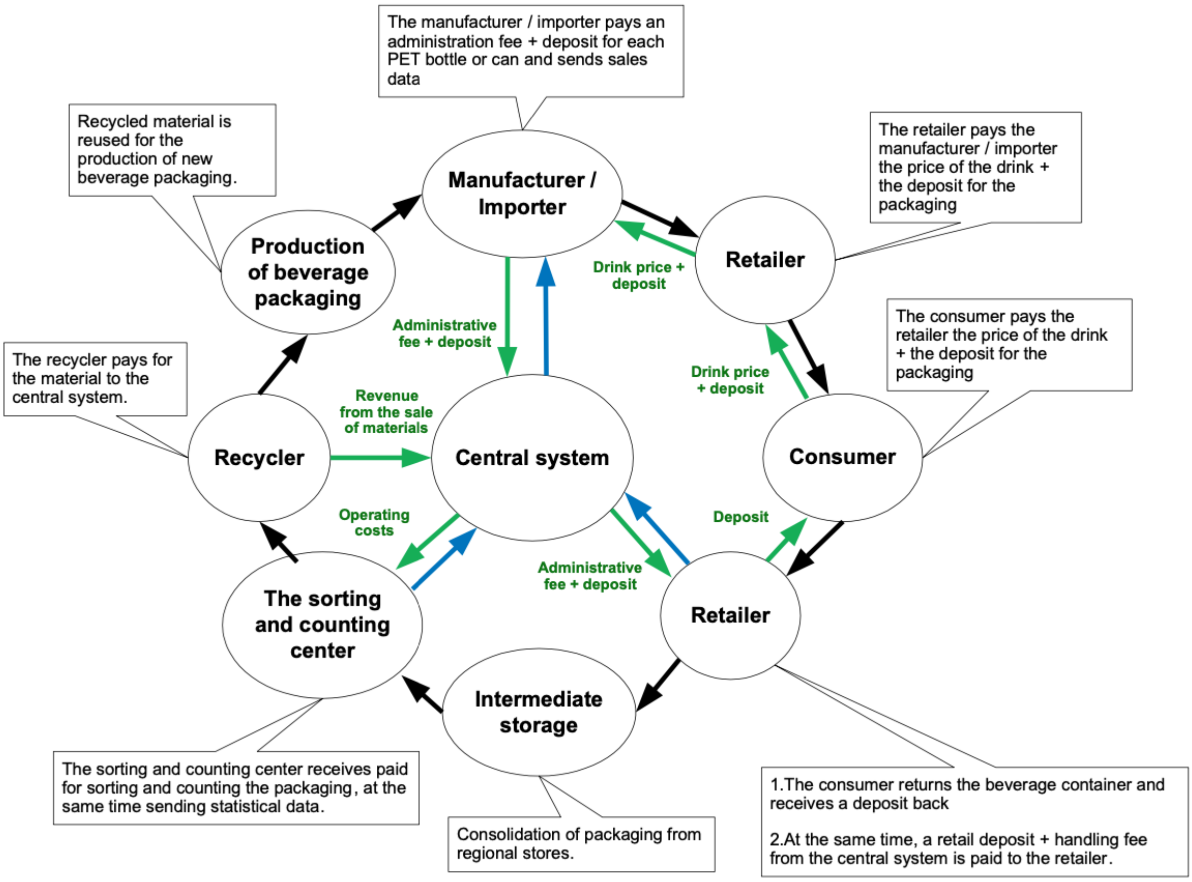


Figure 2: DRS system diagram (Malindzakova et al., 2022)

Producers

To establish and finance the DRS, producers must shoulder responsibilities and pay fees to ensure the system's smooth operation (Görgun et al., 2021). Their active involvement in the DRS is critical to achieving sustainable recycling or reusing outcomes and promoting a circular economy for beverage packaging They are responsible for designing packaging that complies with recycling or reusing standards and taking part in financing and managing the DRS.

Producers play a pivotal role in the success of the DRS as stakeholders under the Extended Producer Responsibility (EPR) policy. They bear significant responsibility, both financially and physically, for the treatment or disposal of post-consumer products (Görgun et al., 2021). Their active involvement is critical as they are responsible for designing packaging that complies with recycling standards and taking part in financing and managing the DRS to meet government-defined recycling targets (Görgun et al., 2021).

In countries with national regulations adhering to the EPR principles, producers have two options to fulfil their responsibilities. They can either set up their own system to collect packaging materials arising from their products or transfer these responsibilities to an authorized organization by paying a fee (Özdemir-Akyıldırım, 2015). On the other hand, if the DSR is implemented industry-wide, it restricts producers' control over their empty packaging and the management of the reverse logistics (Özdemir-Akyıldırım, 2015).

Another compelling reason for producers to participate in a DRS is the significant impact it can have on reducing the Tax on Natural Resources, also called the Eco-tax. The beverage producers are required to pay a tax on each package they produce, with products that have a negative impact on the environment being more heavily taxed. If the cost of participating in the refund system is less than or equal to the tax they pay, then producers have a financial incentive to embrace sustainable practices and participate in the DRS (Malindzakova et al., 2022).

Retailers

Retailers bear the responsibility of collecting the used packaging from consumers, in exchange for the refund of the deposit. The effectiveness of the DRS in achieving recycling targets largely depends on the rate at which consumers return their containers through retailers' operations. Retailers receive a handling fee from the producer to encourage them to allocate space for empty packages, act as intermediaries for deposit collection, and facilitate paybacks to customers (Özdemir-Akyıldırım, 2015). However, smaller retailers without sufficient space to manage returns may face challenges in accommodating this approach (Roca i Puigvert et al., 2020).

Regarding the collection method, beverage packaging can either be collected manually in retail shops or via reverse vending machines. Reusable glass bottles are kept intact, and recyclable PET bottles are crushed in large containers (Görgun et al., 2021). Both systems have the same end goal: increasing the collection rate of these empty packaging. The choice between these two systems therefore mainly depends on the preferences of the retail company.

Retail companies can also choose between two refund options. They can give the deposit value in cash, or they can offer a voucher of equal value, which can be used for another purchase within the same store (Görgun et al., 2021).

Consumers

Consumers have the autonomy to decide whether to return the empty packaging and reclaim the deposit. To encourage this behaviour, collection points are strategically located in retail outlets where consumers can conveniently return empty beverage containers to the store's cash register or make use of reverse vending machines (Malindzakova et al., 2022). Moreover, the possibility for consumers to return packages to any retailer has appeared to be an additional incentive to embrace this system (Roca i Puigvert et al., 2020).

The DRS involves two economic incentives: PULL and PUSH. The PULL incentive motivates consumers to engage in positive behaviour by keeping bottles and cans out of the environment (Malindzakova et al., 2022). This encouragement is aimed at redirecting packaging to recycling or reusing instead of other treatment methods (Malek et al., 2023). Fortunately, consumers are increasingly willing to spend more on environmentally sustainable packaging (Zhu et al., 2022).
The PUSH incentive encourages appropriate behaviour as consumers are motivated to return the packaging for a refund of their deposit value (Malindzakova et al., 2022). Indeed, consumers' involvement can greatly influence the effectiveness of a DRS. The motivation for consumers to achieve a higher return rate in the DRS lies in the opportunity to receive the deposit they initially paid. When consumers pay a deposit alongside the product price, they become more motivated to return empty containers to reclaim the deposit (Görgun et al., 2021).

Consumers have the responsibility to return packaging in proper condition. The DRS system requires returned packages to be in pretty good condition for recognition and refunding of the deposit. However, certain aspects of the DRS, such as asking consumers not to crush packages, may contradict existing habits (Roca i Puigvert et al., 2020).

Furthermore, the recycling behaviour is influenced by the perceived convenience of the system's different features. Factors such as the space required for recycling at home and the ease of waste separation and disposal play a crucial role in shaping citizens' attitudes and behaviours towards the proposed DRS. Socio-demographic variables such as age, gender, and education do not significantly influence recycling behaviour (Roca i Puigvert et al., 2020).

Considering the importance of consumer participation in the collection process, policymakers should focus on fostering their involvement through targeted policies (Simon et al., 2016). By addressing consumer concerns, motivations, and convenience, a DRS can effectively engage consumers as essential stakeholders in achieving sustainable recycling outcomes and promoting a circular economy for beverage packaging.

(PART III: Model Analysis and implementation)

In this section, we begin by introducing Coca-Cola's Ref-PET bottle and examining the factors that can contribute to its successful implementation in a DRS. Subsequently, we take a brief look at Germany's DRS, as it remains for the moment the only European country where Coca-Cola offers Ref-PET beverage packaging for its major brands. Moving forward, we dive into Belgium's waste management systems, focusing particularly on understanding its glass bottle DRS. Finally, leveraging the insights gained from the previous sections, we formulate hypotheses and offer recommendations for the successful implementation of Ref-PET bottle DRS in Belgium.

I chose to focus on implementing Ref-PET bottles in Belgium as a result of my internship experience at Coca-Cola Belgium. During my time at the Customer Collaboration and Innovation Centre, I was introduced to the concept of Ref-PET bottles and witnessed their successful implementation in Germany. This exposure ignited my interest in bringing this innovative packaging solution to Belgium, a sentiment shared by Coca-Cola's dedicated teams who were also eager to introduce it in the Belgian market. Working within the innovation centre gave me valuable insights into packaging innovation around Europe, and I also learned about the difficulties Coca-Cola encountered when trying to convince retailers to embrace new packaging idea.

9. Introduction to the refillable plastic bottle

9.1 The refillable plastic bottle

As part of its World Without Waste Strategy, Coca-Cola invested $25 million in 2018 to create a universal, refillable plastic bottle design (Figure 3) that can be used across multiple brands of Sparkling soft Drinks (SSD) (The Coca-Cola Company, 2019). The company initially introduced this bottle in retail shops in Brazil, investing $400 million in management centres so that the bottles can be recovered, cleaned, and refilled up to 25 times. As a result, all 2-litre bottles of Coca-Cola, Fanta, and Sprite in Brazil share the same colour, shape, and size, making collection, cleaning, and filling more efficient. The positive results from this implementation were so compelling that they implemented it throughout South America and recently decided to expand it to Europe, starting with Germany, the European leader in DRS management (Plastic Soup Foundation, 2022).

The company's ref-PET bottle is an example of upstream innovation, which means finding and fixing the problem at its source. Instead of dealing with waste later, the goal is to keep the packaging in use for as long as possible. In this context, the application of ref-PET bottles is limited to soft drinks and water, as these are currently the only products available in this packaging.

Refillable bottles are experiencing significant growth in various markets, with notable success in Germany and parts of Latin America where they outperform non-refillable alternatives (The Coca-Cola Company, 2022). However, Germany is currently the only EU member state to offer soft drinks in ref-PET packaging (Appendix 3). Nonetheless, with the few markets in which this universal bottle is implemented, the company's ref-PET bottles have successfully replaced 200 million non-refillable bottles annually. Refillable bottles, both glass and PET, play a vital role in Coca-Cola's sustainable strategy in various markets. In fact, the company has the goal to offer at least 25% of its brands in refillable and returnable glass or plastic bottles by 2030 (The Coca-Cola Company, 2019). However, the company has currently only reach 14% in 2022, which is 2% lower than their 2020 results (Oceana, 2023).

Businesses and consumers alike enjoy various benefits from the use of Universal Bottles, creating a positive impact on both the environment and customer loyalty. In Latin America, the adoption of Universal Bottles has significantly reduced plastic bottle production, producing 1.8 billion fewer bottles in Brazil in 2019. Compared to single-use PET bottles, the use of Universal Bottles reduces greenhouse gas emissions by an impressive 47% and water consumption by 45%, making it especially advantageous in water-stressed regions. The lower prices, coupled with a rewarding system for returning bottles, foster consumer loyalty, leading to a return rate above 90% and a 15% higher likelihood of repurchasing. Additionally, the implementation of a single bottle design across various brands streamlines logistics and storage, enabling Coca-Cola to cut costs, enhance efficiency, and offer consumers the flexibility to choose their preferred beverage. By envisioning a global adoption rate of 20% for refillable bottles, the plastic waste generation would be slashed by 39%, preventing 8.1 to 13.5 billion bottles from polluting our oceans (Ellen Macarthur Foundation, n.d.).

The Coca-Cola system is particularly well-developed for new product implementation. Indeed, although Coca-Cola is a global company, it operates on local levels by working with bottling companies (such as CCEP for most of Western Europe), which have national dedicate teams, making it easier for them to reach national recycling and reusability packaging targets. The company has set a target for 2030, aiming to collect and recycle a bottle or can for every one they sell. Their goal is to recycle 100% of the packaging they produce, which might result in giving each package more than one life. This initiative will aid in preventing their packaging from ending up in oceans and harming the environment. In 2019, they already managed to refill or recover around 60% of all the consumer packaging they introduced into the market worldwide (The Coca-Cola Company, 2019).

Figure 3: TCCC's Ref-PET plastic bottle (The Coca-Cola Company, 2019)

9.2 Factors influencing the success of a Ref-PET beverage packaging DRS implementation

This section draws from the PwC report (2022), which assesses the general economic implications for European countries if they were to develop a business model for Ref-PET carbonated soft drink bottles in retail shops.

In 2021, the sparkling soft drinks category represented 30% of the consummated non-alcoholic beverage in the EU, with 51% of those available in PET, 16% in glass and 33% in metal packaging (Unesda, 2022). Therefore, the sparkling soft drinks available in PET bottles account for 16% of the total PET bottles available for non-alcoholic beverages in the EU market.

The supply chain system for Ref-PET bottles is completely different from the recyclable single-use PET bottles. Significant changes are necessary throughout the product lifecycle for the bottle manufacturing, the bottling and used-bottles management processes, the distribution system, the retail layout & management logistics, and the recollection system (reserve logistics) to develop a Ref-PET DRS.

Adopting a Ref-PET DRS would align with the EU's plastic waste reduction requirements, as it offers both environmental and economic benefits by reducing the demand for single-use plastic beverage packaging. However, the coexistence of Ref-PET bottles alongside one-way PET bottles is necessary for two reasons. First, a complete replacement of single-use PET bottles would be too costly and operationally challenging. Secondly, the introduction of Ref-PET bottles in shops should be gradual and not an abrupt replacement for one-way PET bottles to ensure that consumers' shopping habits are not suddenly disrupted and allow for a smoother adoption of the new packaging option.

PwC reports the main factors influencing the success of a Ref-PET bottles DRS implementation. These factors should be considered in a country’s cost-benefit analysis, which will help countries decide if this system is worth implementing in their economy.

Costs and investments

Implementing a DRS Ref-PET will generate substantial implementation costs, and these expenses must be considered to determine whether implementing such a system is worthwhile compared to other alternatives, such as enhancing recycling methods, rates, and products.

Environmental impact

The shift to Ref-PET bottles is driven by the goal of attaining environmental benefits through reduced packaging waste and decreased demand for single-use PET. However, this transition poses challenges, in the additional transport to be recovered, the cleaning products and the water usage. To achieve a net environmental benefit, Ref-PET management centres should ideally be situated at a maximum distance of approximately 600 km from retailers.

Consumers buying habits

PwC assumes that a Ref-PET bottle DRS would on average report a 95% return rate. However, the barriers of consumer behaviour changes needed for Ref-PET bottles may be challenging to overcome, particularly with one-way PET as an alternative. Success relies on deposit return scheme design, pricing, and product characteristics, varying across markets and demographics.

Country specific differences

Countries with already implemented DRS for other packaging are more likely to achieve higher return rates, and the geography of the country also influences logistical costs as bigger countries will need more transportation or management centres to fulfil the market demands.

10. Case analysis: Germany's DRS

10.1. Ambitions for reusable packaging proportion in the beverage portfolio

Many European countries have decided to establish reuse targets, the standout example being Germany, which aims for an impressive 70% of beverage packaging to be reusable (Rethink Plastic alliance, 2023). This goal is in line with their current performance, as they have maintained a portfolio of 40% reusable packaging for several years.

In contrast, other countries with less structured waste collection systems have set smaller and more gradual targets. For instance, France, which does not use a DRS for packaging collection, has set its sights on reaching 5% of all packaging being reusable by 2023, with a subsequent goal of 10% by 2027. Similarly, Sweden aims to increase the proportion of reusable packaging by a modest 20% by 2026 and a slightly higher 30% by 2030 (Rethink Plastic alliance, 2023).

It is evident that these objectives pale in comparison to the ambitions of Germany, which stands out as a leader in waste management practices across Europe.

10.2. DRS

During the 1990s, the German government mandated that the market share of refillable packaging should reach 72% and that failure to meet this target would result in the imposition of a mandatory deposit on single-use beverage packaging (Kalkan, 2020). Since 2003, Germany has been using a mandatory deposit on one-way beverage packaging, making it necessary for consumers to pay a deposit when purchasing such items. The DRS in Germany is a legally enforced initiative designed to encourage recycling and responsible disposal of one-way beverage packaging (Zhou, 2020).

To align with Europe's directives on waste management, the German government enacted the German Packaging Act (VerpackG), which incorporates the provisions of the European Packaging Directive 94/62/EC into national law. As part of this legislation, product traders are required to take responsibility for actively participating in the recycling and appropriate disposal of their packaging materials (Ecosistant, 2021). By implementing the Packaging Act, Germany aims to foster a more sustainable approach to managing packaging waste and contribute to broader European efforts in environmental conservation.

German's DRS (Figure 4) was developed under the retailer-closing model, which means that most of the costs are handled by the retailers, who have the responsibility of collecting and disposing or reselling the empty packaging. They face the risk of getting stuck with used packaging if they cannot dispose of them. However, in the German system, the DPG is there to coordinate all the stakeholder interests and avoid this kind of issue. Consumers are motivated to return both single-use and reusable containers through a deposit system. For all single-use plastic bottles, aluminium cans, and glass bottles, the deposit rate is €0.25. However, reusable bottles carry a lower deposit rate, with €0.15 per plastic bottle and €0.08 per glass bottle (Bloomberg, n.d.). The German beverage packaging deposit-refund system has proven highly effective, with impressive recovery rates for bottles: 96% for standard packaging cans, and 98% for single-use plastic bottles (Zhou, 2020) and 98% for reusable glass bottles (Görgun et al., 2021). This indicates the successful promotion of beverage bottle recycling and reuse.
The Deutsche Pfandsystem GmbH (DPG) is the responsible institution for operating and managing the German beverage packaging deposit-refund system since 2005 (Zhou, 2020). DPG oversees the logistics and processes related to the deposit-refund system, ensuring that it functions smoothly and efficiently. In this system, beverage packaging are identified by two components: the DPG marking and the product number. Certified enterprises by DPG are responsible for label printing. Eco-advantageous packaging is exempt from the deposit-refund system.

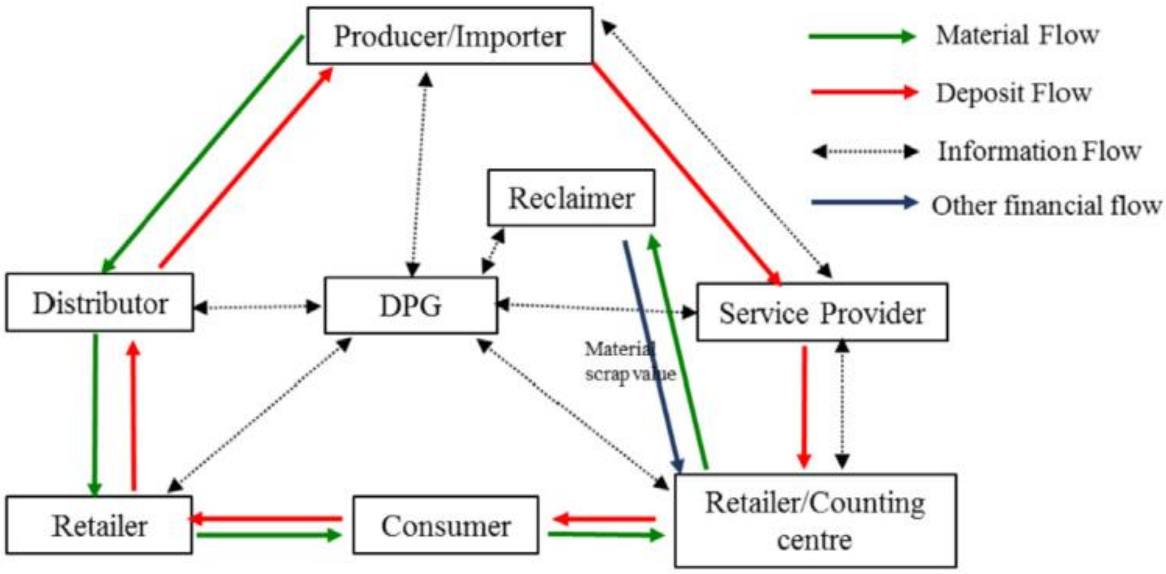


Figure 4: Operation mode of the Germany beverage packaging DRS (Zhou, 2020)

From Germany's DRS example, we learn that government serves as a crucial intermediary between beverage producers and formal recycling entities, by providing management standards, economic incentives, and guidance to recycling enterprises. Therefore, establishing a third-party institution, such as DPG, jointly formed by the government, producers, and consumers has proved to be effective. This institution should be independent of market competition and focus on coordinating recycling interests while acting as an efficient supervisor (Zhou, 2020). The management institution's key responsibilities are to harmonize stakeholder interests, offer guidance on supportive policies, and encourage participants to bear responsibility throughout the life cycle of the product. It plays a vital role in facilitating the regional deposit-refund system's effective functioning.

10.3. The Coca-Cola System's involvement in the German DRS

In Germany, thanks to the deposit system, Coca-Cola Europacific Partners (CCEP,) which is Coca-Cola's bottler for the west of Europe, ensures that all its packages, including PET, glass, tin, and aluminium, are either reused or recycled, making the pressure of the EPR easier to manage. Coca-Cola is currently the only beverage company to have developed the ref-PET packaging and implemented it in some markets around the world, with Germany being the only European country currently offering this packaging (The Coca-Cola Company, 2019). In recent years, CCEP has taken significant steps to minimize the environmental impact of its packaging in Germany. One notable action was the introduction of a uniform 1-litre refillable PET bottle design. By standardizing the bottle design across many of their products, Coca-Cola aimed to boost production capacity, enabling them to cater to a larger customer base.

Another essential initiative undertaken by CCEP its substantial investment in reusable bottling infrastructure. Over the last five years, the company invested around 250 million euros to meet the rising demand for refillable options. This investment reflects Coca-Cola's commitment to promoting sustainability and reducing single-use packaging waste. Looking ahead, they plan to invest an additional 100 million euros in 2023 to further expand their reusable packaging efforts (Coca-Cola Europacific Partners, 2023).

11. Belgium's current waste management systems

11.1 rPET bottles management

In Belgium, all three regions, Flanders, Wallonia, and Brussels-Capital, have implemented specific sorting systems for recycling and recovering waste. The main objective is to minimize the amount of waste ending up in landfills. However, Belgian waste management systems are difficult to standardise as they mostly follow regional guidelines and are specific to each municipality. Indeed, the management of municipal waste is primarily handled by 36 inter-municipal associations, which operate across different regions: 28 in Flanders, seven in Wallonia, and a single operator in Brussels-Capital (Ferreira, 2015).

Among the EU member states, Belgium stands as the only one not planning to introduce a DRS for single-use beverage packaging in the future (Appendix 4). The decision not to implement a DRS is based on the country's already good performance in collection and recycling rates of single-use beverage packaging. This decision is based on the country's already good performance in collection and recycling rates of single-use beverage packaging (Sensoneo, 2023). Recyclable waste is managed through selective waste collection systems for recyclable materials, as well as other waste under the responsibility of authorized organizations following an Extended Producer Responsibility (EPR) System.

Despite the absence of a DRS for single-use beverage packaging, Belgium's waste management system is remarkably efficient and stands out among European countries that do not employ DRS, showcasing the highest collection rate for recyclable goods (Unesda. 2022). Indeed, countries with DRS for PET bottles have high collection rates, ranging from 65% to 95%. In contrast, countries without DRS typically have lower collection rates, spanning from 22% to 73%, with the exception of Belgium, which achieves 85% collection rate for PET bottles (Appendix 5).

11.2 Reusable glass bottles management

However, companies like The Coca-Cola Company and beer manufacturers in Belgium have been using producer-closing mode DSR for reusable glass packaging for years. This choice is motivated by the convenience and cost efficiency of implementing their own system to align with packaging regulations. In addition, it grants them full control over the take-back network.

Surprisingly enough, the Belgian DRS is barely mentioned in the literature, and there is little online information on its functioning. Given our focus on ref-PET, analysing the waste management of reusable glass bottles in this country appears to be the most relevant comparison because of the similarities between those two products and their management.

Mr. Gumer Santos (2023, personal interview), Quality Manager for 23 years at the production and management centre of the Belgian beer company Trappistes de Rochefort (TdR), has kindly agreed to provide insights into how the Belgian DRS operates for this beer company.

TdR is a significant player in the Belgian beer industry, producing 18 million bottles annually, equivalent to 600,000 litres. We will analyse this system under the hypothesis that it is the standard model for Belgium’s returnable glass bottles.

Belgium has adopted a producer-closing mode DRS, where individual producers take responsibility for their own packaging, including the collection and management of reusable glass bottles. Reusable glass bottles do not have a standard bottle shape and often differ between brands. The management of reusable glass bottles would be incredibly simpler if all the reusable glass bottles were standard, but the shape of the bottle is an important factor in the beer industry's history. As a result, each beer brand is responsible for recovering its own bottles, leading big producers such as TdR to invest in their own management centres.

DRS systems are often criticized for excluding small players from their operations. However, one notable advantage in Belgium is that large Belgian producers who have their own management systems offer independent small producers the opportunity to utilize their system for their bottles, in exchange for some financial participation. This inclusive approach empowers smaller producers to contribute to the EU's sustainable target.

The DRS for reusable glass bottles of this company was modelled via a Business Process Model and Notation (BPMN) (Figure 5).

Production

TdR's production involves using crates of 24 bottles of 33 cl. The glass bottles and crates are bought from a manufacturer in the Netherlands. They are then filled in the management centre alongside recovered bottles. This company has 50% of the production allocated for Belgium's domestic market and the remaining 50% for exportation to other countries. Therefore, already 50% of exported bottles, which amounts to 9 M bottles and around 375.000 crates, are not recovered to be refilled. Intuitively, the production process involves filling new bottles for one week and filling recovered bottles every other week.

Transportation

The transportation system of TdR is designed for efficient and cost-effective beer distribution. On a palette, they stack 7 levels of crates, each level containing 9 crates, resulting in a total of 63 crates or 1512 bottles per palette. With between 10 to 15 truck delivery per week, carrying 27 palettes each, they ensure the total distribution of their beer in the country.

To avoid unnecessary transportation, the company adopts a clever strategy. When delivering the empty bottles crates back to the management centre, they simultaneously collect newly filled crates of bottles, ensuring that each trip back to the retailer is not wasted. This optimizes the use of available space and resources during transportation.

TdR does not manage the transportation of its goods but rather works with beer distributors (in TdR's case the companies Maziers and Monceau) who serve as intermediaries between the producer and the retailers. This aspect is particularly crucial because the system operates under a producer-closing Deposit Refund System (DRS). In this setup, producers must reclaim their deposits by recovering the bottles and crates used for packaging. If any bottle or crate is not properly recovered, the producer loses their deposit, emphasizing the importance of efficient transportation and return logistics to maintain the sustainability and profitability of the system.

Journey in the management centre (Appendix 6)

Once the empty bottles are recovered, they start their journey towards being refilled, alongside new bottles. To do so, the bottles and the crates have to go through a significant number of safety standards steps. The first step is to set the palettes on the "depalletizer" machine (1), so the full crates can be put on a treadmill. After this, the full crates go through the "crate erector" machine (2), in which the bottles are separated from the crates. The crates then go on the "crate washer" machine (3), while the bottles are analysed in the "inspector" machine (4), which rejects all non-compliant bottles that don't have the right shape or size. These non-compliant bottles are put in big containers to later be recycled by an external company. The next step for the bottle is to go through the "bottle washer" machine (5) to be deeply cleaned with water and a mix of cleaning products. In the weeks when they only fill up new bottles, these bottles start their journey in the "bottle cleaner" machine (6). The rest of the journey is the same for new and recovered bottles. After machines (5) or (6), the bottles go through the "quality inspector" machine (7), another step to ensure bottles are not broken or dirty. This machine rejects nonconform bottles which will be recycled thereafter. The cleaning machines (4), (5), and (7) are designed to use water and cleaning products efficiently, avoiding unnecessary wastage. Once the quality of the bottles has been acknowledged, they are filled with beer and capped in the "filling and capping" machine (8), followed by the "bottle dryer" (9). Finally, the "labelling" machine (10) adds the label and expiry date on the bottles, which are then put back into the clean crates via the "crate packer" machine (11), 24 at a time.

End of use

According to Mr Santos' knowledge, beer bottles at TdR have an average lifetime of 7 cycles.

The rejected bottles from machines (3) and (6), in addition to the non-recovered bottles at retail shops, represent the total amount of bottles that will not be recovered, which is about 10000 bottles per week, so 520 K bottles per year. Considering this, since 4.5 million TdR bottles are filled every year for Belgium's domestic market, the recovery rate of reusable bottles is around 88,4%. Therefore, the non-recovery rate is 11,6%. This number includes bottles not returned to the supermarkets, bottles not conformed to the brand's bottle and damaged bottles.

Investment for the producer

The machines used for this purpose, in this case of the brand Krones, come with a significant cost ranging from 200 K to 300 K€ each. Since 11 machines are needed in this management system, the average total investment in machinery for this centre is 2,75 M€. However, these machines are valuable assets as they last for 15 to 20 years, guaranteeing a long-term return on investment. While the machines are highly automated, continuous monitoring and oversight are essential to maintain their optimal performance.

In the context of Belgium's DRS, the biggest motivation for beverage producers to invest in reusable bottles lies in the Belgian Eco-tax incentive. The reduction of the eco-tax for using sustainable packaging amounts to approximately 300 K€ per year. This plays a crucial role in making the management of reusable bottles financially viable for TdR. Without the Eco-tax, the costs associated with human management, time, cleaning materials, machinery, and water usage would likely outweigh the financial benefits, making the investment unprofitable.

This system proves to be even more financially beneficial for small beers companies, which did not have to invest in this system, but still get to use it against a small financial compensation and in addition benefit of the whole eco-tax reduction.

Cost and Deposit

The price of a buying a new bottle to the manufacturer is 0.1€, and between 5€ and 6€ for a new crate. When selling the finished good to the retailers, in addition to the selling price, the cost of the deposit per bottle is 0.1€, while the crate deposit amounts to 2.4€. Therefore, the total deposit for a crate along with 24 beers is 4.5€.

Since the price of a new bottle is the same as the deposit for said bottles, the incentive of recovering packaging is more related to recovering crates, as they are more expensive than their deposit fee. Fortunately, the return rate for the crates is nearly 100%.

Retailers

Regarding Retailers in Belgium, we observe two distinct models for the recollection of empty reusable glass bottles. Some retailers, such as Delhaize and Spar, opt for the use of reverse vending machines, while others, like Colruyt, prefer manual collection methods (Appendix 7).

In specific cases, certain retailers like Spar and Lidl may not offer a return option for empty bottles due to their limited space (Appendix 8). As a result, they tend to prioritize single-use packaging and offer a limited selection of returnable glass bottles in their product portfolio. Nevertheless, this limitation does not seem to hinder bottle recovery, as customers have the convenience of returning used bottles to any accepting retailer, regardless of where they were originally purchased. In fact, this approach serves as an incentive for consumers to visit shops that facilitate bottle returns.

Belgian retailers accept various types of beverage packaging in their supermarkets, depending on their consumer's segment. All supermarkets offer SSD in both cans and single-use PET bottles, which currently hold the top position as the most popular packaging choices for SSD products. Additionally, some supermarkets provide Coca-Cola's main products, such as Coke Zero and Coke Original, in either 24 x 20 cl crates or 6 x 1 L crates (Appendix 9). Returnable glass bottles for SSD are currently only available in crates. When it comes to beer glass bottles, retailers have the flexibility to offer them in crates, smaller packs, or even individually, providing consumers with multiple options for their preferences.

Contrary to what the literature states, in TdR's producer-closing DSR, there is no additional deposit paid by the retailer to the producer when acquiring the product. In other words, the retailer only pays the price of the finished good and the deposit fee of 4.5€ per crate, which he recuperates once he returns the empty packaging to the producers.

If the consumer does not return the empty packaging, the retailer incurs no loss because the deposit was already paid by the consumer upon purchase. In such cases, the consumer does not receive the 4.5€ deposit back, and the producer loses between 2.6€ and 3.6€ per crate that remains unreturned.

In conclusion, TdR's DRS is in line with what the literature review in this work exposed. Therefore, we can use this example to model our implementation or ref-PET in Belgium.

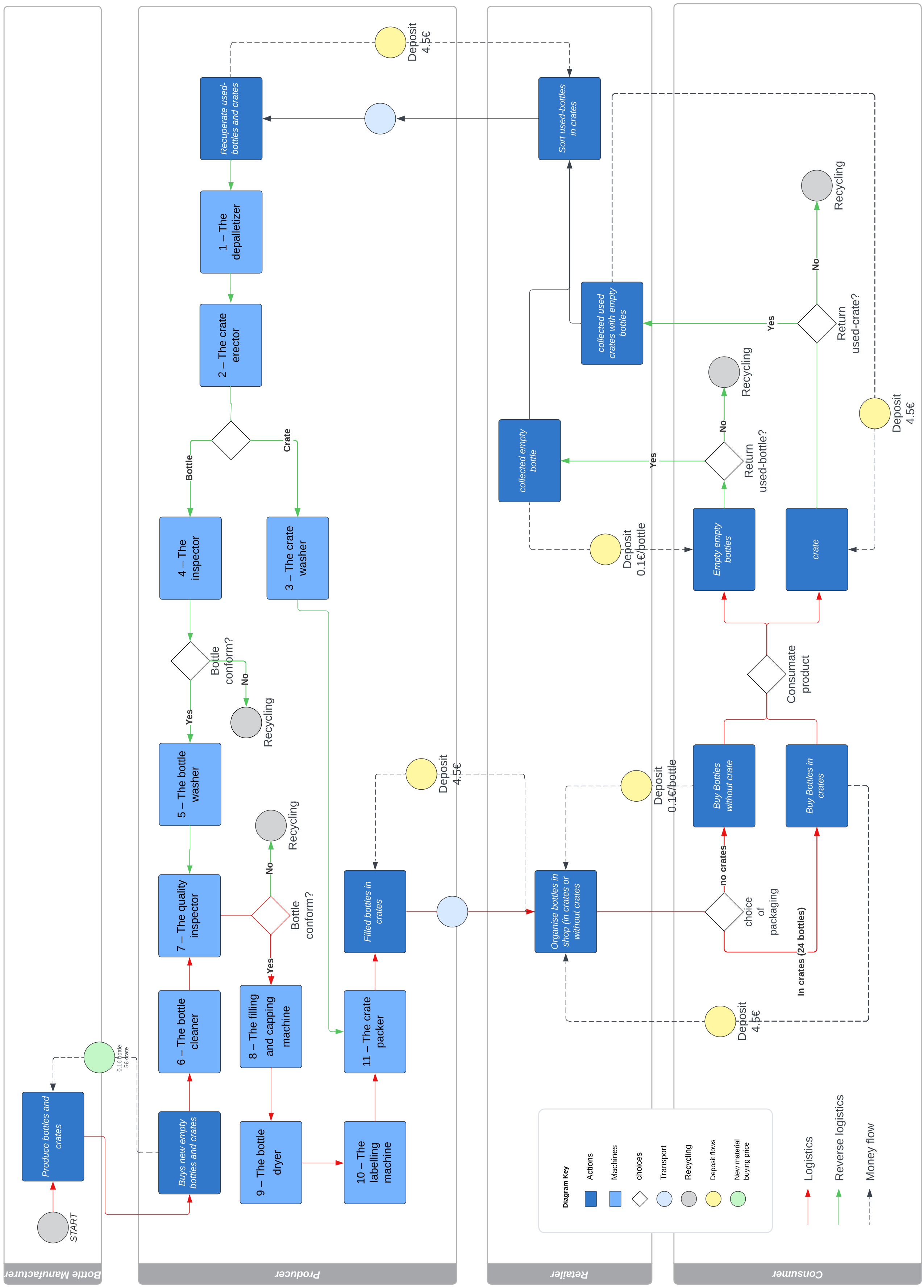


Figure 5: BPMN Diagram of DRS flows in Belgium.

12. Recommendations for the implementation of a DRS for refillable plastic bottles in Belgium

In this section, we offer guidelines for the implementation of a DRS process for ref-PET, based on assumptions derived from analysing the literature on DRS, studying Coca-Cola's strategy for Ref-PET, the Ref-PET DRS implementation in Germany, and Belgium's current reusable glass DRS. By drawing insights from these case studies, we aim to develop a practical and effective approach for introducing the ref-PET DRS system in Belgium. These recommendations consider the successes and challenges observed in similar initiatives and provide valuable guidelines for ensuring a smooth and sustainable implementation of the ref-PET DRS in the context of Belgium's waste management system.

12.1. Assumptions

Assumption 1: The sorting, cleaning, and filling of Ref-PET follows a similar management to the reusable glass bottle management.

Assumption 2: Belgium's smaller size mitigates the transportation impact to some extent, and in any case the 25-cycle lifetime of Ref-PET bottles largely compensates for the environmental impact of water and cleaning products in the management centres.

Assumption 3: Belgian consumers are already well-adapted to the glass bottle DRS, which may ease their adaptation to another product with a deposit and a requirement to be returned to retailers.

Assumption 4: Considering Coca-Cola’s investments in Brazil and Germany for the implementation of a Ref-PET DRS, a similar investment for a Ref-PET DRS in Belgium is to be expected, facilitating the retailer’s adaptation to this new product.

Assumption 5: This model can be extended to other brands and other products in the soft drink industry.

Assumption 6: Considering the refillable targets, one production and management centre are enough per producer, to start.

Assumption 7: Ref-PET bottles are sold in crates, or individually, to the liking of the retailer.

Assumption 8: To simplify the model, only 1L bottles in 6-bottle crates are considered.

Assumption 9: The Ref-PET DRS follows a producer-closing loop, like Belgium's current reusable glass bottle DRS.

12.2. Key investments and operational changes

The logistics and reverse logistics for Ref-PET bottles require a completely new setup to bring and return empty bottles and crates from retailers back to the producer.

Producer

- New investment in bottle manufacturing machines is required because Ref-PET bottles are thicker and up to 2x heavier than one-way bottles.
- Increase production of crates
- New investment in bottle sorting, cleaning and filling machines is required because they differ from current glass management centres and are not required for single use PET
- Investment in a new site for this management centre is needed.
- Ref-PET's distribution logistics require more space, trips, trucks, fuel, and labour due to the larger size and weight of bottles and crates.
- The heavier weight and space of Ref-PET bottles requires more vehicles for transportation.

Retailers

- Retailers need extra space to store Ref-PET bottles and extra labour for sorting bottles and crates for selling and for recollection.
- Retailers need to install reverse vending machines that can handle Ref-PET bottles and crates.

12.3. Conclusion

Implementing a ref-PET DRS in Belgium comes with several main challenges that need to be carefully addressed:

First, there are high investments required for establishing the necessary machinery and management centres for efficient operation. However, the presence of Belgium's Eco-tax serves as a valuable incentive, encouraging businesses and stakeholders to invest in this type of waste management.

Secondly, another challenge involves consumers' buying habits, as transitioning to a new system can be difficult. However, Belgian consumers are already well-adapted to the glass bottle DRS, which may ease their adaptation to another product with a deposit and a requirement to be returned to retailers.

Lastly, addressing the country-specific waste management infrastructure, consumer behaviours, and regulatory frameworks is crucial for overcoming unique obstacles and ensuring the successful implementation of the ref-PET DRS in Belgium. Tackling these challenges requires careful planning, stakeholder cooperation, and targeted measures to ensure the effectiveness and sustainability of a ref-PET DRS in Belgium.

(PART IV: Learnings and limits)

13. Conclusion and learnings

Determining the most sustainable beverage packaging based on the whole life cycle is complex due to various factors. Ref-PET is promising but faces challenges in closed-loop recycling. Reusable packaging's production phase has the highest impact, but durability and proper management can offset it. Reusable bottles generally outperform single-use options after 2-3 cycles. Still, the prevalence of PET bottles in the soft drink industry calls for exploring new materials and better collection systems.

The European Union (EU) currently prioritizes plastic reduction through increased recycling quotas or reusing packaging. DRS have shown efficiency in achieving these goals. DRS benefits include high collection rates, reduced need for virgin materials, better control over collected bottle quality, increased environmental awareness, and alignment with Sustainable Development Goals. DRS have experienced substantial global growth in the past decade, with numerous new programs implemented worldwide, including in Europe. To ensure optimal functioning, a well-constituted governance structure with clearly defined responsibilities among stakeholders is crucial for DRS implementation.

For single-use plastic bottles, Belgium does not plan to introduce a DRS, given its already good performance in collection and recycling rates for such packaging. On the other hand, adopting a Ref-PET DRS would align with the EU's plastic waste reduction requirements and offer environmental and economic benefits by reducing the demand for single-use plastic beverage packaging. However, it is necessary to have the coexistence of Ref-PET bottles alongside one-way PET bottles for cost and operational reasons. The introduction of Ref-PET bottles in shops should be gradual to avoid sudden disruptions in consumers' shopping habits and ensure a smoother adoption of the new packaging option.

Establishing a Ref-PET Deposit Return Scheme (DRS) in Belgium faces challenges like high investments, consumer behavior changes, and addressing waste management infrastructure. The Eco-tax serves as an incentive for investments, while consumers' familiarity with glass bottle DRS may aid the transition. Despite environmental impacts like additional transport and cleaning products, the 25-cycle Ref-PET bottle lifespan compensates. Overcoming these hurdles demands careful planning, stakeholder cooperation, and targeted measures to ensure a successful and sustainable Ref-PET DRS implementation in Belgium.

14. Limits

One of the main challenges we encountered in this study is the limited access to essential information for conducting a comprehensive cost-benefit analysis specifically tailored to Belgium. This restriction significantly hampers our ability to thoroughly assess the financial implications of introducing the Ref-PET DRS in the country. To overcome this limitation, future research should focus on gathering more data and collaborating with relevant stakeholders to gain a more precise understanding of the potential financial benefits and drawbacks associated with the Ref-PET DRS implementation in Belgium.

Additionally, the evaluation of Belgium's return rate for reusable glass bottles does not account for the exportation of products, potentially leading to an incomplete understanding of the system's sustainability.

Lastly, another limitation in this work arises from the assumption that a DRS for Ref-PET bottles in Belgium would be similar to Belgium's existing DRS for reusable glass bottles. This assumption introduces a degree of uncertainty in the analysis, as the two systems may not necessarily align perfectly in terms of logistics, consumer behaviour, and operational complexities. Therefore, while the Ref-PET DRS offers potential benefits, we must acknowledge that the actual implementation and outcomes might deviate from those observed in the current reusable glass bottle DRS. When interpreting the results and recommendations, exercising caution is vital to present a realistic and accurate portrayal of the potential impact of the Ref-PET DRS in Belgium. Future research could explore these assumptions further and consider any divergences that might occur during the practical implementation of the Ref-PET DRS.

Addressing these limitations by acquiring more data and validating assumptions can enhance the accuracy and reliability of the study's findings and recommendations.

15. Referencing

Articles

Abejón, R., Laso, J., Margallo, M., Aldaco, R., Blanca-Alcubilla, G., Bala, A., & Fullana-i-Palmer, P. (2020). Environmental impact assessment of the implementation of a deposit-refund system for packaging waste in Spain: A solution or an additional problem? *Science of The Total Environment*, *721*, 137744. https://doi.org/10.1016/j.scitotenv.2020.137744

Agnusdei, G. P., Gnoni, M. G., & Sgarbossa, F. (2022). Are deposit-refund systems effective in managing glass packaging? state of the art and Future Directions in Europe. *Science of The Total Environment*, *851*, 158256. https://doi.org/10.1016/j.scitotenv.2022.158256

Calabrese, A., Costa, R., Levialdi Ghiron, N., Menichini, T., Miscoli, V., & Tiburzi, L. (2021). Operating modes and cost burdens for the European deposit-refund systems: A systematic approach for their analysis and Design. *Journal of Cleaner Production*, *288*, 125600. https://doi.org/10.1016/j.jclepro.2020.125600

Coelho, P., Corona, B., & Worrell, E. (2020, December 6). *Executive summary: Reusable vs single-use packaging - a review of environmental impact*. Zero Waste Europe. https://zerowasteeurope.eu/library/executive-summary-reusable-vs-single-use-packaging/

Ferreira, S., Cabral, M., De Jaeger, S., Da Cruz, N. F., Simões, P., & Marques, R. C. (2015). Life cycle assessment and valuation of the packaging waste recycling system in Belgium. *Journal of Material Cycles and Waste Management*, *19* (1), 144–154. https://doi.org/10.1007/s10163-015-0383-x

Hailstone, J. (2023, February 28). *Plastic consumption could nearly double by 2050, study warns*. Forbes. https://www.forbes.com/sites/jamiehailstone/2023/02/27/plastic-consumption-could-nearly-double-by-2050-study-warns/

Görgün, E., Adsal, K., Misir, A., Aydin, E., Ergün, Ç., Keskin, N., Acar, A., & Ergenekon, Ş. (2021). Deposit refund system for beverage containers as a best practice example for recycling maximization. *Environmental Research and Technology*, *4* (3), 199–205. https://doi.org/10.35208/ert.862611

Kalkan, D. (2020, December 15). *How the deposit return scheme was introduced in Germany*. ECOnomia. https://www.economia.rs/how-the-drs-for-packaging-was-introduced-in-germany/

(not used yet) Lemos Junior, W. J., do Amaral dos Reis, L. P., de Oliveira, V. S., Lopes, L. O., & Pereira, K. S. (2019). Reuse of refillable pet packaging: Approaches to safety and quality in soft drink processing. *Food Control*, *100*, 329–334. https://doi.org/10.1016/j.foodcont.2019.02.008

Malek, W., Mortazavi, R., Cialani, C., & Nordström, J. (2023). How have waste management policies impacted the flow of municipal waste? an empirical analysis of 14 European countries. *Waste Management*, *164*, 84–93. https://doi.org/10.1016/j.wasman.2023.03.040

Malindzakova, M., Štofková, J., & Majernik, M. (2022). Economic–environmental performance of reverse logistics of disposable beverage packaging. *Sustainability*, *14* (13), 7544. https://doi.org/10.3390/su14137544

Özdemir-Akyıldırım, Ö. (2015). Deposit-refund system vs. compliance scheme membership: How to comply with producer responsibility regulations? *International Journal of Production Economics*, *162*, 25–44. https://doi.org/10.1016/j.ijpe.2014.12.027

Puigvert, M., Ayuso, S., Bala, A., & Fullana-i-Palmer, P. (2020). What factors determine attitudes towards the implementation of a packaging deposit and refund system? A qualitative study of the perception of Spanish consumers. *Journal of Environmental Management*, *270*, 110891. https://doi.org/10.1016/j.jenvman.2020.110891

Shamsuyeva, M., & Endres, H.-J. (2021). Plastics in the context of the circular economy and Sustainable Plastics Recycling: Comprehensive Review on Research Development, standardization and market. *Composites Part C: Open Access*, *6*, 100168. https://doi.org/10.1016/j.jcomc.2021.100168

Simon, B., Amor, M. B., & Földényi, R. (2016). Life cycle impact assessment of beverage packaging systems: Focus on the collection of post-consumer bottles. *Journal of Cleaner Production*, *112*, 238–248. https://doi.org/10.1016/j.jclepro.2015.06.008

Zhou, G., Gu, Y., Wu, Y., Gong, Y., Mu, X., Han, H., & Chang, T. (2020). A systematic review of the deposit-refund system for Beverage Packaging: Operating mode, key parameter and development trend. *Journal of Cleaner Production*, 251, 119660. https://doi.org/10.1016/j.jclepro.2019.119660

Zhu, Z., Liu, W., Ye, S., & Batista, L. (2022). Packaging design for the Circular Economy: A Systematic Review. *Sustainable Production and Consumption*, *32*, 817–832. https://doi.org/10.1016/j.spc.2022.06.005

Online resources

Bloomberg. (n.d.). *Deposit Return Scheme: Germany.* https://www.bloomberg.com/netzeropathfinders/best-practices/deposit-return-scheme-germany/, consulted on 10/05/2023.

Coca-Cola Europacific Partners (2023, June 14). *We're acting with urgency to reduce the impact of our packaging* [Thumbnail with link attached] [Post]. LinkedIn. https://www.linkedin.com/feed/update/urn:li:activity:7084586874043789312/, consulted on 10/05/2023.

Coca-Cola Europe. (n.d.). *Cola Germany is working towards a world without waste*. https://www.coca-cola.eu/news/supporting-environment/how-coca-cola-germany-is-working-towards-a-world-without-waste, consulted on 10/05/2023.

Ecosistant. (2021, December 15). To whom does the German Packaging Act (VerpackG) apply and what will change in 2022? https://www.ecosistant.eu/en/german-packaging-act-2022/, consulted on 18/05/2023.

Ellen Macartuhur Foundation. (n.d.) *A reusable drinks bottle design for multiple brands: Universal Bottle.* https://ellenmacarthurfoundation.org/circular-examples/a-reusable-drinks-bottle-design-for-multiple-brands-universal-bottle, consulted on 10/05/2023.

EU. (2008). *Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098, consulted on 15/06/2023.

EU. (2018). *Directive (EU) 2018/851 of the European Parliament and of the council of 30 may 2018 amending Directive 2008/98/EC on waste (31).* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018L0851, consulted on 15/06/2023.

EU. (2019). *Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment.* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098, consulted on 15/06/2023.

EU. (2020). *Communication from the commission to the European Parliament, the council, the European economic and social committee and the committee of the regions A new Circular Economy Action Plan For a cleaner and more competitive Europe.* https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN, consulted on 15/06/2023.

EU. (2023). *Revision of the Packaging and Packaging Waste Directive* https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/745707/EPRS_BRI(2023)745707_EN.pdf, consulted on 12/07/2023.

European Plastics Pact. (2020). *Targets*. https://europeanplasticspact.org/targets/, consulted on 15/06/2023.

Eurostat (2020). *Plastic packaging waste: 38% recycled in 2020*. https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20221020-1, consulted on 15/06/2023.

Oceana. (May 18, 2023). *Coca-Cola and Its Bottlers Regress on Reuse Goal, Produce Billions More Single-Use Plastic Bottles*. https://oceana.org/press-releases/coca-cola-and-its-bottlers-regress-on-reuse-goal-produce-billions-more-single-use-plastic-bottles/, consulted on 24/07/2023.

Plastic Soup Foundation. (2022, March 28). *The future of the refillable bottle is promising*. https://www.plasticsoupfoundation.org/en/2022/03/the-future-of-the-refillable-bottle-is-promising/, consulted on 10/05/2023..

PwC. (2022). *Economic study of returnable refillable PET in the EU soft drinks industry* [PDF]. https://www.unesda.eu/wp-content/uploads/2022/10/PwC-Economic-study-of-returnable-refillables-PET_2022.pdf, consulted on 10/05/2023.

Rethink Plastic alliance. (2023). *Feedback on the Packaging and Packaging Waste Regulation proposal*. https://eeb.org/library/rethink-plastic-alliance-feedback-on-the-packaging-and-packaging-waste-regulation-proposal/, consulted on 12/07/2023.

Sensoneo. (2023). *Detailed overview and results of the current deposit return scheme implementations in Europe.* https://sensoneo.com/waste-library/deposit-return-schemes-overview-europe/, consulted on 12/06/2023.

The Coca-Cola Company. (2019). *World Without Waste Report* [PDF]. https://www.coca-colacompany.com/content/dam/journey/us/en/reports/coca-cola-world-without-waste-report-2019.pdf, consulted on 12/06/2023.

The Coca-Cola Company (2022, November 11). *The Coca-Cola Company Announces Industry-Leading Target for Reusable Packaging.* https://www.coca-colacompany.com/media-center/coca-cola-announces-industry-leading-target-for-reusable-packaging, consulted on 12/06/2023.

Unesda. (2022, October 24). *Circular packaging vision 2030.* https://www.unesda.eu/circular-packaging-vision-2030/, consulted on 10/05/2023.

Unesda. (2022). *Deposit Refund Systems.* https://www.unesda.eu/deposit-refund-systems/, consulted on 10/05/2023.

Other References

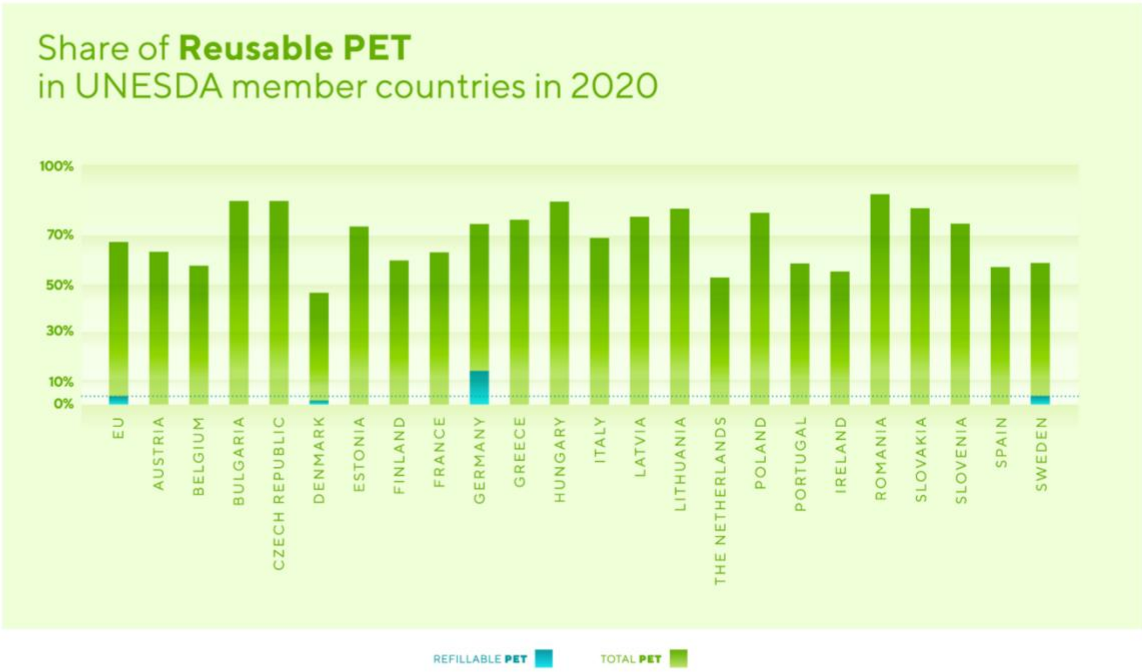
Santos, G. (2023, July 20). Personal interview

16. Appendices

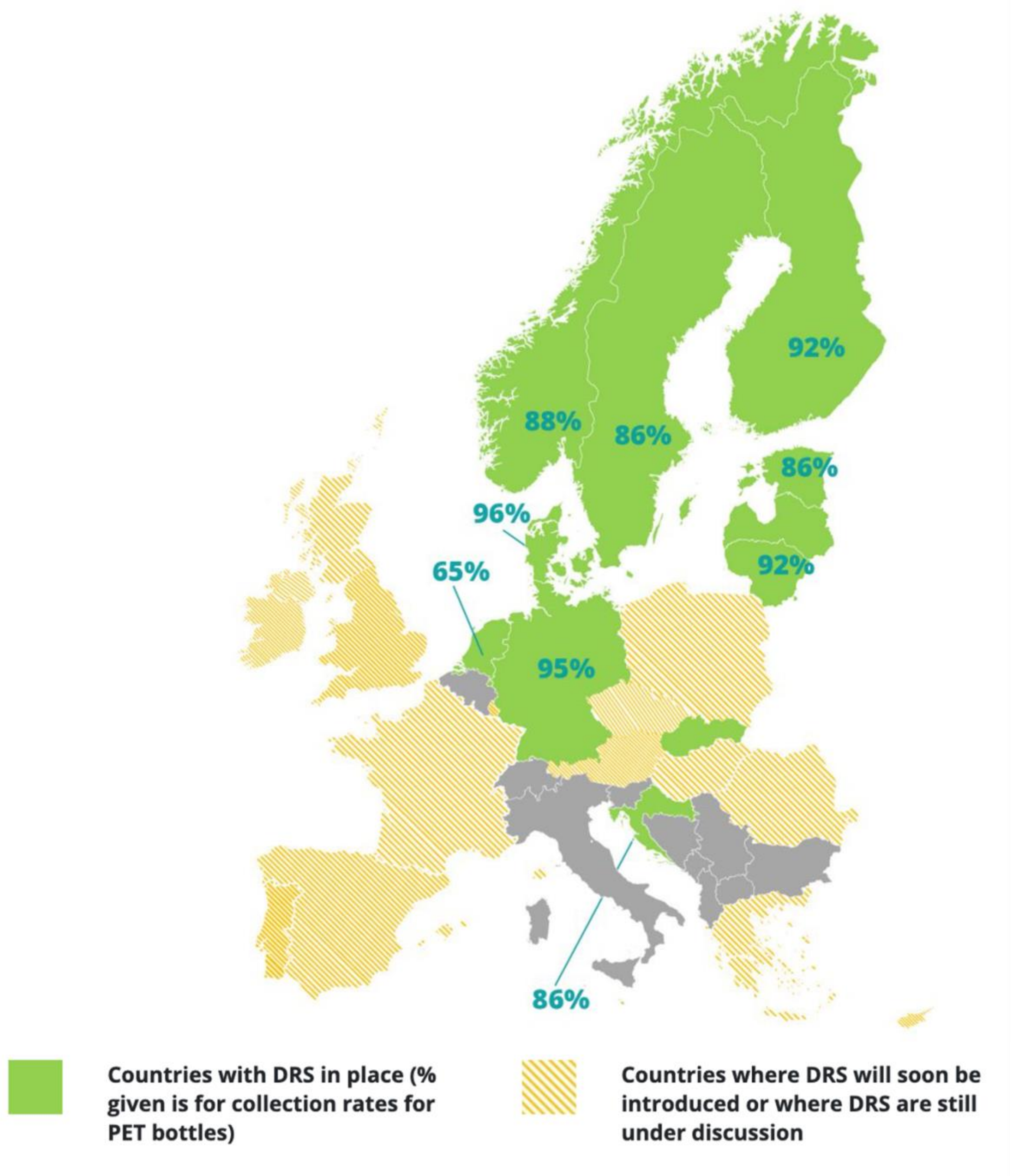
Appendix 1: Number of times a glass bottle is reused and the decrease in Global Warming Potential (g CO^2 eq/l) (Coelho et al., 2020)

Appendix 2: Average results of the LCAs, which represents the relation between the distance vs. CO2 emissions of one entire life (Coelho et al., 2020)

Appendix 3: Graph of the share of Reusable PET in EU member states (Unesda, 2022)



Appendix 4: Map of the single-use plastic DRS across Europe (Unesda, 2022)



Appendix 5: Single-use PET collection rates per country (Sensoneo, 2023)

Country	State of DRS	PET bottles collection rate	Implementation year
Austria	Ongoing discussion	75%	
Belgium	Ongoing discussion	89%	
Croatia	Implemented	86%	2006
Cyprus	Legislation adopted	not reported	2025
Czech Republic	Ongoing discussion	82%	
Denmark	Implemented	96%	2002
England	Legislation adopted	59%	2023
Estonia	Implemented	86%	2005
Finland	Implemented	92%	1996
France	Ongoing discussion	47%	
Germany	Implemented	95%	2003
Greece	Legislation adopted	28%	2023
Hungary	Legislation adopted	42%	2024
Iceland	Implemented	87%	1989
Ireland	Legislation adopted	62%	2023/24
Italy	Ongoing discussion	46%	
Latvia	Implemented	54 % (first six months)	2022
Lithuania	Implemented	92%	2016
Luxembourg	Ongoing discussion	58%	
Malta	Legislation adopted		Nov-22
Netherlands	Implemented	65%	2005
Norway	Implemented	88%	1999
Poland	Legislation adopted	43%	2023
Portugal	Legislation adopted	45%	2023
Romania	Legislation adopted	52%	2023
Scotland	Legislation adopted	59%	2023
Slovakia	Implemented	69 % (first seven months)	2022
Slovenia	Ongoing discussion	65%	
Spain	Ongoing discussion	66%	
Sweden	Implemented	86%	1984
Turkey	Legislation adopted		2023

Appendix 6: Order of machinery and examples of machinery in TdR's management centre

Machines:

1 – The depalletizer: removes crates from palettes

2 – The crate erector: separates bottles and crates

3 – The crate washer: crates are disinfected and cleaned

4 – The inspector: rejects non-compliant bottles (other shape, too big, too small,…). These non-compliant bottles are recycled by an external company (in this case, Monseu).

5 – The bottle washer: cleans only used-bottles

6 – The bottle cleaner (for new bottles): cleans only new bottles

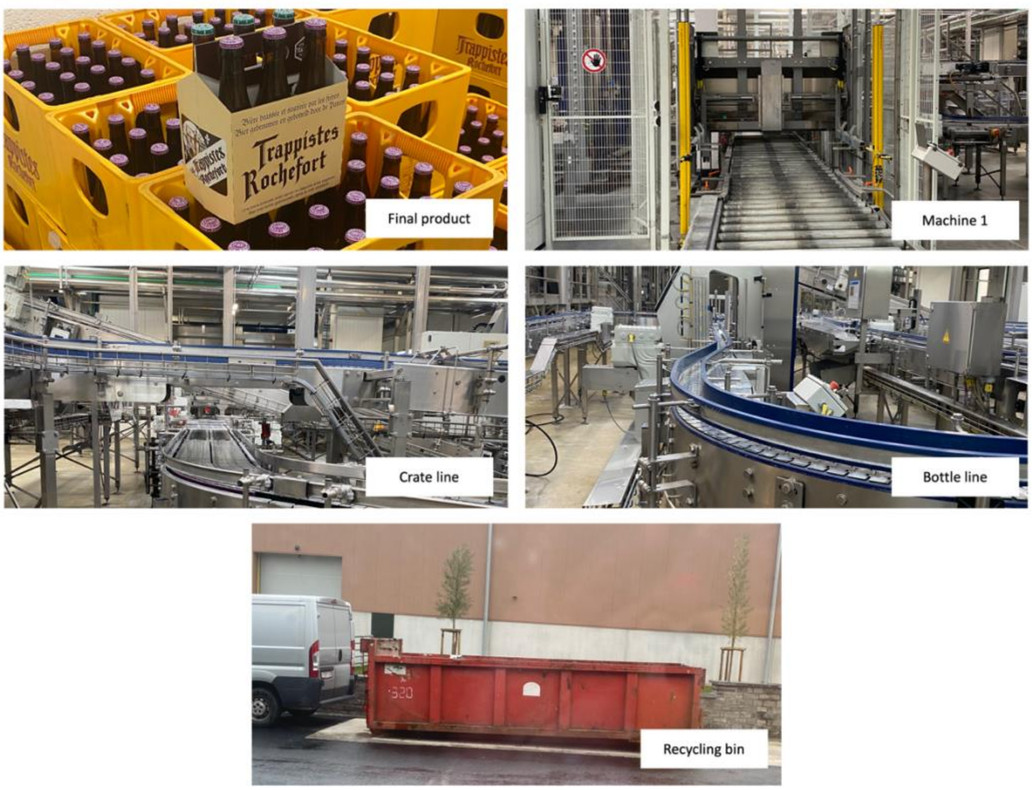
7 – The quality inspector: inspect that bottles are now conform to clean bottles (looks for dirtiness, breakage…) and rejects nonconform bottles. Requires human assistance every 3000 bottles to test the machine's detection skills.

8 – The filling and capping machine

9 – The bottle dryer

10 – The labelling machine: + printer expiration date

11 – The crate packer: associate now cleaned and filled bottles in crates. 24 bottles per crate.



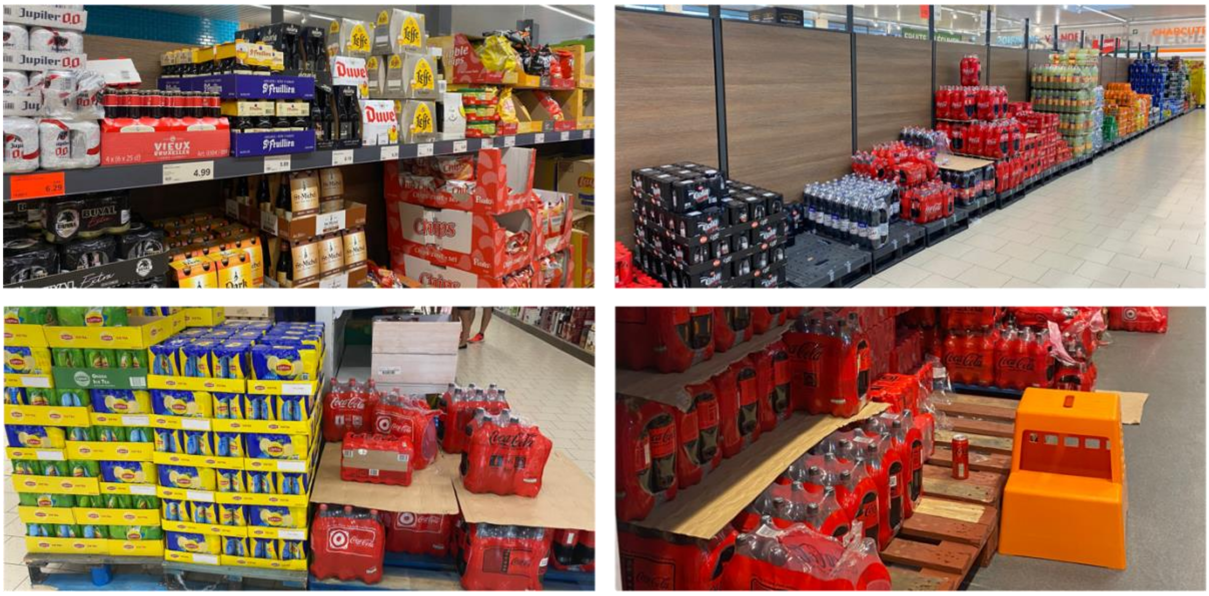
Examples (pictures):

- Final product: filled bottled, new or reused, in crates of 24 bottles per crate.
- Crates are removed from the palettes in Machine 1 and further on crates go on the crate line and bottles on the bottle line.
- The recycling bin if for all the bottles that are not recovered in the management center (rejected bottles from machines (4) and (7)

Appendix 7: Example of two collection systems in Retail shops in Belgium.
At Colruyt, a Deposit voucher (1) is given to the consumer when individual glass bottles are manually counted and directly sorted in the shop (2) or when crates are brought back (3).

At Delhaize, an automatic reverse vending machine (4) is present at the entrance of the shop. The machine accepts both individual bottles and crates. Then, the store personnel have to sort the empty bottles in the back.

Appendix 8: Example of available soft drinks and beer bottles in Belgium retail shops that do not participate in the returnable glass bottle DRS, like Lidl and Aldi. As we can see, the product range is limited and mostly consists of single-use PET bottles or cans.



Appendix 9: Example of available crates in retail shops that do participate in the returnable glass bottle DRS. As we can see, bottles are available in crates for multinational brands (Coca, Jupiler, Cristal), and individually for smaller or local brands (Kwak)

Abstract: This study investigates the complexities surrounding sustainable beverage packaging, with a focus on the entire life cycle of packaging materials. It explores the potential of Ref-PET (refillable plastic) bottles, and the environmental impact of reusable packaging production, considering its durability and proper management. By analysing the performance of reusable bottles in comparison to single-use options, the research highlights the need for exploring new materials and collection systems, given the prevalence of PET bottles in the beverage industry. The European Union's (EU) commitment to plastic reduction through recycling quotas and reusing packaging is examined, with Deposit Return Schemes (DRS) emerging as an efficient approach to achieving these goals. The study proposes the implementation of a Ref-PET DRS in Belgium as a viable means of reducing plastic waste. While acknowledging the challenges, such as high investments and consumer behaviour, the research suggests that Belgium's Eco-tax can serve as an incentive for investment in waste management. Drawing insights from successful Ref-PET strategies and DRS implementations in other countries, the study provides valuable recommendations for overcoming country-specific obstacles and fostering stakeholder cooperation. Ultimately, this research aims to pave the way for the effective and sustainable integration of Ref-PET DRS in Belgium's beverage packaging landscape.

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
Louvain School of Management
Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve
Boulevard Emile Devreux 6, 6000 Charleroi, Belgique
Chaussée de Binche 151, 7000 Mons, Belgique
www.uclouvain.be/lsm