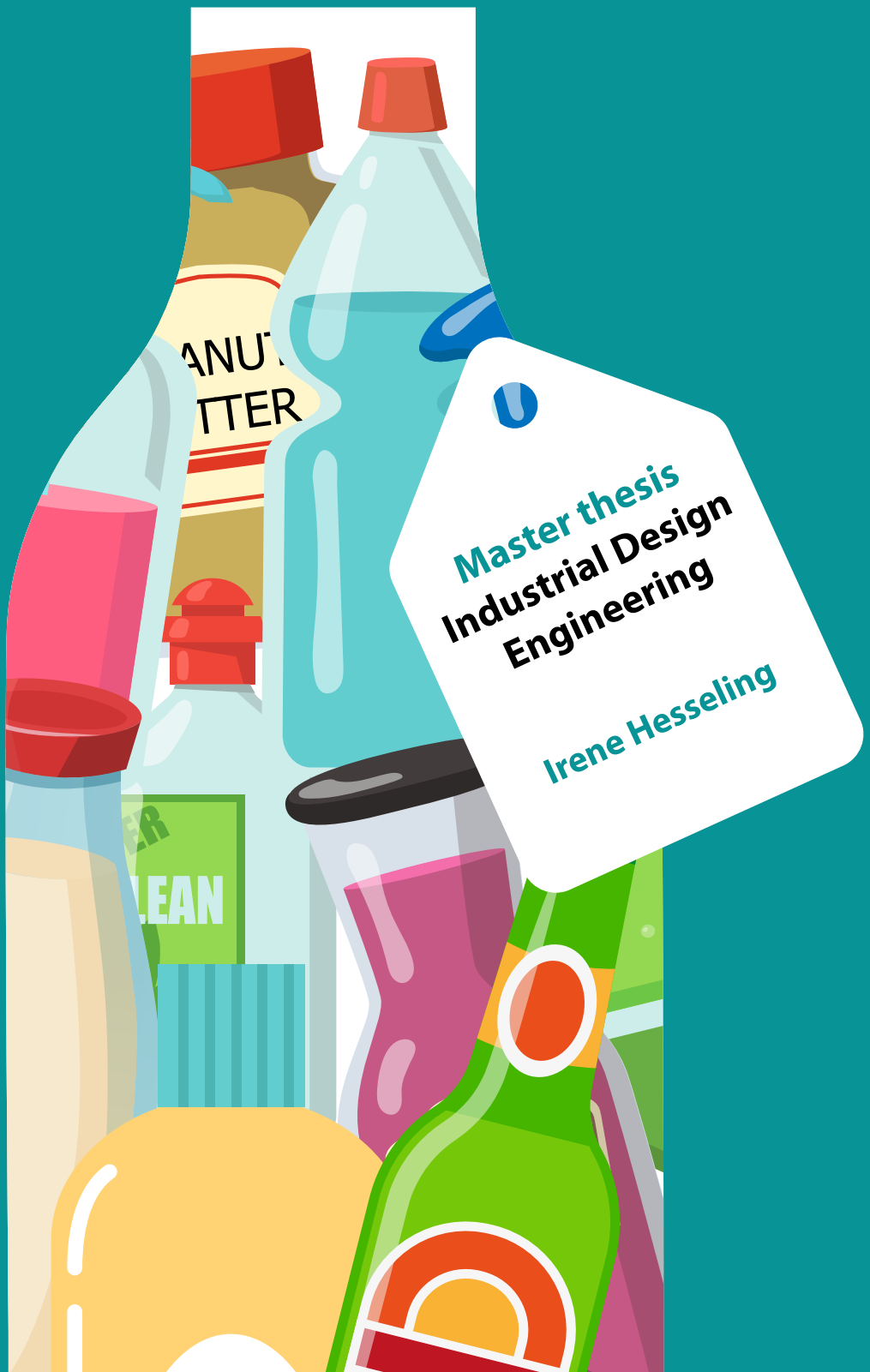
From single-use to reuse:
development of a decision support tool for FMCG packaging

Commissioned by NVC Netherlands Packaging Centre



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UNIVERSITY OF TWENTE.

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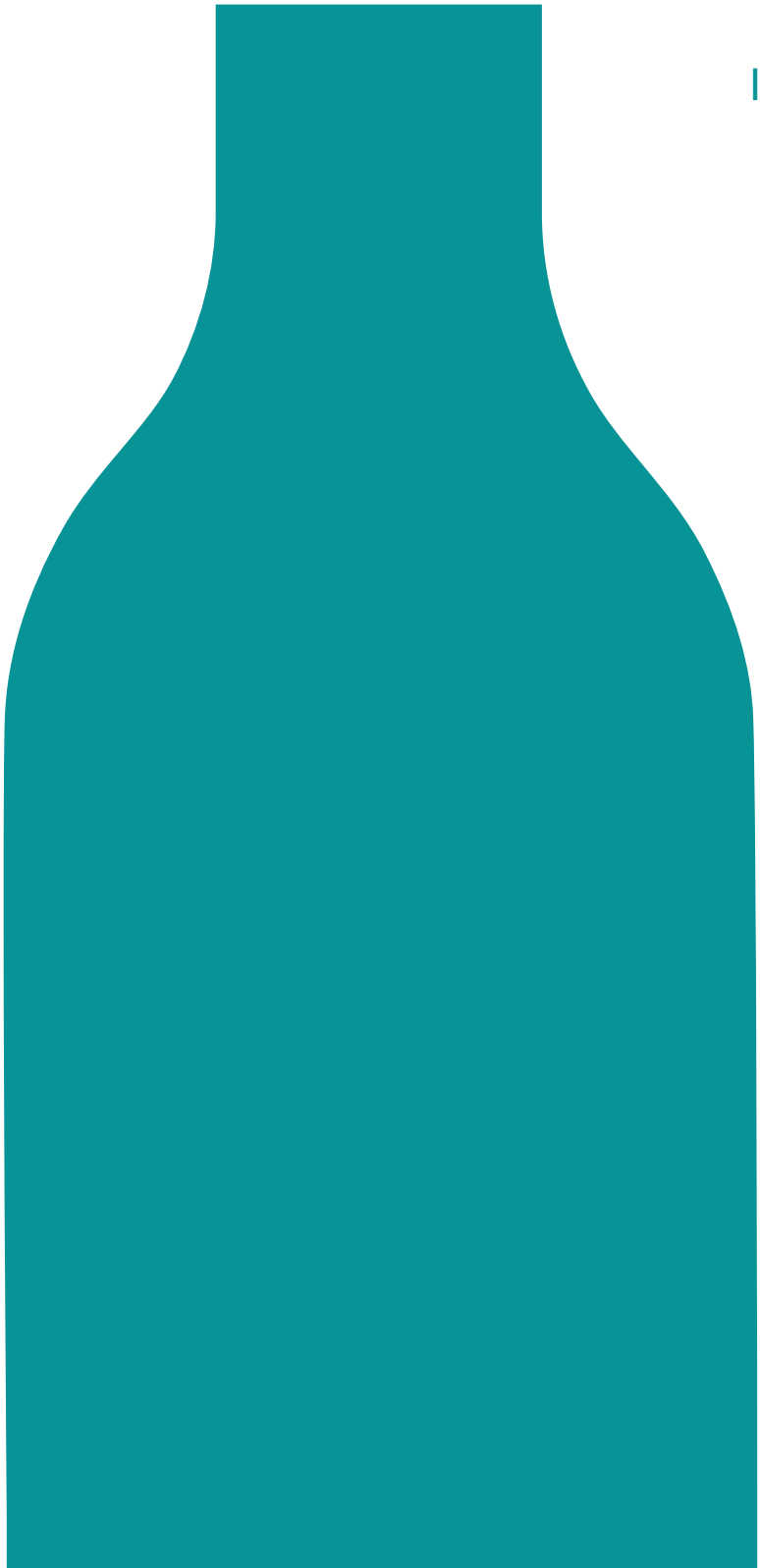
Master thesis | **DPM 1907**
Industrial Design Engineering

Irene Hesseling



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From single use to reuse: development of a decision support tool for FMCG packaging

Master thesis
DPM 1907
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NVC NETHERLANDS PACKAGING CENTRE

Preface

Before you lies the master thesis report “From single-use to reuse: development of a decision support tool for FMCG packaging”. It has been written as part of my graduation research for the master Industrial Design Engineering in the direction of Management of Product Development at the University of Twente. I was engaged in researching and writing this thesis from June 2021 to March 2022.

With the growing global demand for more sustainable packaging, reusable packaging has emerged as a promising alternative to single-use packaging. The master thesis project was undertaken at the request of the NVC Netherlands Packaging Centre, whose members have expressed interest in this development.

Undertaking this master thesis project was challenging at times but fortunately there were several people I could reach out to. I would like to thank my supervisor prof.dr.ir. Roland ten Klooster and my mentor from the NVC, Corné Huijben for their guidance and support during this project.

I would also like to express my gratitude to the people that participated in the interviews. Your perspectives from within the packaging industry were of great value to this master thesis project.

Lastly, I would like to thank my family and friends for motivating me in the more difficult times and for always providing a sympathetic ear. My sister Simone deserves a particular note of thanks: your support towards the end of this thesis has helped me a lot.

Irene Hesseling

Arnhem, March 17, 2022.

Summary

The one-off nature of the majority of fast-moving consumer goods (FMCGs) contributes to a throw-away society in which linear flows are the norm. The consumption and mass production of FMCGs has put a strain on the environment, as it contributes to global waste issues and to the depletion of resources. Civilians, NGOs and entrepreneurs have become increasingly aware of the issues and are expressing their concerns.

With this growing global demand for more sustainable packaging, the reusable packaging trend has emerged that could offer a promising alternative to single-use packaging. Given the high placement of reuse on the waste hierarchy ladder, reuse has the potential, when executed properly, to contribute to a more circular economy. Reuse slows material flows and is capable of prolonging the value of resources, therefore reducing waste and resource consumption.

Reuse is not new, but it has been put back on the map as a more sustainable alternative. The reintroduction of reusable packaging systems has sparked interest among the member companies of the NVC Netherlands Packaging Centre. The NVC is an association of companies with 550 members representing companies throughout the whole packaging supply chain.

This master thesis was executed on behalf of the NVC and had two main aims. The first aim was to determine the preferred conditions and requirements involved in the development of primary reusable packaging concepts. The second aim was to translate the results of the research into a decision support tool to guide NVC members in their decision-making process around reusable packaging. The focus is on business-to-consumer (B2C) settings, as research indicated that there is more knowledge on B2B than on B2C reusable packaging systems, thereby addressing the gap in literature. The following main research question was defined:

What are the preferred conditions and requirements for reusable primary packaging systems (for e-commerce) in business-to-consumer markets and how can these be reflected in a decision support tool to guide NVC members in their development process?

Novel reuse models are emerging in the FMCG industry and in order to identify the preferred conditions and requirements for reusable primary packaging systems this thesis distinguishes between these reuse models. In this thesis, a combined reuse model framework was developed which divided reuse into two systems: exclusive or sequential reuse systems. Exclusive reuse was further divided into “refill at home” and “refill on the go”. Sequential reuse was further divided into “return from home” and “return on the go”.

To identify the preferred conditions and requirements for reusable primary packaging systems, factors that play a role in the viability and the successful development of primary reusable packaging systems were identified and divided into six categories: Economics, Logistics, Environment, Packaging Design, Consumer and Legislation. These factors are interlinked and influence each other inside as well as outside of their own category. The research identified the following main factors that influence the viability of reusable packaging systems: the number of reuse cycles, return rates and losses, transportation distances, durability of the packaging, scale and standardisation. In terms of environment, the key trade-off between a single-use system and a reusable system is the impacts associated with materials production and disposal on the one hand, and the impacts of increased transport on the other hand.

Interviews were conducted with relevant players in the FMCG sector to learn from their experiences with reuse and perspectives and barriers for reuse. Results were divided into enablers of reusable packaging systems and challenges of reusable packaging systems. The following main enablers were deducted: standardisation and harmonisation, legislation, collaboration (especially for sequential reuse), local scope (for sequential reuse), scale, high purchase frequency, limited product range (for sequential reuse), deposit return schemes (for sequential reuse), quality controls and collapsible and nestable packaging, The following main challenges were deducted: convenience, mainstreaming reuse, reverse logistics (for sequential reuse), durability, funding, hygiene and safety, infrastructure and misuse.

The research phase identified factors, as mentioned above, that influence the viability and successful development of reuse systems. These factors are reflected and further specified in the decision support guide, which structure is based around the following logic: firstly, prior to the development process, it is important to determine whether reuse could be a viable option for a brand and/or product and secondly, it is important to determine which reuse system and corresponding reuse model is most suitable. Therefore this guide is divided into levels. In Level 1, users determine the general viability of reuse for their brand and/or product. In Level 2 users determine suitable reuse model(s). In Level 3 users determine strategic focus points for development. In Level 4 users explore how to implement reusable packaging from a packaging and system perspective.

To enable holistic decision making support on the topic of reusable packaging, Levels 1, 2 and 3 take four perspectives into account: business and brand, customer and consumer, product and content and environment and sustainability. This is because in order to be viable, reuse needs to perform from the viewpoint of all four perspectives.

Results from the evaluation indicated that the decision support tool provides a good overview of the decisions and considerations involved in the development of reusable packaging systems. However, due to its high information density, the tool is not very accessible for everyone. Nevertheless, it was found that the decision support tool is very suitable for packaging experts. The value of the decision support tool lies in the fact that the information around reusable packaging development is synthesized in one place.

Key recommendations for the decision support tool are to investigate the option of developing a more simplified online version of the tool and to collaborate with R&D packaging teams from specific companies to configure and format the tool according to their needs and general workflows to maximise the usability.

In conclusion, the decision support tool enables NVC members to make holistic based decisions, learn about the consequences of their decisions and determine a point of departure for reusable packaging development through four consecutive levels.

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Setting the stage

This part introduces the thesis project and insights from literature are combined as a point of departure for this thesis project.

Part II
Research & Analysis

This part combines insights from literature and interviews to obtain understanding of the different reuse models, the major factors involved in reuse systems and barriers for implementing them.

Part III
Development

This part revolves around the development of a decision support tool for reusable packaging. Firstly, the decision support tool's aim, target group, functions and requirements are described. Secondly, the design and development process of the decision support tool is described.

Part IV
Evaluation

This part revolves around the evaluation of the decision support tool for reusable packaging. It describes the two methods used to evaluate the decision support tool.

Part V
Wrap-up

This part wraps up this research project by by discussing the limitations and recommendations in the dicussion and answering the research questions in the conclusion.

Chapter 1
Introduction

This master thesis project was carried out on behalf of the NVC Netherlands Packaging Centre. The NVC is an association of companies with 550 members representing companies throughout the whole packaging supply chain. The NVC offers projects, information services and education programs that stimulate the continuous improvement of packaging. The NVC holds the Chair Packaging Design and Management at the Faculty of Engineering Technology of University of Twente. This chapter describes the project background and aims. Furthermore, the chapter introduces the project's research questions, research methods as well as the thesis outline.

1.1 Project Background and Aims

This research is conducted in response to two trends in the retail and packaging sector, namely the steady growth of e-commerce and the (re)introduction of reusable and refillable packaging concepts. Firstly, fuelled by the COVID-19 pandemic in 2020, the online channel has gained a permanent place in retail. Online shopping is expected to continuously grow in the European Union because of the COVID-19 restrictions and changes in habits and preferences of consumers (Eurostat, 2021). Secondly, with the growing global demand for more sustainable packaging, the reusable packaging trend has emerged that could offer a promising alternative to single-use packaging. Reuse is not new, but it has been put back on the map as a possible more sustainable alternative. Packaging is a primary user of virgin materials, because of the required material quality of packaging solutions. So, reusing materials for as long as possible will reduce the need for virgin materials. In turn, it can reduce the environmental footprint of the material usage, if the material loops are closed in a sustainable way (Coelho et al., 2020a). These trends have not gone unnoticed by the members of the NVC. Particularly, the NVC Web Retail Packaging workgroup expressed interest in finding out more about the factors and decisions involved in reusable packaging in combination with e-commerce.
This led to two main aims of this thesis project. The first aim is to determine the preferred conditions and requirements involved in the development of primary reusable packaging concepts. The second aim of this project is to translate the results of this research into a decision support tool to guide NVC members in their decision-making process around reusable packaging development. The focus is on business-to-consumer (B2C) settings, as research indicated that there is more knowledge on B2B than on B2C reusable packaging systems, thereby addressing the gap in literature.

1.2 Research Questions

From the project background and aims, the following main research question for this thesis project has been defined:

What are the preferred conditions and requirements for development of reusable primary packaging systems (for e-commerce) in business-to-consumer markets and how can these be reflected in a decision support tool to guide NVC members in their development process?

The main question is supported by two sub-questions. To investigate possible differences and similarities between e-commerce and traditional retail primary packaging, the first sub-question was formulated:

1. *To what extent does or should reusable primary packaging for e-commerce differ from reusable primary packaging for traditional retail?*

To translate the results of the main question and the first sub-question into a visually engaging decision support tool, the second sub-question was formulated:

2. *How can a decision support tool around reusable packaging be created to guide NVC members in the development of reusable packaging?*

1.3 Methods

To answer the research questions an extensive literature review was executed, interviews were conducted and a decision support tool was developed. The first research phase consisted of exploratory research into reuse, with the aim of exploring the definition of reuse, the sustainability potential of reuse and the different reuse models (Chapters 2 and 3). Secondary data was collected by means of scientific papers, institutional reports, online articles and websites.

The second phase of the research dived deeper into the factors that influence the successful development of reusable packaging systems (Chapters 4 and 5). Again, secondary data was collected by means of scientific papers, institutional reports, online articles and websites. Furthermore, primary qualitative data was collected through semi-structured interviews (Chapter 6). This form of interviewing was chosen as it allowed for flexibility during the interview session. Transcripts of the interviews are confidential.

Two methods were used to evaluate the decision support tool (Chapter 9). Firstly, a semi-structured interview was conducted with the head of sustainability in marketing from a multinational chemical and consumer goods company to assess the completeness and user-friendliness of the tool. Secondly, to assess whether the information and considerations used in the decision support tool were complete and usable, eight student reports on reusable packaging development were applied to the decision support tool.

1.4 Thesis outline

This thesis is divided into five parts (see next page). In the current part, Part I: Setting the Stage the thesis project is introduced. Furthermore, FMCG packaging is introduced by discussing the definition of packaging, the functions of packaging and packaging materials. The environmental pressure on the FMCG sector will be shortly addressed as well as the ranking of reuse on the waste management hierarchy. The part is concluded with a section on why reuse could be a promising strategy to move from a linear, "throwaway" society to a more circular society, thereby setting the stage for the research to come.

In Part II: Research & Analysis insights from literature and interviews are combined to get insight in different reuse models, reuse systems and the major factors involved in the successful development of reuse systems and barriers for implementing them. The factors are divided into six categories: Economics, Logistics, Environment, Packaging Design, Consumer and Legislation. Part II aims to answers in part the main research question and the first sub-question.

In Part III: Development the requirements for the decision support tool and the development process of the decision support tool are described. Part III answers in part the main research question and the second sub-question.

In Part IV: Evaluation the decision support tool is evaluated by assessing the usability and applicability of the tool. It describes the two evaluation methods, namely interviewing and reviewing.

In the final part, Part V: Wrap-up, this thesis project is wrapped up, by describing limitations of the research and recommendations of the decision support tool in the discussion and by answering the research questions in the conclusion.

Part I
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Chapter 2
Background

This chapter explores the definition, functions and materials of packaging. Furthermore, the chapter elaborates on the environmental issues that are caused by the FMCG sector. It describes the role of reuse in solving these issues by looking at the ranking of reuse in the waste management hierarchy.

2.1 Introduction to FMCG packaging

Fast-moving consumer goods (FMCGs) are repeatedly purchased packaged goods, such as liquid and solid foods, beverages, toiletries and cosmetics, with a high convenience (Zeeuw van der Laan & Aurisicchio, 2019). These goods only temporarily satisfy continuous user needs and therefore need to be purchased again and again. Typically, after satisfying these needs, the empty packaging is thrown away. The need is satisfied by the content of the packaging. For FMCGs the packaging is generally an indispensable prerequisite to be able to transport, sell and use the product (De Lange et al., 2013). The following sections discusses the definition, functions and materials of packaging.

2.1.1 Definition of packaging

The Puma Manifesto defines packaging as follows: "*Packaging is the activity of temporarily integrating an external function and a product to enable the use of the product*" (NVC Netherlands Packaging Centre, 2020).

In the Packaging Waste Directive the definition of packaging is described as follows: "*Packaging shall mean all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. 'Non-returnable' items used for the same purposes shall also be considered to constitute packaging*" (EU Directive, 1994/62).

The directive further specifies packaging into three categories (see Figure 1) :

1. Primary packaging or sales packaging or shelf unit: *"Packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase"*. It is worth noting that at point of purchase, the primary packaging itself may be composed of several 'layers', meaning the unit itself can consist of several packages. Sometimes, in the pharmacy industry, primary packaging is denoted by that which is in direct contact with the product (Ten Klooster et al., 2008). In this thesis report, the definition by the Packaging Waste Directive is applied meaning that the primary packaging can consist of several packages.
2. Secondary packaging or grouped packaging or stock keeping unit: *"packaging conceived so as to constitute at the point of purchase a grouping of a certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale; it can be removed from the product without affecting its characteristics"*.
3. Tertiary packaging or transport packaging: "*Packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packagings in order to prevent physical handling and transport damage. Transport packaging does not include road, rail, ship and air containers.*" Tertiary packaging mainly concerns the packaging that encases the secondary packaging (Ten Klooster et al., 2008).

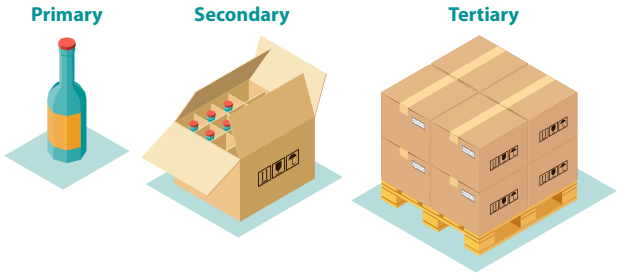


Figure 1 - Primary, secondary and tertiary packaging

2.1.2 Functions of packaging

What became clear from the definitions of packaging is that packaging has to fulfil functions of containment, protection, preservation, distribution transportation, information, identification and facilitation. Packaging also influences the convenience of use of a product and is instrumental in selling the product, as it has to attract the consumer. Packaging is the 'the silent salesman', for retail packaging as well as industrial packaging (Ten Klooster, 2008). The main functions of packaging are to:

1. ***Contain the packaged product*** – Packaging should prevent leakage and loss of parts (Emblem & Emblem, 2012). The function is about bundling, arranging and portioning the packaged product and facilitating the filling process (Ten Klooster et al., 2008).
2. ***Protect the packaged product*** – Packaging should prevent and reduce physical damage to the product during all stages of life (Emblem & Emblem, 2012).
3. ***Preserve and conserve the packaged product*** – Packaging should prevent change due to biological and chemical hazards. The objective of preservation is to extend the shelf life of the contained product (Emblem & Emblem, 2012).
4. ***Distribute the packaged product from producer or merchandiser to buyer*** – The packaging should facilitate transport. This includes ensuring that the packaging is graspable, manageable and stackable (Ten Klooster et al., 2008).
5. ***Provide information*** – The many users in the packaging chain need information. Therefore the packaging should provide, among others, information about the packaging itself, the filling process, the product it contains, the price, usage of the product and the origin (Ten Klooster et al., 2008).
6. ***Facilitate usage and disposal*** – In terms of usage, this includes easy opening of the packaging, resealing of the packaging and dosing of the product. In terms of disposal, this can include facilitating separating, returning, recycling and/or reusing of the packaging (Ten Klooster et al., 2008).

2.1.3 Packaging materials

Various materials are used for packaging, including: plastics metals, glass, wood, paper, board, pulp, biologically degradable materials, textiles such as jute and cotton, ceramics and cork (Ten Klooster et al., 2008). The materials can be divided into six principle material packaging groups:

1. ***Metals*** – This includes the metals such as steel and aluminium.
2. ***Glass*** – This includes soda-lime glass, which is the most prevalent type of glass used for packaging.
3. ***Paper and board*** – This includes among others folding boxboard and corrugated board.
4. ***Rigid plastics*** – This includes plastics such as high density polyethylene (HDPE), polyethylene terephthalate (PET) and polypropylene (PP).
5. ***Flexibles and laminates*** – This includes plastics such as low density polyethylene (LDPE) and PVC.
6. ***Other*** – This group includes among others biologically degradable materials, textiles, ceramics and cork.

According to Ten Klooster (2008), based on turnover, about 38% of packaging materials used is plastic, 35% is fibre based material (such as paper, board, corrugated board and pulp), 12% is metal and about 10% is glass. The rest, about 5% is wood (pallets and boxes), jute, cotton, biologically degradable materials (starch and polylactides) and others.

2.2 Environmental pressure on FMCG sector

The one-off nature of the majority of FMCGs contributes to a throw-away society where linear resource flows are the norm. In the FMCG linear flow, products are used once to satisfy the need of the consumers and afterwards thrownaway (Zeeuw van der Laan & Aurisicchio, 2019). The consumption and mass production of FMCGs has put a strain on the environment, as it contributes to global waste issues and to the depletion of resources (Ellen MacArthur Foundation, 2017).

Each year, at least 8 million tonnes of plastics leak into the ocean. Research currently available estimates that there are 150 million tonnes of plastics in the ocean today. If no action is taken, the ocean is expected to contain 1 tonne of plastic for every 3 tonnes of fish by 2025, and by 2050 more plastics than fish (per weight) (Ellen MacArthur Foundation, 2016).

Civilians, NGOs and entrepreneurs have become increasingly aware of these issues and are expressing their concerns (Bruijnes et al., 2020). It is worth noting that as a rule of thumb, 90% of the overall environmental footprint of a product packaging can be attributed to the product itself, where only 10% is the packaging. Nevertheless, issues resulting from the throw-away society, such as the accumulating waste polluting our environment and micro- and nano plastics contaminating our biosphere should not be overlooked. The most important issues will be shortly addressed in the following paragraphs.

(Marine) litter – The issue of litter, piled up in landfills and floating in our oceans has attracted extensive amount of attention in recent years (Bruijnes et al., 2020) and poses a huge problem. The Great Pacific Garbage Patch composed of many single-use containers, has been estimated to be as large as a continent (Ertz et al., 2017).

Micro- and nanoplastics – These are small pieces or fibres of plastics originating from among others personal care products, larger parts of plastics and synthetic clothing. The amount of microplastics found in our biosphere is growing (Bruijnes et al., 2020). Although the potential harm these plastics can do to living organisms is not entirely clear yet, it is known that these interventions in our biosphere are largely irreversible. This is why the World Wildlife Fund for Nature (WWF) as well as the World Health Organization (WHO) have expressed their concern and stress that his pollution must come to a halt.

Resource depletion – The packaging industry is a major user of virgin plastic materials, due to the large market and growing population (Muranko et al., 2021). The industry uses virgin materials as they offer the needed material quality for safety and aesthetic reasons (Coelho et al., 2020a). Over 90% of plastics produced are derived from virgin fossil feedstocks (Ellen MacArthur Foundation, 2016). Plastics are derived from natural gas and crude oil, contributing to finite resource depletion and extinction of resources.

Overproduction – While recycling is the most widely chosen waste prevention strategy, it doesn't address the overproduction of materials associated with FMCGs (Muranko et al., 2021). Production processes are energy extensive processes, thereby emitting greenhouse gasses. Overproduction produces harmful emissions that can be prevented by producing less.

2.3 Waste management

Existing measures to mitigate plastic pollution in the European Union (EU) are mainly concerned with waste treatment, including recycling, energy recovery and correct disposal. Measures for waste prevention are far less considered, despite their importance highlighted in the waste management hierarchy (see Figure 2) (Steinhorst & Beyerl, 2021). Besides recycling, strategies have also focused on small changes in the packaging, such as reducing the amount of volume of material used, light-weighting of packaging or replacing conventional materials with biobased ones (Circular Economy Portugal, 2021b; Coelho et al., 2020b; Muranko et al., 2021).

2.3.1 Waste management hierarchy

The EU Waste Framework Directive (EU Directive, 2018/851) is a political framework that sets waste prevention objectives and a waste management hierarchy. Prevention of waste is the preferred option and disposal of waste (sending waste to landfill) is the least preferred option (see Figure 2). Therefore, EU member states are obliged to prioritize measure of waste prevention over preparing for reuse, recycling, recovery or disposal (European Commision, 2019). However, the current waste management practice prioritizes quite the opposite. Furthermore, the EU measures for waste prevention are not yet as far-reaching and fundamental as they should be according to the EU Waste Framework Directive (Steinhorst & Beyerl, 2021).

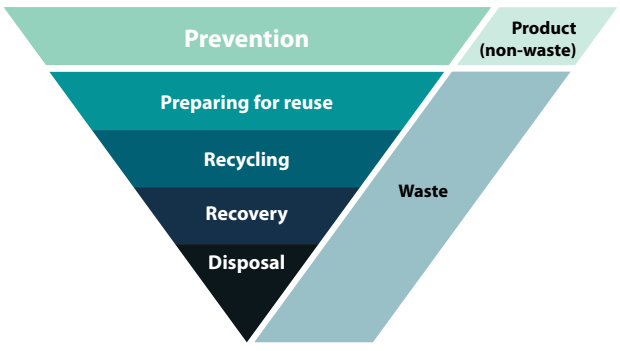


Figure 2 - The waste management hierachy

2.3.2 R-ladder

The Netherlands Institute for Sustainable Packaging (KIDV) developed a more extensive framework for dealing with waste in general and packaging waste specifically in the form of a ladder (see Figure 3). The ladder is developed from the Lansink's Ladder, which is from low to high: landfill, incineration, energy recovery, recycling, reuse and prevention (Bruijnes et al., 2020). The idea behind Lansink's Ladder is to climb the ladder as high as possible. The next paragraphs discusses the waste processing principles briefly, starting at the top and ending at the bottom of the ladder (most favourable to least favourable).

Refuse – Refuse dictates that any packaging material that is functionally questionable and environmentally unsustainable must be identified and development halted.

Rethink – Rethink calls for profound innovation, so that packaging serves both the environment and the economy. Rethink dictates innovation that improves existing solutions as well as create solutions that do not exist yet.

Reduce – Reduce is about reducing the amount of waste produced by for example using less resources and materials in the lifecycle of a product. All the materials that are not introduced can never generate waste and will therefore not pose a problem.

Reuse – Reuse involves reusing products again and again to perform the original function. Reuse is defined in the EU Waste Framework Directive as "any operation by which products or components that are not waste are used again for the same purpose for which they were conceived" (EU Directive, 2008/98).

Repair – Repairing involves repairing and maintaining of products, so that they can be reused and their value is prolonged.

Refurbish – Refurbishing involves refurbishing or modernizing an old product so that it can be used for an extended period of time.

Remanufacture – Remanufacturing involves reusing parts of old or discarded products in a new product with the same function.

Repurpose – Repurposing involves reusing parts of old or discarded products in a new product with a different function.

Recycle – Recycling involves converting waste materials into new materials. As mentioned previously, recycling is the most common waste prevention strategy applied by industry. However, recycling has proven to not always be very effective for several reasons. First of all, low recycling rates make recycling strategies not very effective. This is due to several factors, which are limitations in product design, insufficient collection systems and inefficient recovery processes. Because of this FMCGs often end up in landfill or the environment (Muranko et al., 2021). Currently, only 14% of our plastic waste actually gets recycled (Ellen MacArthur Foundation, 2017). Secondly, most recycled plastic is downcycled, which means it is turned into something less useful than before. Thirdly, plastic is often only recycled once and afterwards headed to landfill or ocean. Lastly, 100% recycling is practically and thermodynamically impossible (Bruijnes et al., 2020). Therefore recycling can never fully close the loop.

Recover – Recovery follows a linear principle and involves incineration of waste for size reduction and energy recovery. Recovered waste can be put to use.

Reconcentrate – Reconcentrating follows a linear principle and involves the collection and concentration of waste. Waste is concentrated in landfills or nuclear waste depositories.

Redistribute – Redistributing follows a linear principle and involves the redistribution of waste in order to minimize its negative effective by means of dilution. Waste is littered or dumped in oceans.

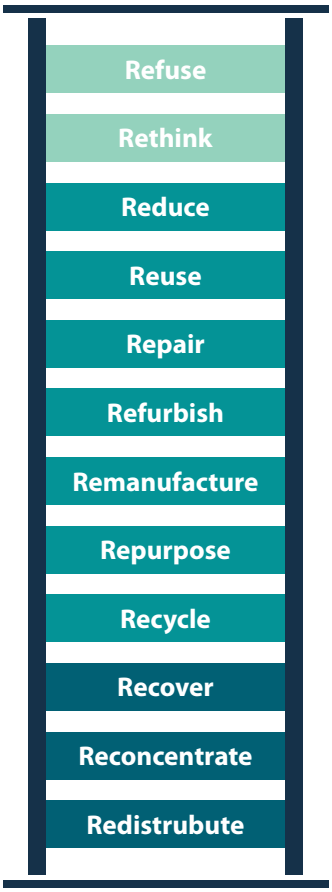


Figure 3 - R-ladder adapted from Bruijnes et al. (2020)

2.4 Why reuse?

Given the high placement of reuse on the waste hierarchy ladder and the R-ladder as described in the previous section, reuse has the potential, when executed properly, to contribute to a circular economy. Reuse slows material flows and is capable of prolonging the value of resources, therefore reducing waste and resource consumption. Similarly, Greenwood et al. (2021) state that plastic packaging waste can be reduced through maintaining the use, value and worth of packaging and they propose reusable packaging systems as a way of achieving this.

Also the Ellen MacArthur Foundation states that reusable packaging is a critical part of the solution to eliminate plastic pollution. Over 500 companies have committed to the New Plastics Economy Global Commitment led by the Ellen MacArthur Foundation. These companies have recognized that, wherever relevant, reuse business models should be explored to reduce the need for single-use plastic packaging (Ellen MacArthur Foundation, 2019). By signing the Global Commitment, these companies have explicitly acknowledgded that recycling alone will not solve the environmental waste issues. As mentioned before, recycling can never fully close the loop.

Europe has set itself the target to make all packaging reusable or recyclable in an economically viable way by 2030 in the Circular Economy Action Plan (European Union, 2020). Presently reusable packaging is at a low level. Reuse has been gradually declining in the last decades, even in sectors where reuse once thrived, such as the beverage sector. However, there are signs of change and brands are implementing pilots (Rethink Plastic Alliance, 2021). More and more research show the potential environmental benefits of reuse such as reducing waste and emissions (Coelho et al., 2020b). Therefore, exploring the economic and environmental viability of reusable packaging systems is very relevant for governments as well as companies.

For companies and manufacturers reuse offers the opportunity to lower their extended producer responsibility (EPR) (Circular Economy Portugal, 2021b). EPR is defined as "a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products" (OECD, n.d.). Reuse reduces the amount of single-use, disposable packaging introduced to the market and could therefore lower EPR financial costs.

Another opportunity of reuse for companies is that by offering reusable packaging systems, companies are perceived by users as more sustainable, which could improve their brand image and could possibly attracts more customers (Coelho et al., 2020a). Furthermore, reuse can improve consumer loyalty through deposit and reward schemes as packaging needs to be refilled again and again.

From a design point of view, reuse models enable use of materials like metals, higher quality glass and high-performance plastics to become economically viable. This offers opportunities for innovative design. Furthermore, reuse models offer the opportunity to rethink how consumers engage with and derive value from products and packaging (World Economic Forum, 2021a). This is underpinned by Tom Szaky, CEO of TerraCyle and Loop who beliefs that the opportunity of reuse is to unlock future ways of interacting with product packaging by making it more functional, exciting and beautiful than single-use packaging (Szaky, 2020).

Part I
Setting the stage

This part introduces the thesis project and insights from literature are combined as a point of departure for this thesis project.

Part II
Research & Analysis

This part combines insights from literature and interviews to obtain understanding of the different reuse models, the major factors involved in reuse systems and barriers for implementing them.

Part III
Development

This part revolves around the development of a decision support tool for reusable packaging. Firstly, the decision support tool's aim, target group, functions and requirements are described. Secondly, the design and development process of the decision support tool is described.

Part IV
Evaluation

This part revolves around the evaluation of the decision support tool for reusable packaging. It describes the two methods used to evaluate the decision support tool.

Part V
Wrap-up

This part wraps up this research project by by discussing the limitations and recommendations in the dicussion and answering the research questions in the conclusion.

Chapter 3
Characterisation

Novel reuse models are emerging in the FMCG industry. Several studies have aimed at characterising reuse (Coelho et al., 2020a; Ellen MacArthur Foundation, 2019; Muranko et al., 2021). As mentioned previously the definition of reuse is defined by EU Waste Framework Directive as "*any operation by which products or components that are not waste are used again for the same purpose for which they were conceived*" (EU Directive, 2008/98). In this chapter, different reuse models are described and combined into one framework for further reference in this report.

3.1 Reuse frameworks

The matter of ownership is a determining factor in reuse models. Deciding on packaging ownership – consumer or business owned – greatly influences the reusable packaging system as it defines the degree of responsibility one has in the reuse cycle (Muranko et al., 2021). With consumer owned packaging, preparation for reuse activities such as refilling and cleaning are typically the responsibility of the consumer. Whereas with business owned packaging, activities such as refilling and cleaning are typically the responsibility of the business. To indicate, a consumer owning a reusable water bottle is responsible of refilling his bottle and responsible for keeping his bottle clean. When a consumer uses a product that is business owned, such as Heineken beer bottles in the Dutch DRS system (Deposit Return Scheme), the consumer buys the bottles with a deposit and simply returns the empty bottle after consumption to claim the deposit back. In that case, the business is responsible of cleaning and refilling the bottles.

Muranko et al. (2021) distinguish ownership of the packaging by looking at the reuser behaviour. Reuser behaviour describes the consumption interaction with the reusable product system. A distinction is made between exclusive reuse and sequential reuse. With exclusive reuse, a consumer or household consumes individually and keeps and owns the reusable product. With sequential reuse, a consumer or a household consumes along with multiple successive individuals and returns the reusable product. In an exclusive reuse model, the consumer has individual and unlimited access to the reusable product, while in an sequential reuse model the consumer shares the reusable product through successive access. The differences between exclusive and sequential reuse are illustrated in Figure 4.

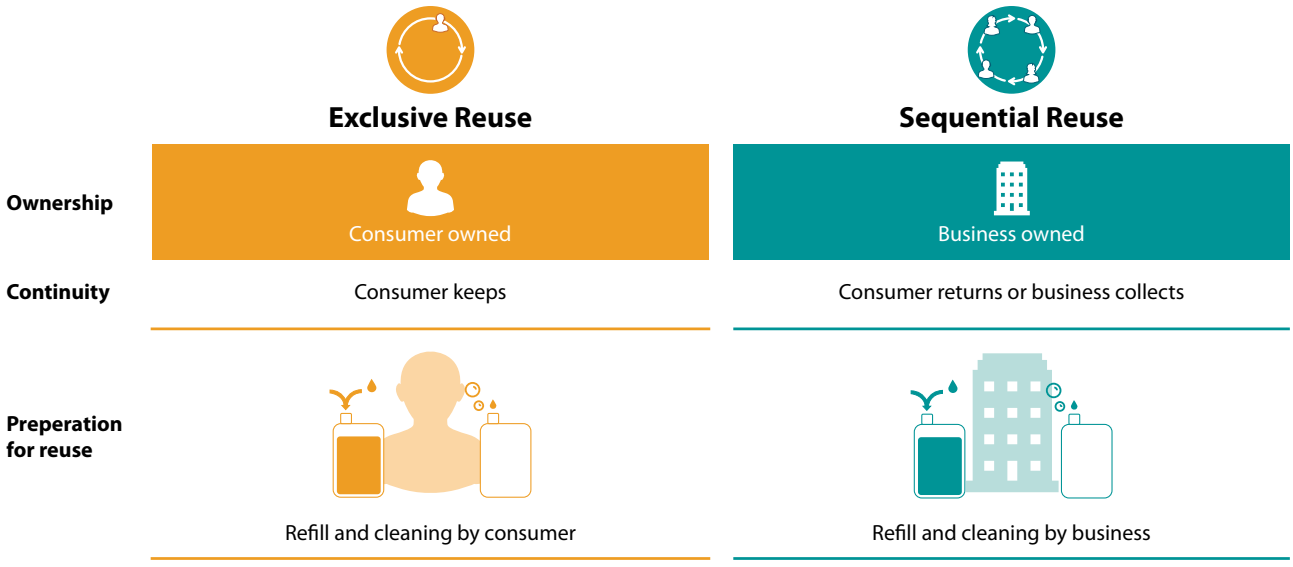


Figure 4 - Differences between exclusive and sequential reuse

3.1.1 Framework by Muranko et al. (2021)

Muranko et al. (2021) analysed ninety-two reuse offerings with the aim of developing a characterisation of reuse models. Based on the analysis, they developed a framework consisting of five main reuse models (see Figure 5), namely Model 1: Exclusively reused products, Model 2: Exclusively reused products with reuse-enabling infrastructure, Model 3: Reuse-enabling infrastructure for exclusively reused products, Model 4: Sequentially reused products with reuse-enabling infrastructure and Model 5: Sequentially reused products.

The framework is divided into three system elements: reuser behaviour, reusable product and reuse-enabling infrastructure. The first system element, reuser behaviour, divides the reuse models into two groups: exclusively reuse products and sequentially reuse products. The second element, reusable product, distinguishes the models based on ownership of the product: consumer owned or business owned. The third element, reuse-enabling infrastructure, distinguishes the models based on the infrastructure provided for the preparation and recovery of reusable products.

Preparation for reuse typically involves refilling the reusable product with a consumable. Recovery for reuse typically involves cleaning and maintaining the reusable product, so it is ready for the next reuse cycle. Preparation for reuse and recovery for reuse can be consumer or business operated.

Model 1: Exclusively reused products – This model represents offerings that provide consumers with a reusable product only. An example of a model 1 offering is a refillable water bottle, such as the one from Dopper (Picture 1, Figure 5). This durable bottle can be refilled with infrastructure available to the consumer, for example a tab or a water dispenser.

Model 2: Exclusively reused products with reuse-enabling infrastructure – This model represents offerings that provide consumers with a reusable product and a reuse-enabling infrastructure. An example of a model 2 offering is the kitchen beverage maker SodaStream (Picture 2, Figure 5). The SodaStream offering consists of a reusable product (the bottle) and an assistive appliance (the dispenser) which are owned by the user. Preparation for reuse activities are consumer-operated. The consumer needs to combine carbon dioxide, flavouring and water to prepare a beverage.

Model 3: Reuse-enabling infrastructure for exclusively reused products – This model represents offerings that provide consumers with reuse-enabling infrastructure only. The offering is either an assistive appliance or an assistive product. An example of a model 3 offering are the dilutable refill pouches from Ocean Saver (Picture 3, Figure 5). These refill pouches supply reusable bottles with detergents in concentrated form.

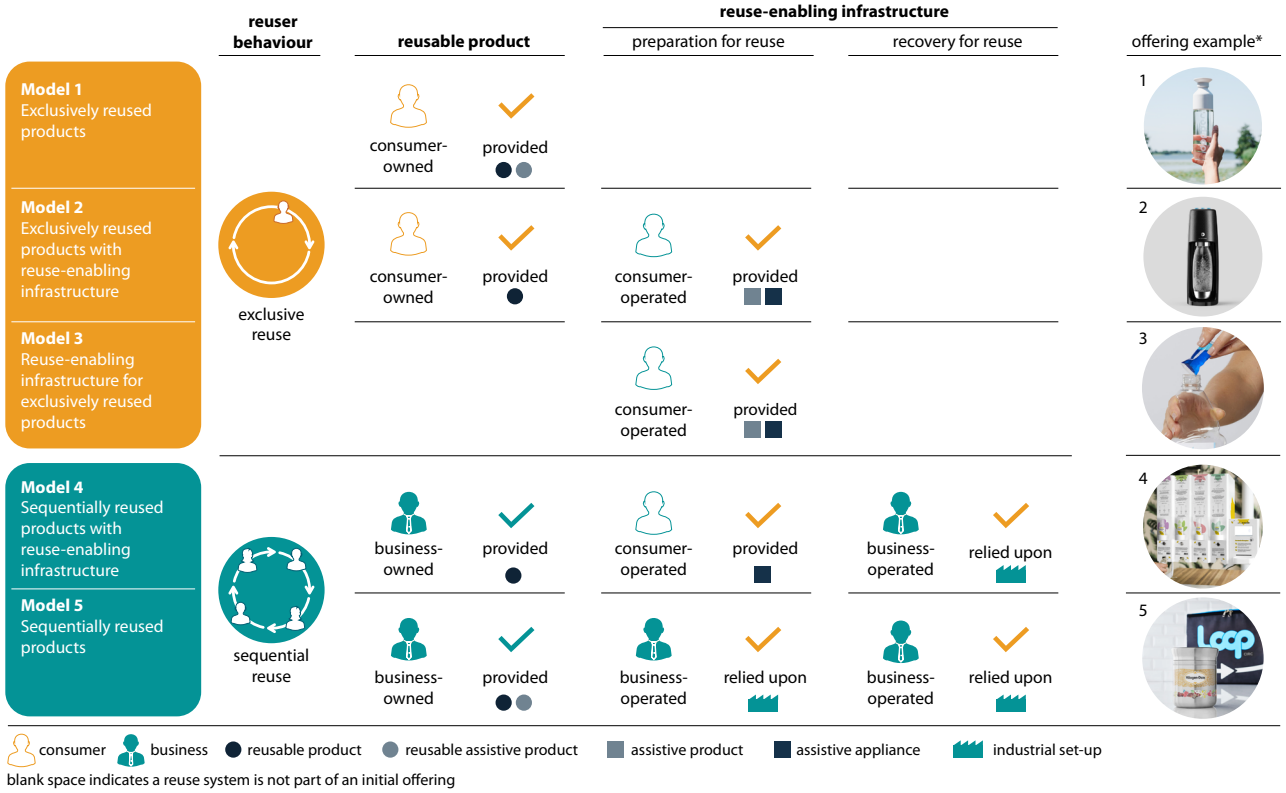


Figure 5 - Reuse model framework adapted from Muranko et al. (2021)

Model 4: Sequentially reused products with reuse-enabling infrastructure – This model represents offerings that provide consumers with reusable product and reuse-enabling infrastructure. Preparation for reuse is performed by the user, through a consumer-operated assistive appliance. Recovery for reuse is performed by the business through a business-operated industrial set-up. The reusable product and the assistive appliance are shared among consumers. An example of a model 4 offering is the in-store refill dispenser station by Cozie (Picture 4, Figure 5). Consumers refill bottles through the refill station (preparation for reuse) and return the empty bottles at a specific location when they are empty. The business then cleans the product (recovery for reuse) to bring it back to a usable state.

Model 5: Sequentially reused products – This model represents offerings that provide consumers with a reusable product only. In this model, the reusable product is always ready for consumption. Preparation and recovery for reuse are performed by the business through an provider-operated industrial set-up. An example of a model 5 offering are the sequentially reused durable vessels containing foods by Loop (Picture 5, Figure 5).

3.1.2 Framework by EMF (2019)

The Ellen MacArthur Foundation (EMF) (2019) developed a framework consisting of four B2C reuse models, namely refill at home, refill on the go, return from home, and return on the go (Figure 6). There are two core behaviours performed by consumers that differentiate the models into two categories: 'refill' on the one hand and 'return' on the other hand. They also distinguish the models in terms of ownership: for refill at home and refill on the go models the packaging is consumer owned and in return from home and return on the go models the packaging is business owned.

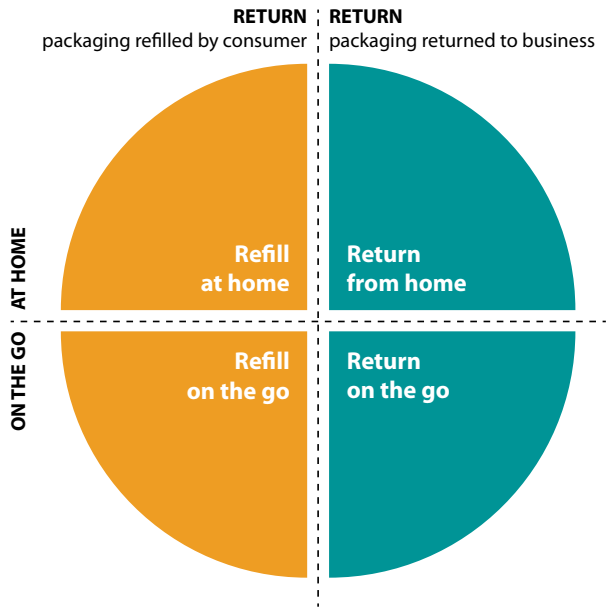


Figure 6 - Reuse model framework adapted from EMF (2019)

Refill at home – In refill at home models consumers refill their reusable containers at home, with refills delivered at home or bought in a store. An example of a refill at home model offering is a durable water bottle, which can be refilled by using tab water from the kitchen. Typical activities involved in refill at home models are depicted in Figure 7 on the next page.

Refill on the go – In refill on the go models consumers refill their reusable containers away from home. An example of a refill on the go model offering is a juice dispenser station in a supermarket, where consumers can bring their own durable bottles to be refilled on location. Typical activities involved in refill on the go models are depicted in Figure 8 on the next page.

Return from home – In return from home models empty packaging is picked up from home by a pick-up service. An example of a return from home offering are the durable packaging containers by, previously mentioned, Loop: consumers buy products in luxurious packaging that is delivered to and picked-up from their doorsteps when empty. Typical activities involved in return from home models are depicted in Figure 9 on the next page.

Return on the go – In return on the go models consumers return the empty packaging at a store or drop-off point (e.g. in a deposit return machine or mailbox). A well-known example of a return on the go offering is the beer deposit system by for example Heineken and Grolsch in the Netherlands: users buy a crate of beer and return the empty bottles at a deposit return machine at their local supermarkets. Typical activities involved in return on the go models are depicted in Figure 10 on the next page.

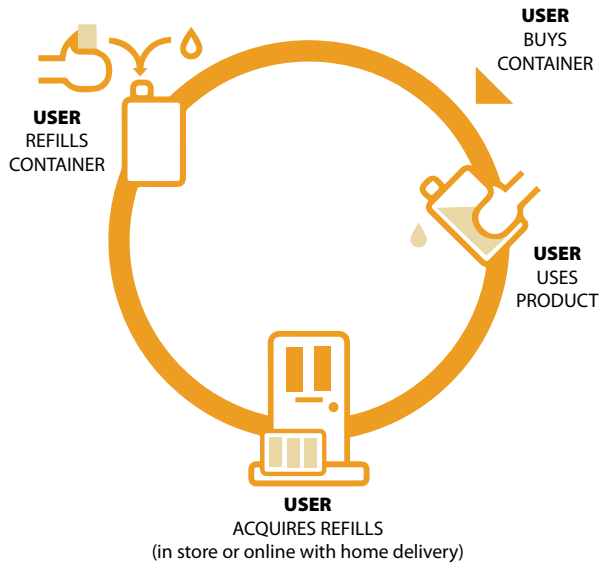


Figure - 7 Refill at home adapted from EMF (2019)

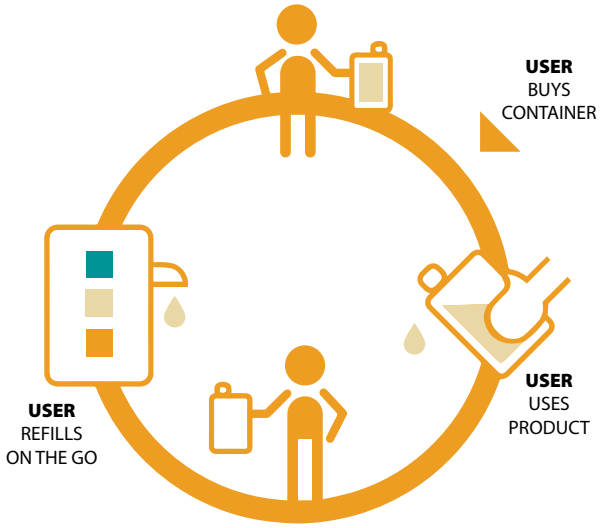


Figure - 8 Refill on the go adapted from EMF (2019)

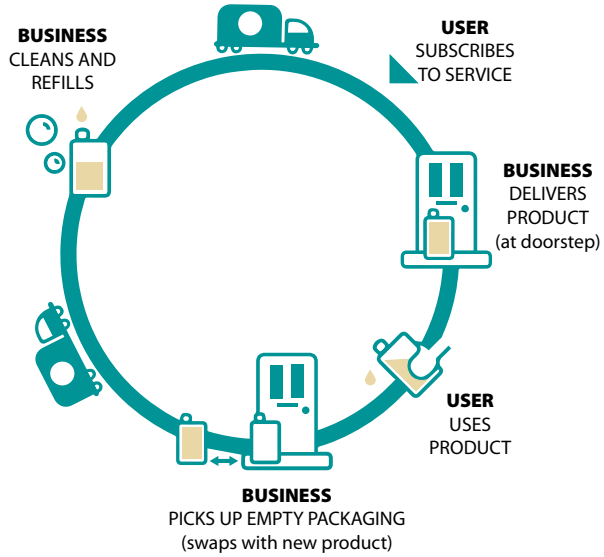


Figure 9 - Return from home adapted from EMF (2019)

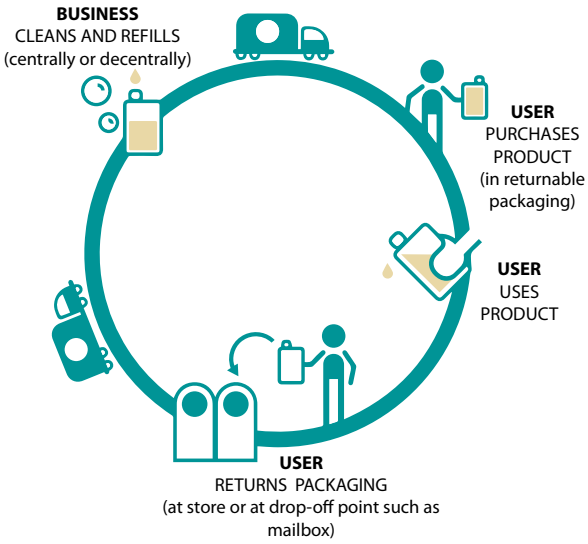


Figure 10 - Return on the go adapted from EMF (2019)

3.1.3 Framework by Coelho et al. (2020a)

Coelho et al. (2020a) classified reusable packaging systems into four reuse models, namely Refillable by Bulk Dispenser or Zero-Waste, Refillable Parent Packaging, Returnable Packaging and Transit Packaging. They further divided the four models into two groups that give continuity to reusable systems: Reused by Consumer and Taken back by Business (see Figure 11). Systems classified under Reused by Consumer depend only on the consumer to continue the reuse cycles. Refillable by Bulk Dispenser and Refillable Parent Packaging fall under the Reused by Consumer Category. Systems classified under Taken back by Business depend also on the involvement of the company to continue the reuse cycles, and require reverse logistics and infrastructure to take-back, clean and maintain the packaging. Returnable Packaging and Transit Packaging fall under the Taken back by Business category. Coelho et al. (2020a) indicate that a reusable packaging can fit two categories at the same time. For example, a brand's container used for bulk dispensing can be refilled and used several times by one consumer before being returned to the business to be cleaned.

	Reused by Consumer		Taken back by Business	
Packaging type	Refillable Parent Packaging	Refillable by bulk dispenser	Returnable Packaging	Transit Packaging
Packaging description	**Bottle, container, pouch, pod, tablet, powder.** The refill packaging is made with less material than the parent packaging. Parent packaging can be refilled by: • Pouring product inside parent packaging; • Placing container inside of parent packaging; • Diluting concentrated product in water inside parent packaging.	**Container, bottle, cup.** Customers use their own reusable packaging or the branded refillable packaging provided in-store or at a mobile truck thereby avoiding the need to produce new packaging.	**Container, bottle, cup, plate, bowl.** Customers return empty packaging that will be cleaned and refilled for future use by the business/provider retailer/producer which can be combined with a deposit system to provide a financial incentive.	**Boxes, containers, soft packages.** Customers receive the product in reusable packaging, which is returned by door delivery/pick up, or through the post office. **Crates, pallets, wrappers** Customer reuses packaging multiple times before beign returned to the producer or disposed of.
Product examples	Make-up, dental floss, tooth and mouth wash tabs, cleaning products, cosmetics, hair care products, flavoured water, deodorant, perfume.	Cereals, grains, candy, wine, juice, mineral water, beer, olive oil, detergent, soap, hair care products, body and face lotion.	Beer, soft drinks, mineral water, perishables, detergent, soap, cosmetics, hair care products. Reusable cups, containers, plates (for events, cafes, restaurants)	Reusable packaging for transport or shopping of perishables or non-perishables.

Figure 11 - Classification of reusable packaging adapted from Coelho et al. (2020a)

3.2 Combined reuse model framework

The three distinct frameworks of Muranko et al. (2021), Ellen MacArthur Foundation (2019) and Coelho et al. (2020a) were combined into one framework as a foundation for this thesis project, see Figure 12. This frameworks divides reuse models into two main categories: exclusive and sequential reuse as depicted by Muranko et al. (2021). Reusable packaging systems based on exclusive reuse are further divided into the models refill at home and refill on the go and reusable packaging systems based on sequential reuse are further divided into the models return from home and return on the go as depicted by Ellen MacArthur Foundation (2019). The different reuse models are linked to the packaging types as described by Coelho et al. (2020a)

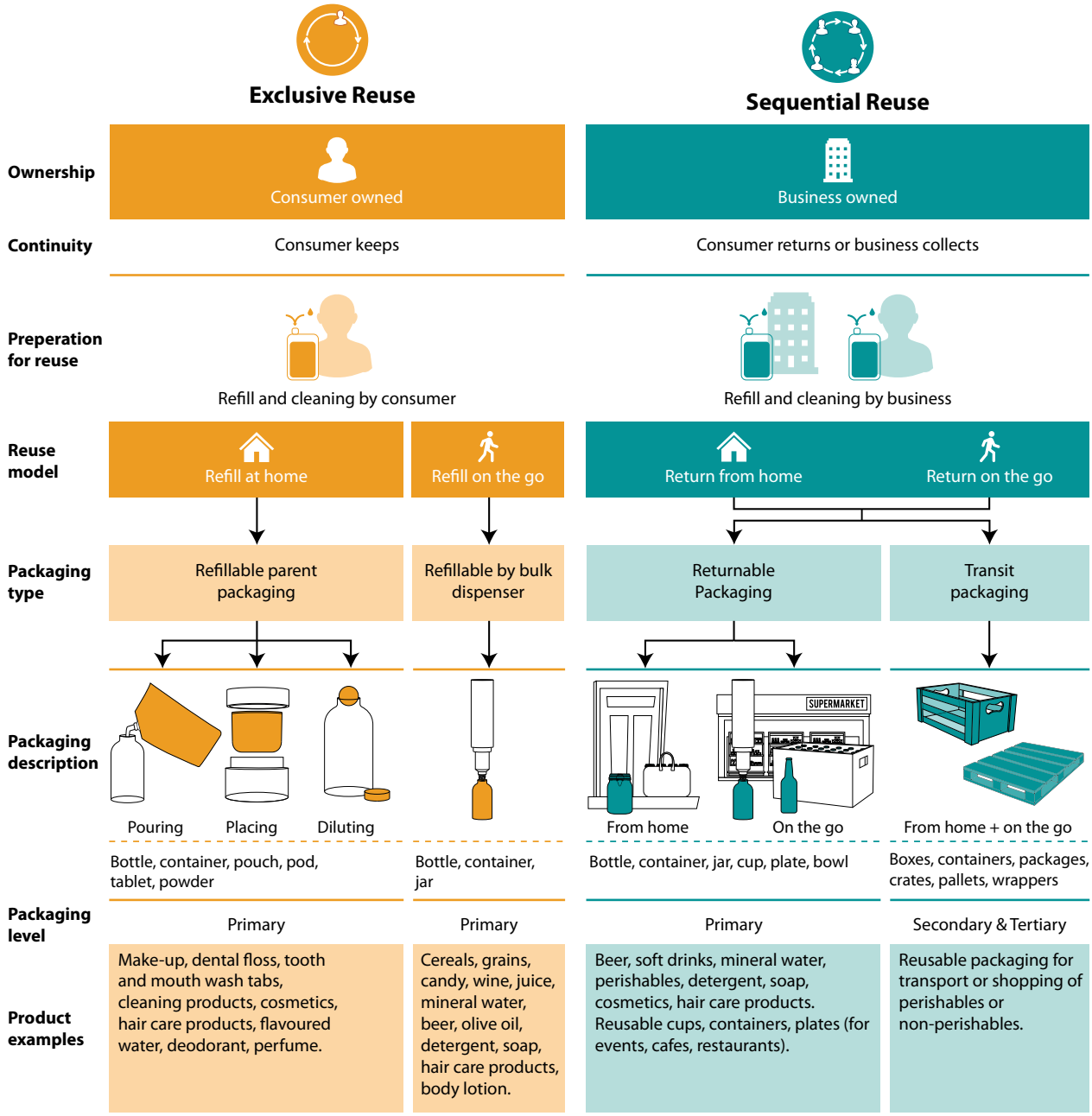


Figure 12 - Combined reuse model framework based on Muranko et al. (2021), EMF (2019) and Coelho et al. (2020a)

3.3 Waste of reuse models

Greenwood et al. (2020) ranked the different reuse models in terms of anticipated packaging waste generated, of which an adaptation is shown in Figure 13. The product delivery that generates the most waste is single-use. To the right of that is repurpose, when packaging is used for a secondary purpose other than for which it was conceived. To the right of repurpose there is refill at home. Refills at home with a refillable parent packaging still require a single-use packaging component (e.g. a pouch, a small container or a pod, see Figure 12 on the previous page) to refill, which is why it has been placed to the right of single-use and repurpose. Refill on the go has been placed to the right of refill at home, because this type of refill does not require a single-use packaging component. The product offerings that generate even less amount of waste are placed to the right of refill on to go and are return from home and return on the go. Return from home or on the go systems with collective pool systems create the least amount of waste and are therefore placed to the right from return from home or on the go with single company ownership.

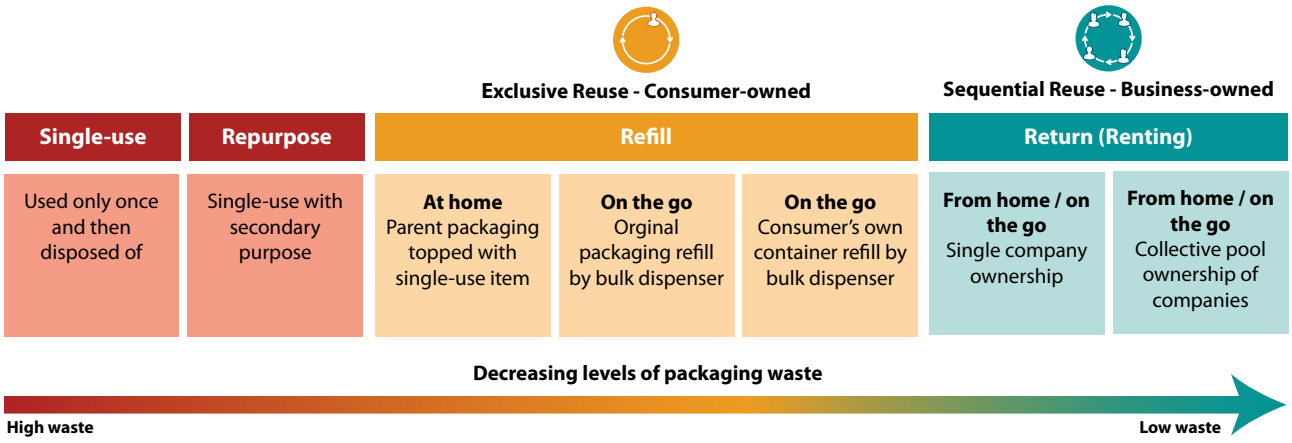


Figure 13 - Anticipated packaging waste from single-use to reuse adapted from Greenwood et al. (2020)

Chapter 4
Reuse systems

This chapter discusses the available literature on reusable packaging systems. A distinction is made between reusable primary packaging on the one hand, and reusable secondary and tertiary packaging on the other hand. In section 4.1 the differences and similarities as described by Carrasco-Gallego et al. (2012) between reusable primary and secondary and tertiary packaging are briefly discussed. Section 4.2 discusses reusable secondary and tertiary packaging systems in more detail. Section 4.3 discusses reusable primary packaging systems in more detail by analysing current market offerings through customer journey mapping.

4.1 Differences and similarities

Primary reusable packaging is in direct contact with the product the end customer wants to consume (or at least parts of it). Secondary and tertiary packaging are not in direct contact with the product consumed by the end customer and are used to transport items. They are also referred to as returnable transport items (RTI) or as transit packaging as mentioned in section 3.2. Because reusable secondary and tertiary packaging are not in direct contact with the product to be consumed, these packaging solutions tend to be standardised, and reusable primary packaging less so. As primary packaging is in direct contact with the product to be consumed it makes it more difficult to standardise, also because of marketing and technical reasons. From a marketing perspective, primary packaging designs are used by brands to differentiate from its competitors and therefore standardisation is often less desirable. From a technical perspective, primary packaging protects specific products with specific dimensions and needs, making standardisation more difficult. Another difference is that reconditioning of primary packaging (such as cleaning and inspection) tends to be more difficult for primary packaging than for secondary and tertiary packaging, due to the fact that primary packaging is in direct contact with the product to be consumed. Therefore, reusable primary packaging needs more thorough cleaning (Carrasco-Gallego et al., 2012). Despite the differences between the different types of reusable packaging (primary vs secondary and tertiary) there are also similarities: in sequential reuse systems primary, secondary and tertiary packaging share the same logistical characteristics (Carrasco-Gallego et al., 2012). To indicate, in sequential reuse systems return and reconditioning activities need to be organized and return rates need to be maximized. This means that results obtained from one type, can be extended to all types of reusable packaging

4.2 Secondary and tertiary systems

Only a couple of studies have focused on the logistics system of reusable packaging, of which most revolved around reusable secondary and tertiary packaging (Carrasco-Gallego et al., 2012). The aspects of ownership and responsibility (of managing, cleaning, controlling, maintaining and storing containers) are determinants of the design of the return logistics system (Mahmoudi & Parviziomran, 2020). The study by Kroon & Vrijens (1995) focuses on the organizational design of the reuse of secondary packaging material. Although returnable secondary packaging can be different things, such as crates, containers or wrappers, they use the term returnable containers, irrespective of the actual type of the returnable packaging. They provide an in-depth discussion and an overview of potential return logistics systems. Return logistic systems are divided into three categories: switch-pool systems, systems with return logistics (including transfer and depot systems) and systems without return logistics (Kroon & Vrijens, 1995). Systems with return logistics will be described here, due to their applicability for primary packaging systems. As they are less applicable for primary reusable packaging systems, switch-pool systems and systems without return logistics can be found in **Appendix A: Additional reverse logistics systems.** Carrasco-Callego et al. (2012) classified return logistics systems into two categories: star systems and multi-depot systems, which will be discussed here as well as they resemble the systems with return logistics as described by Kroon & Vrijens (1995).

4.2.1 Systems with return logistics

In a system with return logistics the containers are owned by a third-party, such as a central agency. The agency is responsible for the return of the empty containers after they have been emptied by the recipient. The agency can also subcontract logistic operations to a logistics service organization. In this system, the recipient is expected to bundle and store empty containers until a sufficient number of containers has accumulated for cost-effective collection. Depending on the role of the central agency, Kroon & Vrijens (1995) depict two variants of systems with return logistics: a transfer system and a depot system. Figure 14 provides an overview of the characteristics of systems with return logistics.

Transfer system – In the transfer system, the sender always uses the same containers. The central agency is only responsible for the return of the containers from recipients to sender. The other responsibilities, such as cleaning, tracking and tracing, administration, maintenance and storage lie with the sender. The sender also needs to take care that the stock levels of containers are adequate. Suppose a sender wants to send goods to a specific recipient. The information and goods flow related to the transfer system are presented in Figure 14 below. The sender notifies the agency of the fact that he wants to use their reusable containers (1). Then, the agency notifies the carrier and the desired number containers are transported to the sender (2). The sender packs the goods in the containers and the carrier transports the goods to the recipient (3). After the recipient has received the delivery, he notifies the agency (4). The agency notifies the carrier that the empty containers are ready to be picked up (5). The carrier collects the containers from the recipient and returns them to the sender (6). Before the next delivery, the sender cleans and maintains the container. From here onwards, for all the deliveries to come only step 3 until 6 are repeated as the sender always uses the same containers.

Depot system – In the depot system, the containers that are not in use are stored at container depots owned by the agency. When a sender needs containers, the appropriate amount is shipped from the depot to the sender. After these containers have been transported to the recipient, the empty containers are collected and returned to a container depot. The containers are then cleaned and maintained at the container depot to be used for next shipments. Kroon & Vrijens (1995) described a depot system with a deposit structure in detail. The information and goods flow related to this system are represented in Figure 14 below. A sender wants to send goods to a specific recipient and wants to use returnable containers to pack these goods. First, the sender lets the agency know that he wants to use their returnable containers (1). Then, the agency lets the logistics service organization know that the containers need to be delivered to the sender (2). Afterwards, the logistics service organization transports the desired number of containers from the nearest container depot 1, to the sender (3). The sender packs the goods and sends the goods to the recipient (4). When the recipient receives the containers, he lets the agency know (5). Then,

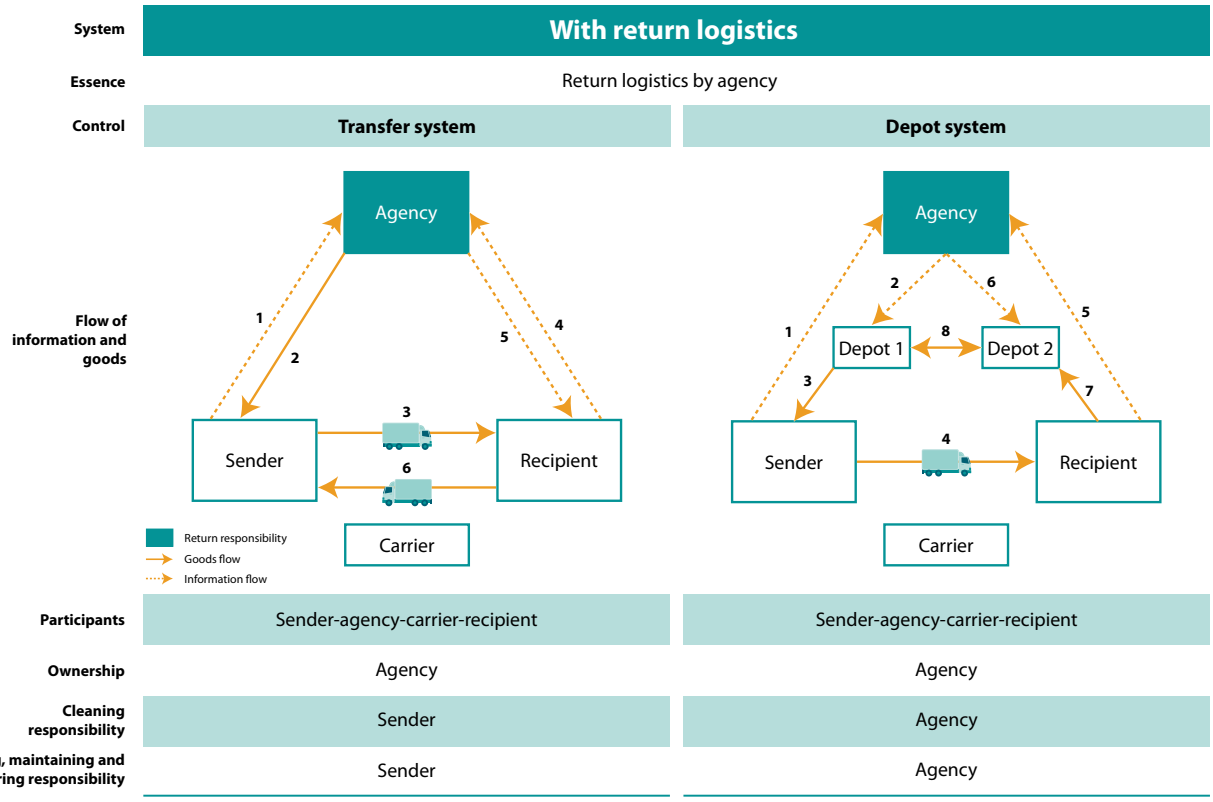


Figure 14 - Characteristics of systems with return logistics developed from Kroon & Vrijens (1995)

the agency notifies the logistics service organization to organize a pick-up (6). The logistics service organization collects the containers from the recipient and delivers them at the nearest container depot 2 (7). The containers are cleaned and maintained at this container depot. It is important that the appropriate numbers of containers are in stock at the container depots. The logistics service organization is responsible for this. Therefore, if at some point there is an unbalance between the depots, a number of containers may have to be relocated between depots to solve the unbalance (8).

4.2.2 Star systems and multi-depot systems

As previously mentioned Carrasco-Callego et al. (2012) only use two categories to classify return logistics system networks: star systems and multi-depot systems. Figure 15 depicts the difference between the two network models. In star systems, reusable articles return to the same plant or depot from where they were originally issued after they are used. In multi-depot systems, the reusable articles do not need to be returned to the depot where they were origanally issued. The multi-depot structure is similar to the depot structure depicted by Kroon and Vrijens (1995).

In star systems, the central depot D either directly supplies to end customers (C1) or supply indirectly via intermediate distributors (d1, d2). These intermediate distributors supply to the end customers in a given region (C2 to C6). No matter what forward flow the reusable article takes, they are always returned to the central depot D. Here they will receive reconditioning operations, such as inspection, maintanance, sterilisation and refilling.

In multi-depot systems, returnable articles are issued from a depot (D1, D2), used by several customers in the supply chain (C1 and C2, C3 and C4). After the customers have used the article, they can be returned to any depot in the network. To indicate, the reusable article can be returned to a depot that did not issue the article (D1-C1-C2-D2 flow) or it can return to the orginal sender (D2-C3-C4-D2 flow). An example of a reusable article that makes use of this network are consumer goods pallets (Carrasco-Gallego et al., 2012). Empty pallets are send to manufacturer C1, who uses the pallet to pack his goods and then delivers the loaded pallets to the retailer C2. The retailer sends the empty pallets back for reconditioning to any depot in the network. Two examples of companies that use multi-depot networks are CHEP and ContainerCentralen.

Concluding, in the multi-depot system all depots must be able to perform reconditioning and preparation for reuse activities. In star-systems, only one depot has this responsibility. The simpler the reconditioning activities the more favourable a multi-depot system becomes. For secondary and tertiary packaging (RTI) this is usually the case as these have relatively simple reconditioning activities: inspection, cleaning and minor repairs.

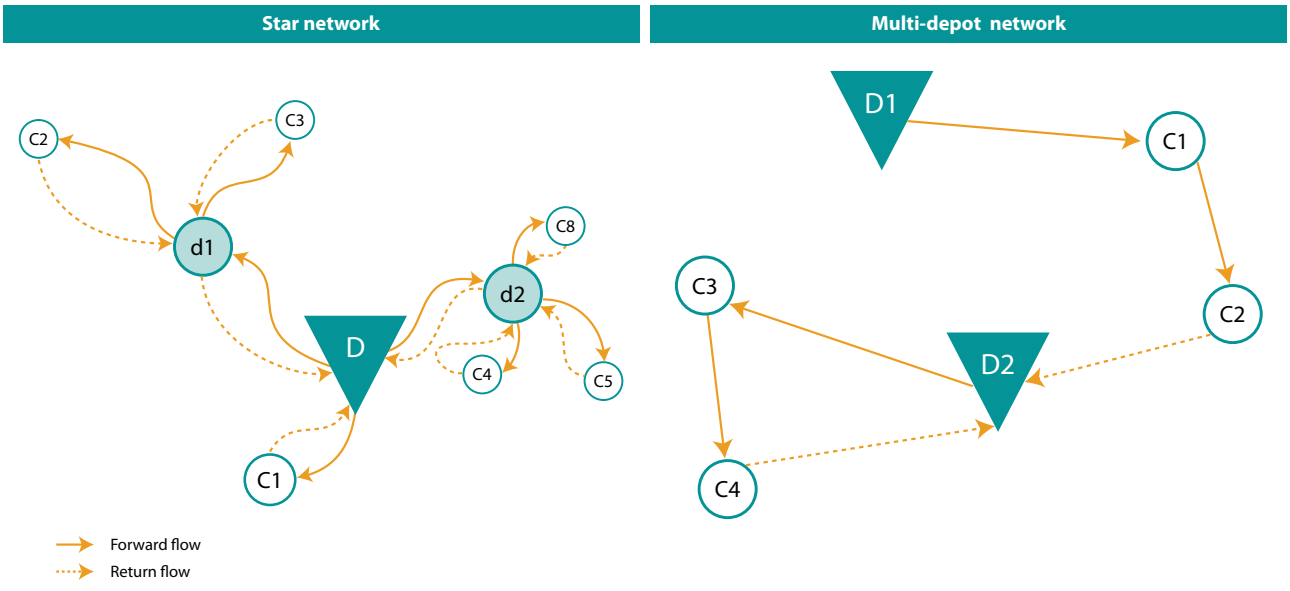


Figure 15 - Star network vs multi-depot network adapted from Carrasco-Callego et al. (2012)

4.3 Primary systems

In the year 2022 several reusable primary packaging offerings exist. This section focuses on six distinct offerings. The combined reuse model framework as depicted in section 3.3 is used to select the different primary reusable packaging offerings, so that each branch in the framework is represented. In Table 1 the chosen offerings and corresponding models are summarized.

Offerings are depicted by means of a customer journey map. A customer journey map is a visual representation of all the stages customers go through when interacting with a product (Van Boeijen et al., 2013). Through the customer journey maps the different offerings can be compared in terms of user activities, user touchpoints and user efforts. User effort is assessed on the distance a consumer has to travel to return the product and how much effort it takes to prepare the product for use.

Zeeuw van der Laan and Aurisicchio (2019) have depicted the customer journey maps of several FMCGs. They showed the FMCGs' complete use cycle divided into three stages, namely purchase, use and disposal. Furthermore, they listed several activities per stage. These stages and corresponding activities are adopted in this research. The stages and corresponding activities are as follows and occur in sequence:

- ***Purchase stage:*** visit (web)shop, choose product, prepare, purchase, become owner, stock
- ***Use stage:*** remove, prepare, consume, maintain
- ***Disposal stage:*** remove, stock, prepare, transit, detach

It is worth noting that the activities 'become owner' and 'consume' always occur but that other activities not always occur in the different offerings.

4.3.1 Exclusive Reuse

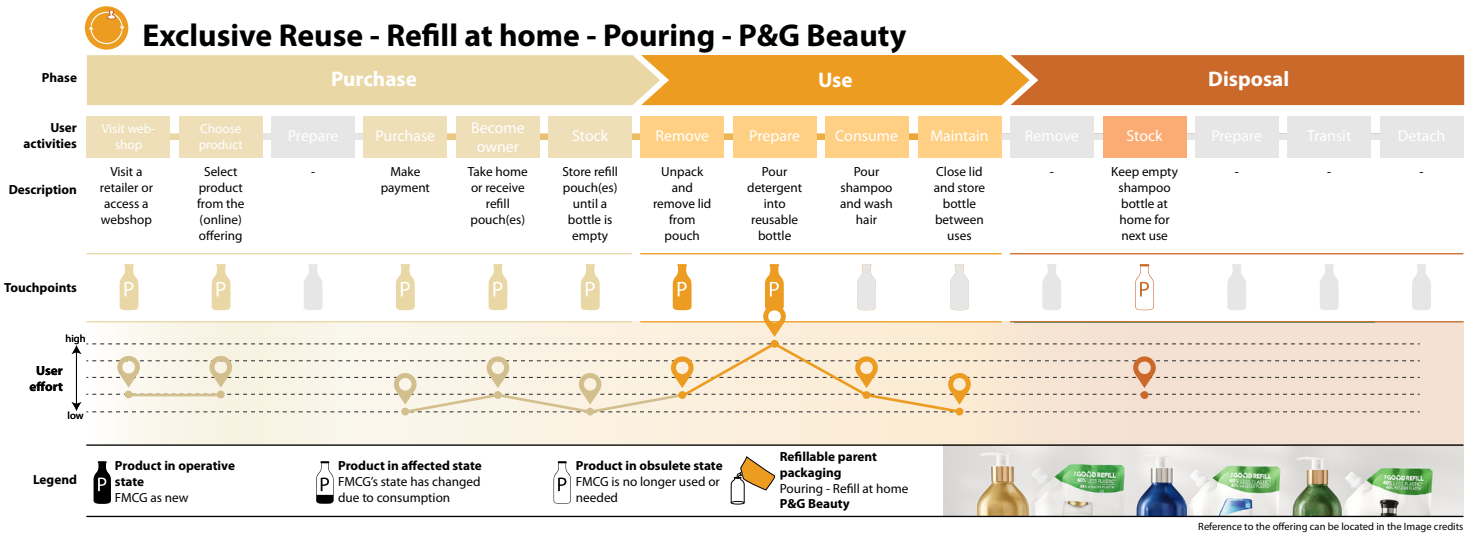
Refill at home – Refillable parent packaging by pouring
The example used for this customer journey are the refillable pouches and reusable aluminium bottles by P&G Beauty. As visible from the customer journey the highest required user effort is in the use stage, where users need to pour product into their bottles (see Figure 16 on the next page).

Refill at home – Refillable parent packaging by placing
The example used for this customer journey are the body cream refills by Rituals. As visible from the customer journey the highest required user effort is in the use stage, where users need to place the refill container in the parent packaging (see Figure 17 on the next page).

Refill at home – Refillable parent packaging by diluting
The example used for this customer journey are the dilutable and dissolvable tablets and pouches by Ocean Saver. As visible from the customer journey the highest required user effort is in the use stage, where users have to mix the refill with water in the bottle (see Figure 18 on the next page)

Table 1 - Selected primary packaging offerings

	Primary reuse model	Packaging type	Offering
Exclusive reuse	Refill at home	Refillable parent packaging by *pouring*	P&G Beauty
	Refill at home	Refillable parent packaging by *placing*	Rituals
	Refill at home	Refillable parent packaging by *diluting*	Ocean Saver
Sequential reuse	Refill on the go	Refillable by bulk dispenser	Ecover
	Return from home	Returnable packaging	Pieter Pot
	Return on the go	Returnable packaging	Grolsch



Reference to the offering can be located in the Image credits

Figure 16 - Customer journey for P&G Beauty's refillable shampoo bottles

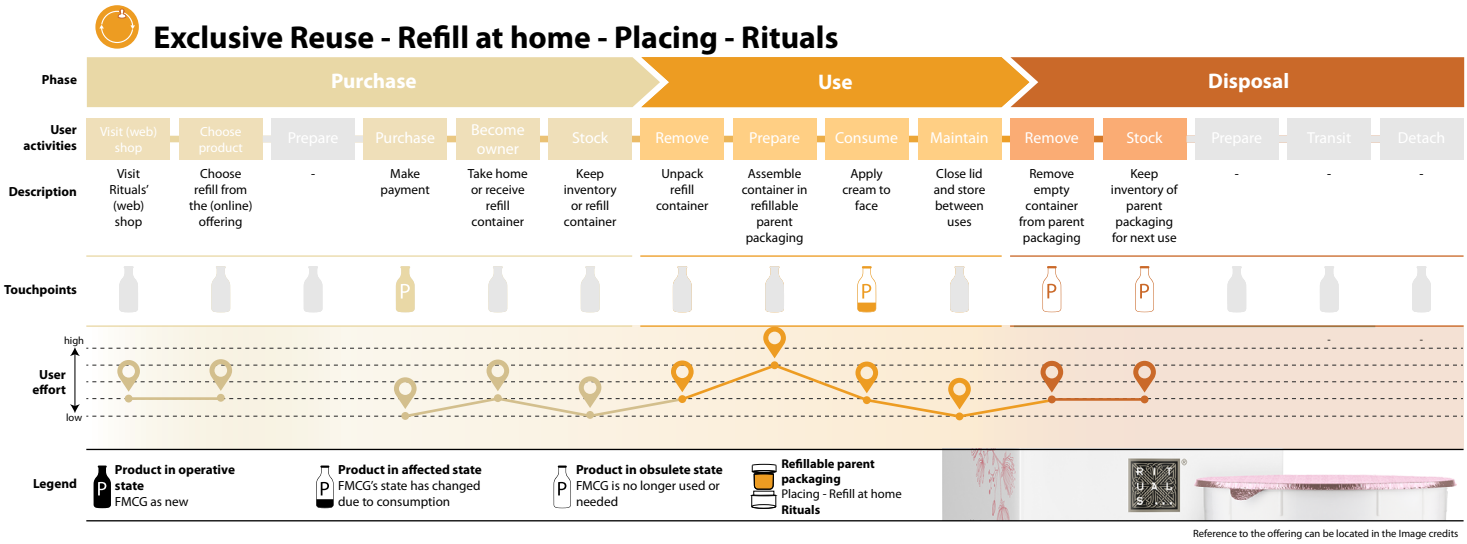


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Figure 17 - Customer journey for Rituals' body cream refills

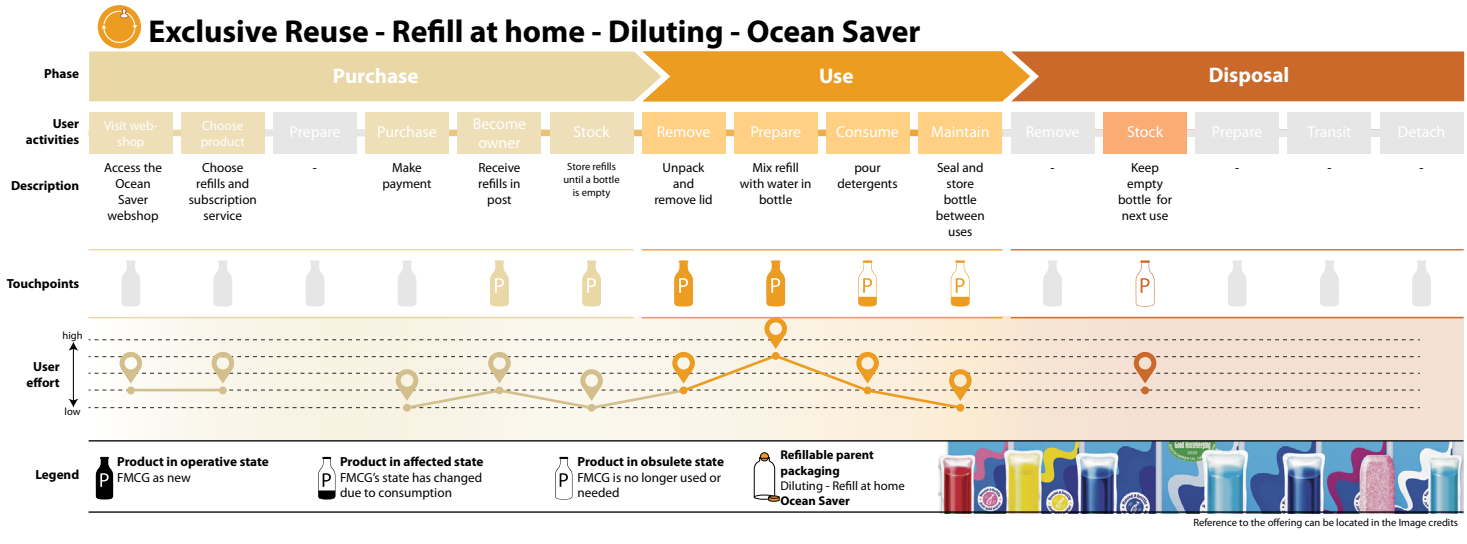

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Figure 18 - Customer journey for Ocean Saver's dilutable refills

Refill on the go – Refillable by bulk dispenser
The example used for this customer journey are the bulk refillable bottles by Ecover. As visible from the customer journey the highest required user effort is in the purchase and disposal stage (see Figure 19 on the next page). In the purchase stage people have to visit a retail to (re)fill their bottles from a bulk dispenser. In the disposal stage the bottle has to be taken back to the retailer to refill.

4.3.2 Sequential Reuse

Return from home – The example used for this customer journey is the online circular market place Pieter Pot from the Netherlands. Pieter Pot fills preserving jars with bulk product which they receive from producers and offers them to the consumer. As visible from the customer journey the required user effort remains low (see Figure 20 on the next page). User do not need to do any preparation activities, nor do they have to leave their house to refill or return the packaging. According to Schoemaker (2020), founder of Pieter Pot, a true circular packaging system needs to be "econvenient" (eco-friendly and convenient). This means that using the service should not cost the consumer extra time, money or effort

Return on the go – The example used for this customer journey are deposit beer bottles from the Dutch brewery Grolsch. As visible from the customer journey the highest required user effort is in the disposal stage, where users have to take the beer crates to the retailer and place it in a reverse vending machine to get their deposit back (see Figure 21 on the next page)

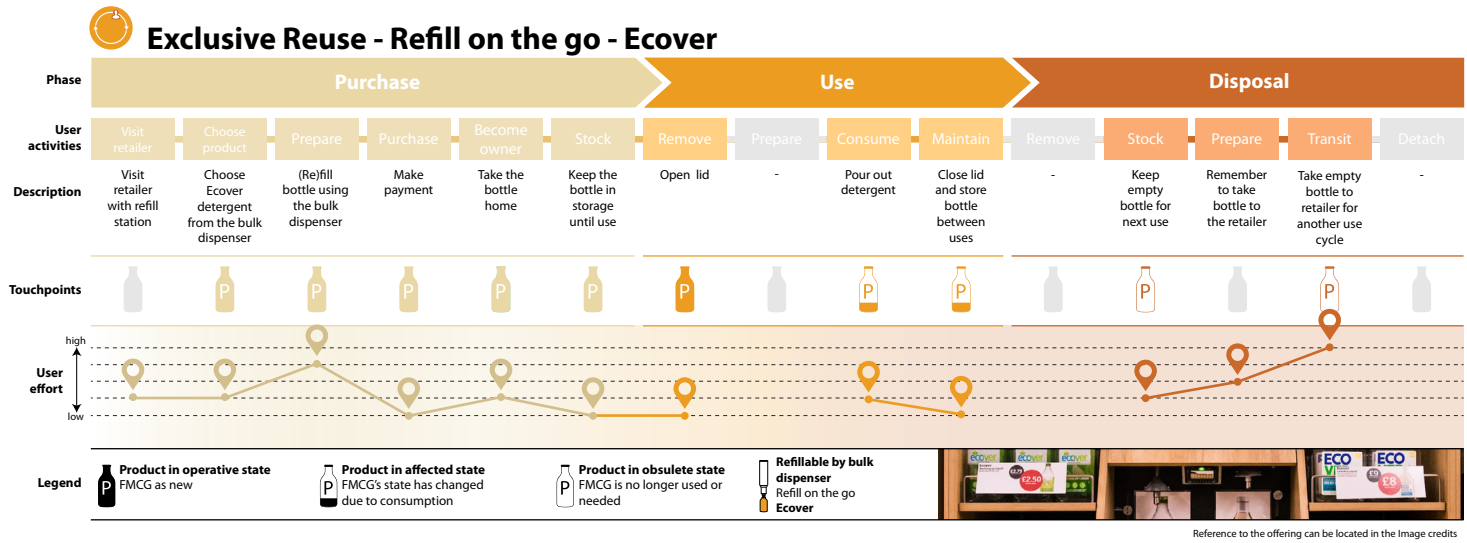

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Figure 19 - Customer journey for Ecover's refillable detergents

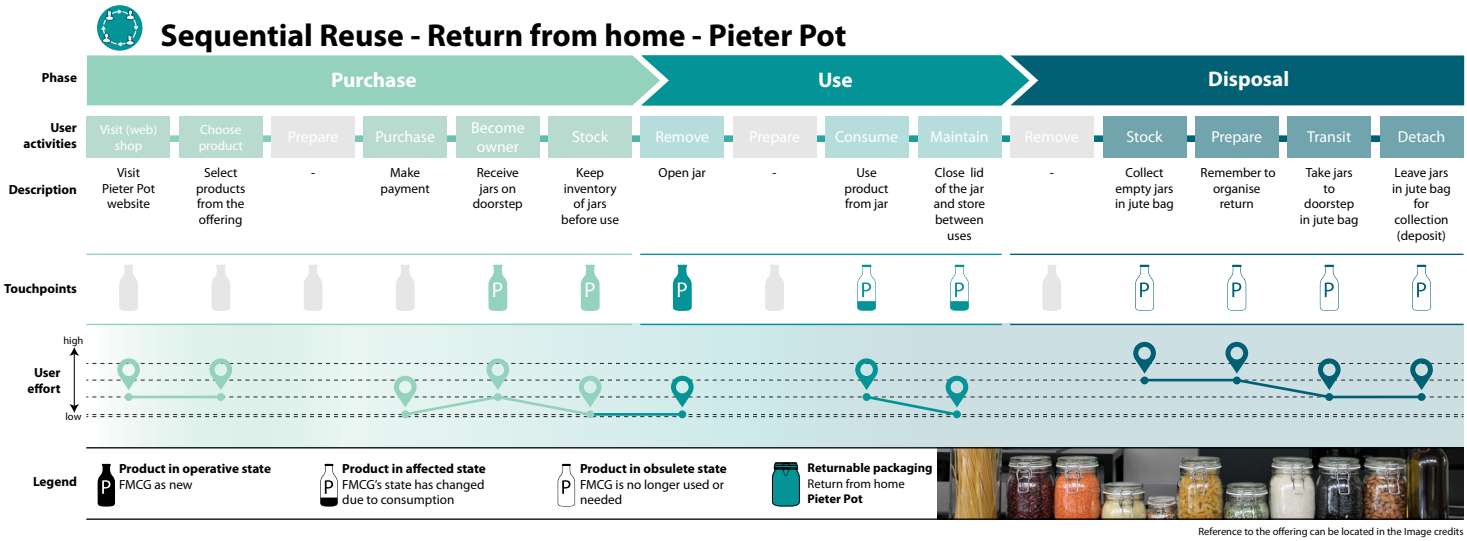

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Figure 20 - Customer journey for Pieter Pot's reusable jars

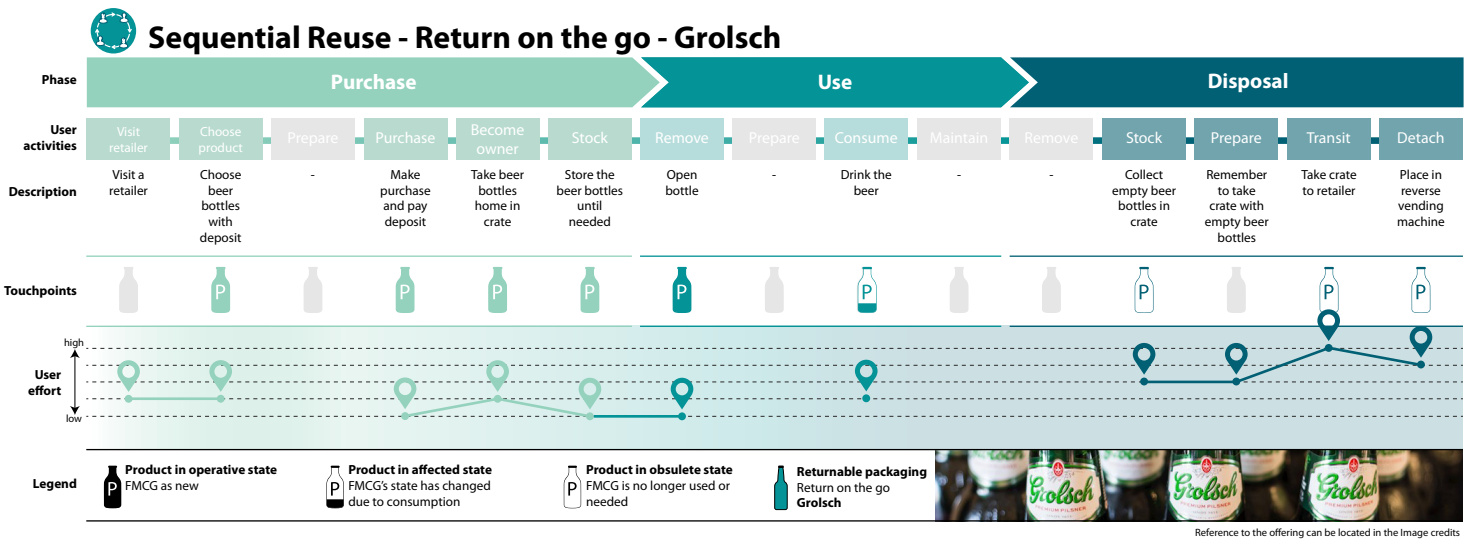

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Figure 21 - Customer journey for Grolsch' beer bottles

Chapter 5
Reuse factors

This chapter elaborates on the factors that play a role in the viability and the successful development of primary reusable packaging systems. These factors are applicable for reusable packaging sold through traditional retail as well as reusable packaging sold through e-commerce. The factors are divided into six categories: Economics, Logistics, Environment, Packaging Design, Consumer and Legislation as depicted in Figure 22. The factors are interlinked and influence each other inside as well as outside of their own category.

The factors involved in reuse systems are depicted in the overview in Figure 23 on the next page.The arrows illustrate relationships between factors. The categories and their associated factors and relationships will be addressed separately and in more detail further on in this chapter. It is worth noting that category membership of a factor does not mean the factor solely impacts factors belonging to that category. For example, the factor 'material and material extraction' is classified under environment as the choice of material deeply influences the environmental impacts of a reuse system and end-of-life waste management strategy, such as whether a packaging is recyclable or not. However, material choice does not solely affect the environmental impact of a system; in terms of economics the choice of material also affects the cost price of the packaging and in terms of packaging design the choice of material affects the look and feel and durability of a packaging.

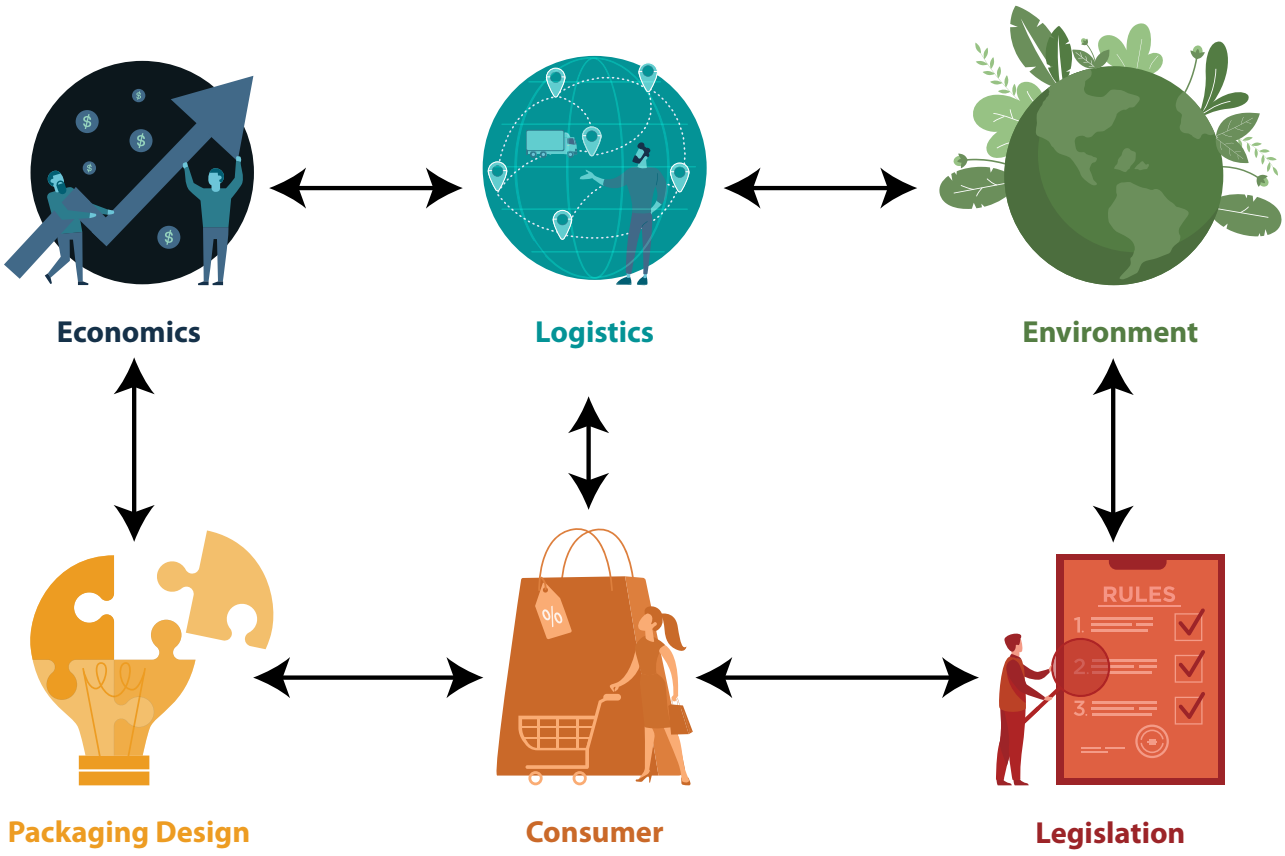


Figure 22 - Reuse factor categories

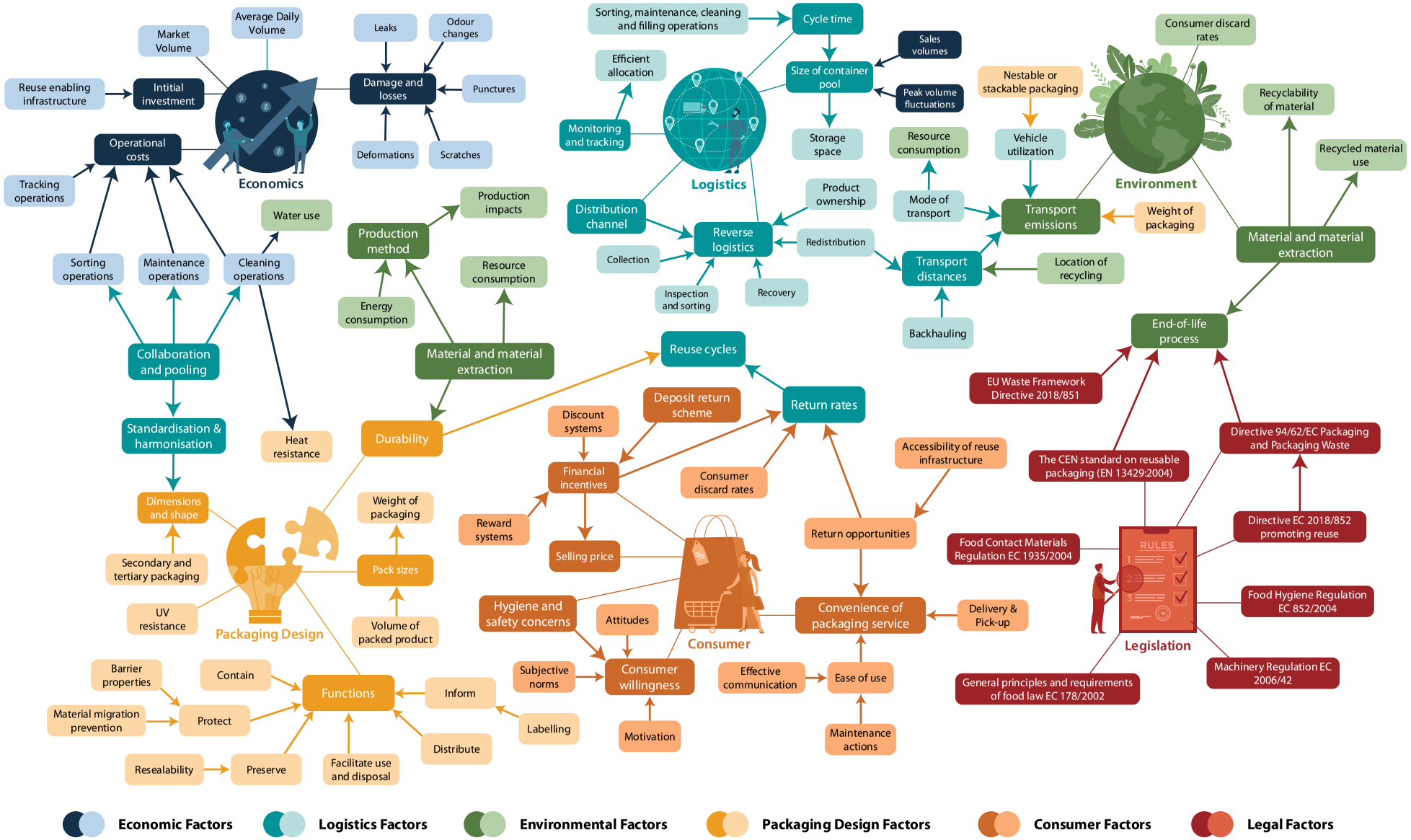


Figure 23 - Reuse factors overview

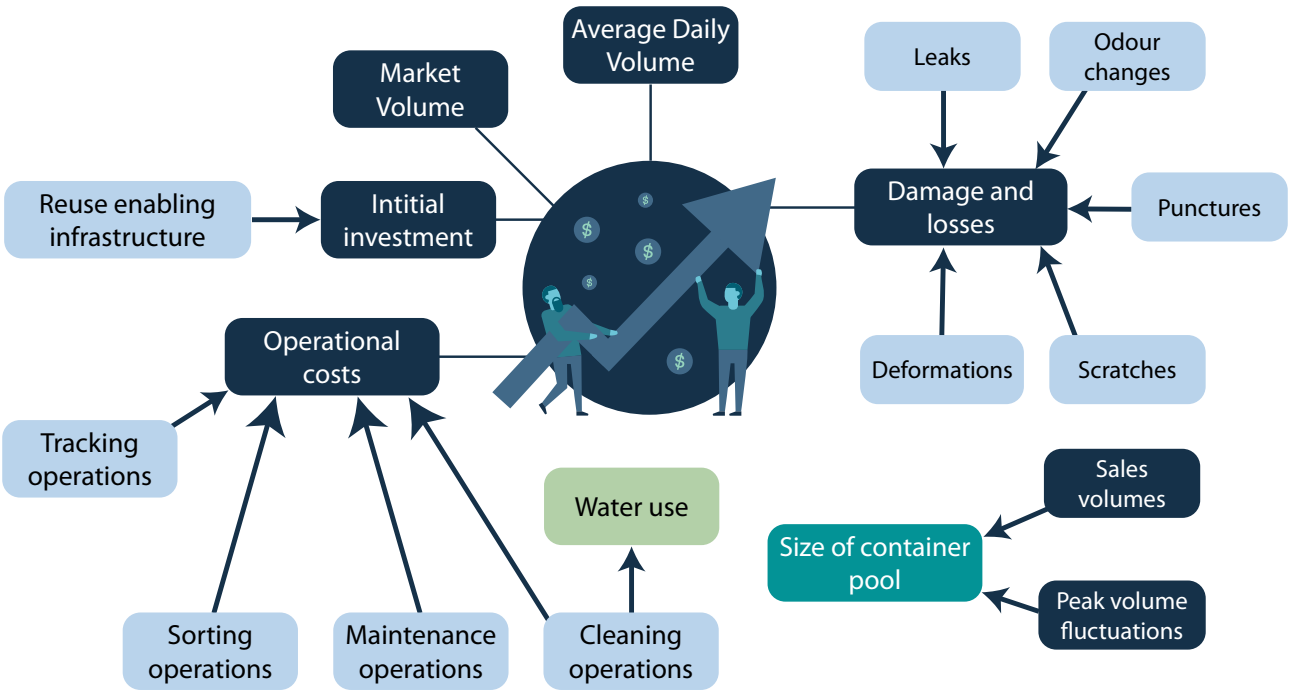


Figure 24 - Overview economic factors

5.1 Economics

Economic factors are factors that have great financial impact on the business providing reusable packaging systems and therefore determine the economic viability of the reusable packaging system. This section discusses the factors categorised under Economics (see Figure 24). It is worth noting that economic viability is greatly affected by the logistics. This category is however discussed separately, as it is also plays a major role in the development of successful reusable packaging systems.

5.1.1 Initial investment

A key economic factor determining the successful development of reusable packaging system is whether businesses are willing to make up-front investments. This required initial investment needed to set-up a reusable packaging system is a hurdle for business seeking to advance reusable packaging (Coelho et al., 2020a). The switch from the standard single-use business model to a reusable business model requires the development of new (reverse) logistics and reuse enabling infrastructure. There is insufficient reuse infrastructure available, as current systems are established around a linear delivery model (World Economic Forum, 2021d).

Circular Economy Portugal (2021b) mention several required investments for implementation of reuse systems:

- ***Warehousing*** – Investments need to be made in warehousing space for storing, cleaning, inspection and maintenance of the reusable packaging.
- ***Recovery*** – Investments need to be made in take-back mechanisms, such as reverse vending machines.
- ***Transport*** – Investments need to be made in transport vehicles for collecting, delivering or pooling the reusable packaging system. However, it is often the case that transport is outsourced to a logistics company.
- ***Cleaning equipment*** – Investments need to be made in equipment to clean, sanitize and dry the reusable packaging.
- ***Technology*** – Investments need to be made in software and apps to manage user engagement and deposits. Furthermore, investments need to be made in tracking and monitoring equipment. Tracking technology such as RFID tags can help track the reusable packaging in real time and allows for monitoring of reuse cycles.
- ***Reusable packaging pool*** – Investments need to be made in the reusable packaging pool, which is the number of packaging units that is needed to sustain the reusable packaging system.

Coelho et al. (2020a) mention the required investments in new production steps or complete lines as shifting to a reusable packaging system requires the development of new packaging designs. The reusable packaging will undergo several trips, so the design of the packaging must be able to withstand multiple use-cycles and should therefore be of sufficient quality. Current single-use packaging is not designed for this.

Reusable packaging systems based on exclusive reuse, where the consumer owns the packaging and holds the responsibility of preparing for reuse, tend to be easier

to implement as these systems do not require take-back mechanisms or infrastructure for cleaning and storing (Coelho et al., 2020b). Therefore it is expected that the required initial investment is lower for exclusive reuse models.

The initial investment can be significantly reduced when infrastructure is shared among different parties, so the costs can be divided. Furthermore, reuse enabling infrastructure for storing and cleaning the packaging for business-to-business (B2) models is more widely available, so therefore leveraging existing infrastructure of B2B sector could reduce investment costs for B2C models.

5.1.2 Operational costs

The operational costs of the reuse system is another key factor determining the economic viability of reuse models. Operational costs are due to the reverse logistics of reusable packaging. These costs include the costs of monitoring and tracking the reusable containers and the costs of collection, sorting, inspecting, maintaining and cleaning the packaging:

- ***Sorting operations*** – Sorting operations are needed when packaging of different brands are returned or collected at the same point. For example, empty bottles returned via reverse vending machines at supermarkets need to be sorted to be returned to the corresponding brand owners to be refilled again.
- ***Inspection operations*** – During inspection collected items are classified into reusable items and waste material. A first inspection is done before washing to remove damaged items. A second inspection is done after washing to ensure that all items are in good condition for reuse.
- ***Maintenance operations*** – In some case reusable packaging might be partly damaged and maintenance actions are performed, such as replacing parts of the reusable packaging. For example, a the damaged lid of a food container will be replaced but the bowl can be reused.
- ***Cleaning operations*** – After each use, reusable packaging needs to be cleaned. Cleaning operations include washing, sanitizing and drying the packaging. Cleaning operations are a costly process because of the energy and resources used. The use of hard-to-clean labels and the lack of standardisation of packaging can drive up the operational cleaning costs even more. Packaging Services Europe, a company specialized in services for reusable packaging, indicated that labels can pose a problem for cleaning. Glue used to attach the label to the container can be hard to clean and the glue might cause contamination. Different type of labels used in industry need different cleaning treatments ranging from low to high intensity, making cleaning operations more complex and costly. If labels were standardized this problem can be avoided. Similarly, if standards were applied to dimensions of packaging it would make cleaning easier as switching between different heights and diameters make cleaning more difficult (Personal Communication, Community of Practice on Reusable Packaging Meet & Greet, July 1, 2021).

5.1.3 Market volume

Another factor impacting the economic viability of reusable packaging systems is the total volume of the market (Coelho et al., 2020a). A high total volume of the market is preferred as reusable packaging systems need a certain scale to become financially attractive. Moreover, low volumes may restrict opportunities for sector-wide collaboration.

5.1.4 Average daily volume

Mollenkopf et al. (2005) state that reusable containers are more economically viable if the average daily volume of product to be transported is high. As average daily volume increases, reusable systems become more economically viable as products can be "continuously looped through the system for reuse" and rate of circulation is high. With increasing daily volume, system cost increases as well. However, the system cost increase at a decreasing rate, meaning the relative reusable system costs decrease. A high average daily volume is critical, as if systems do not achieve economies of scale they may not become profitable (Circular Economy Portugal, 2021b).

5.1.5 Sales volumes and peak volume fluctuations

In general it can be said that the bigger the sales volume the better, as with increasing sales volume economies of scale can be reached. Furthermore, peak volume fluctuations are relevant for sequential reuse models. In terms of peak fluctuations, Mollenkopf et al. (2005) argue that with increasing fluctuation in peak volume, single-use containers become increasingly economically attractive over reusable containers. According to them, this is most likely due to the fact that with high fluctuations in peak volume, it becomes increasingly difficult to predict demand of containers and to position reusable containers in the system. If volumes are not at consistent or predictable levels, the initial capital investment for reusables may not be justified. Sales volumes and peak fluctuations, among others, determine the required container pool size for the sequential reuse system. This will be further explained in subsection 5.2.9.

The importance of sufficient volume is illustrated in Figure 25. On the left hand side, a basic sequential reuse is depicted where a sufficient amount of reusable packages, in this case bottles, are circulating through the system. Transport and storage space are optimally used and inspection, cleaning and refill activities can run efficiently. However, on the right hand side, there is an insufficient amount of reusable bottles resulting in excess storage and transport space and inefficient inspection, cleaning and refill activities. Therefore, a system needs a certain volume to run smoothly. If not, inefficiency and unused space will increase the systems cost drastically.

5.1.6 Damages and losses

Another key factor impacting the economic as well as environmental viability of reusable packaging is damage and losses (WRAP, 2010). Damaged and lost containers in the system need to be replaced in the reusable packaging pool. Furthermore, if a packaging is damaged in distribution it results in the waste of that product. Especially for reusable packaging, where the impacts and costs associated with the manufacture of the reusable container are divided over its reuse cycles, damage and losses are extra costly, as it prevents the reusable container to fulfil its intended reuse cycles to be economically and environmentally viable. Packaging is in high risk of damage during distribution (e.g. dropping and shaking of packaging during transport) and during use (e.g. through inappropriate use of packaging). Typical damages include leaks, odour changes, punctures, scratches and deformations.

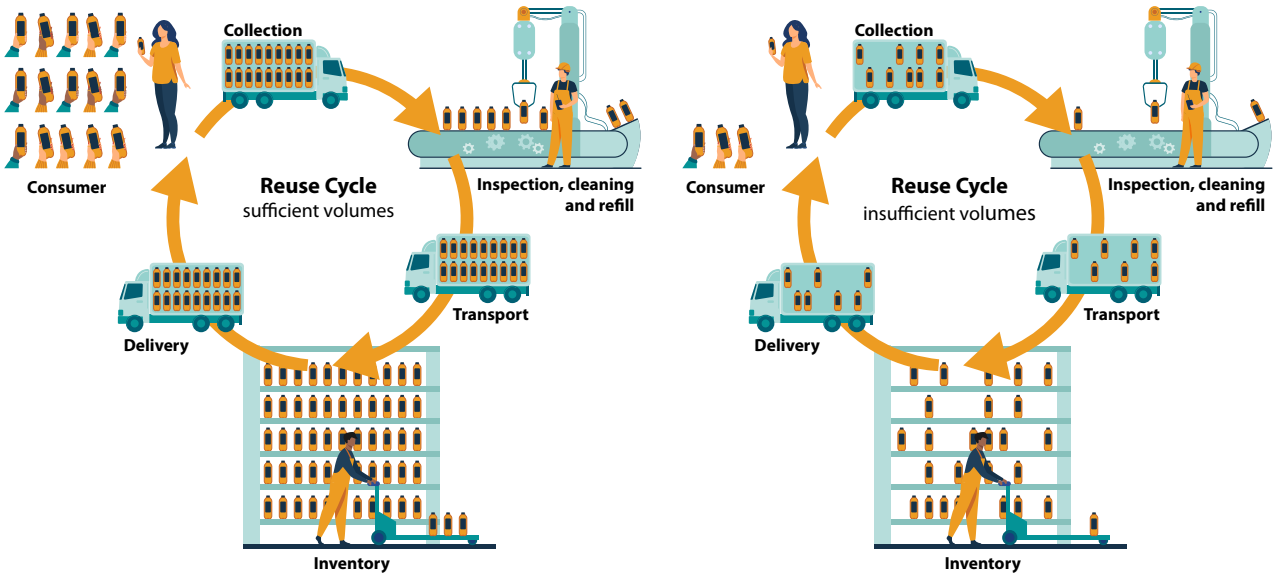


Figure 25 - Basic sequential reuse cycle and importance of volume

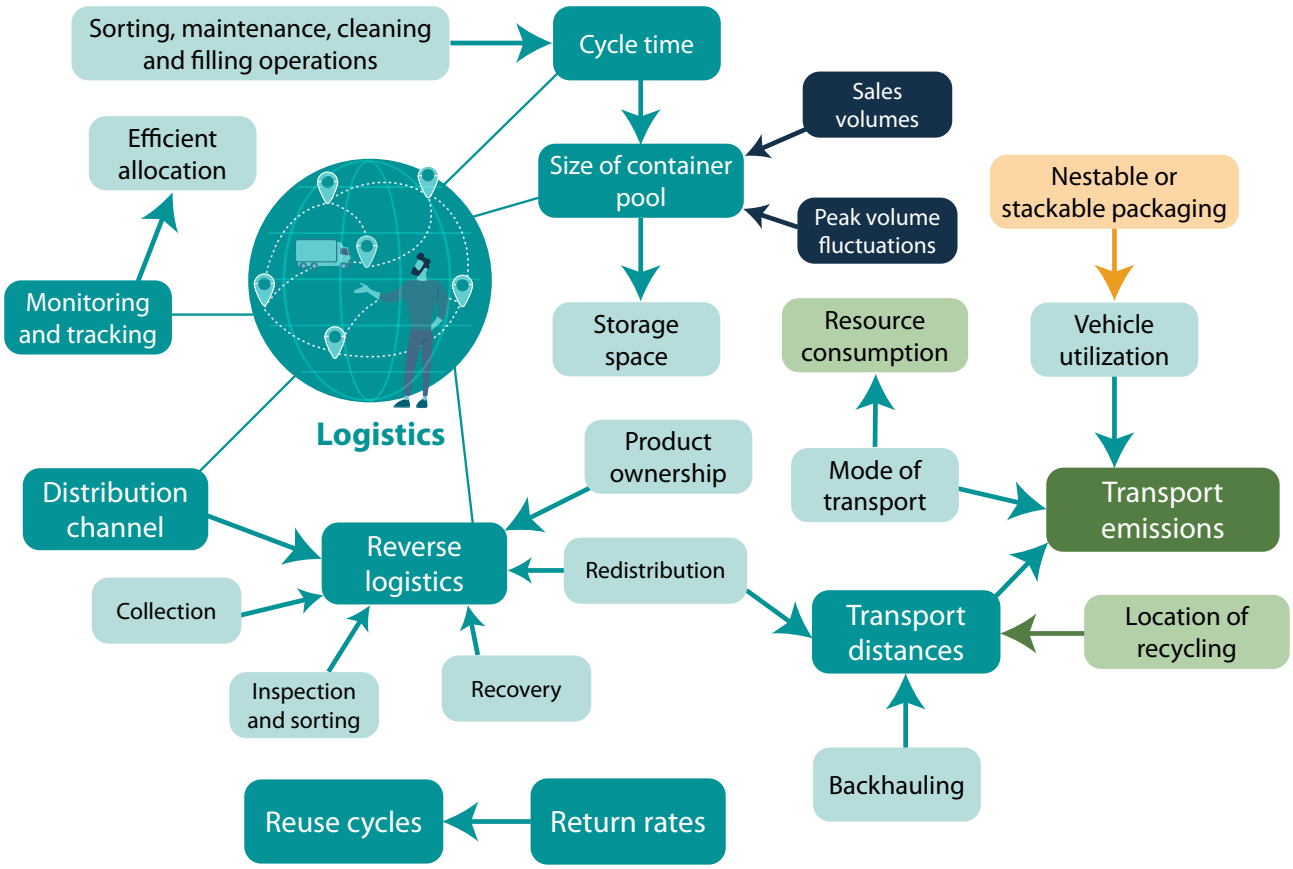


Figure 26 - Overview logistic factors

5.2 Logistics

Logistics factors are concerned with the activity of organizing transportation, collection, reconditioning and selling of reusable containers (see Figure 26).

5.2.1 Reverse logistics

Whether or not a business needs to set-up a reverse logistics system depends on product ownership. As mentioned in chapter 3, in exclusive reuse models, a consumer consumes individually and keeps the reusable product and therefore owns the packaging. In sequential reuse model, a consumer consumes along with multiple successive individuals and returns the reusable product and therefore doesn't own the packaging. Therefore, there is only a reverse flow of primary packaging in sequential reuse models (return from home and return on the go).

Successful management of the return logistics for is critical for reusable primary packaging systems. The four key logistical activities for return logistics according to Sangwan (2017) are:

- ***Collection*** – There are three methods of collection, namely collection by the original equipment manufacturer, collection by retailers and collection by third party logistics providers.
- ***Inspection and sorting*** – Inspection and sorting of the reusable packaging can either be done at a centralized or decentralized location. For example, reusable packaging can be sorted at the point of collection (decentralized) or at the recovery location (centralized).
- ***Recovery*** – Recovery activities include cleaning, sterilization, maintaining and refilling of the reusable packaging.
- ***Redistribution*** – After recovery reusable packaging is redistributed to the shops, in case of traditional retail channels or to delivery depots in case of e-commerce sales channels.

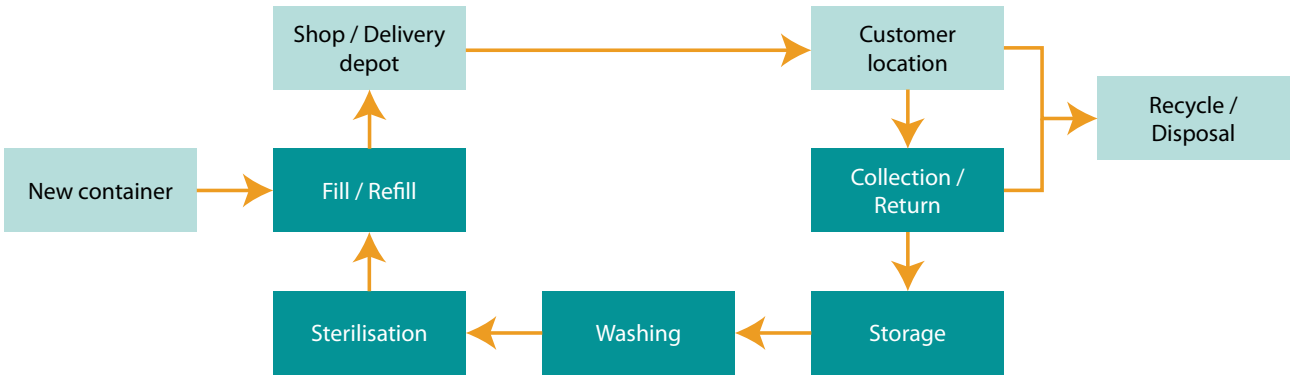


Figure 27 - Basic reverse logistics for primary reusable packaging adapted from Greenwood et al. (2020)

A basic reverse logistics activity overview adapted from Greenwood et al. (2020) for reusable packaging is given in Figure 27. The arrows indicate transport movements.

For efficient reverse logistics, supply chains with a local or national scope are preferred over supply chains with a global or international scope given the numerous transport movements involved in collecting, refilling and redistributing the packaging. Also in terms of environmental viability, local or national supply chains are preferred as they ensure shorter transport distances resulting in lower transport emissions. More information on the impact of transport can be found in subsection 5.3.3.

Furthermore, vertically integrated supply chains are preferred over horizontally integrated supply chains, since control and capacity to implement a refill system is higher for vertically integrated supply chains (Circular Economy Portugal, 2021a). In a vertically integrated supply chain a business owns or has control over more stages in the supply chain. For example, a company with a vertically integrated supply chain has control over manufacturing, distributing and selling a product, making it easier to manage the reverse logistics of a refill system. In horizontally integrated supply chain a business owns one level of the supply chain, making it harder to manage the reverse logistics. In that case, collaboration with external parties is needed.

The biggest challenge in reverse logistics is setting up a viable reuse and refill system. In Chapter 4 several reuse systems for transit packaging were described. These are now applied to primary reuse systems. For a primary reusable packaging system in a national or local supply chain, the star system as described by Carrasco-Callego et al. (2012) can be viable. In this system all packaging is returned to one central depot. Here they will receive reconditioning operations, such as inspection, maintanance, sterilisation and refilling. Due to the relatively short transport distance from the collection or return location to the central depot location impacts of transport are limited. In Figure 28 an example illustration is given of a star network on national level, in this case the Netherlands.

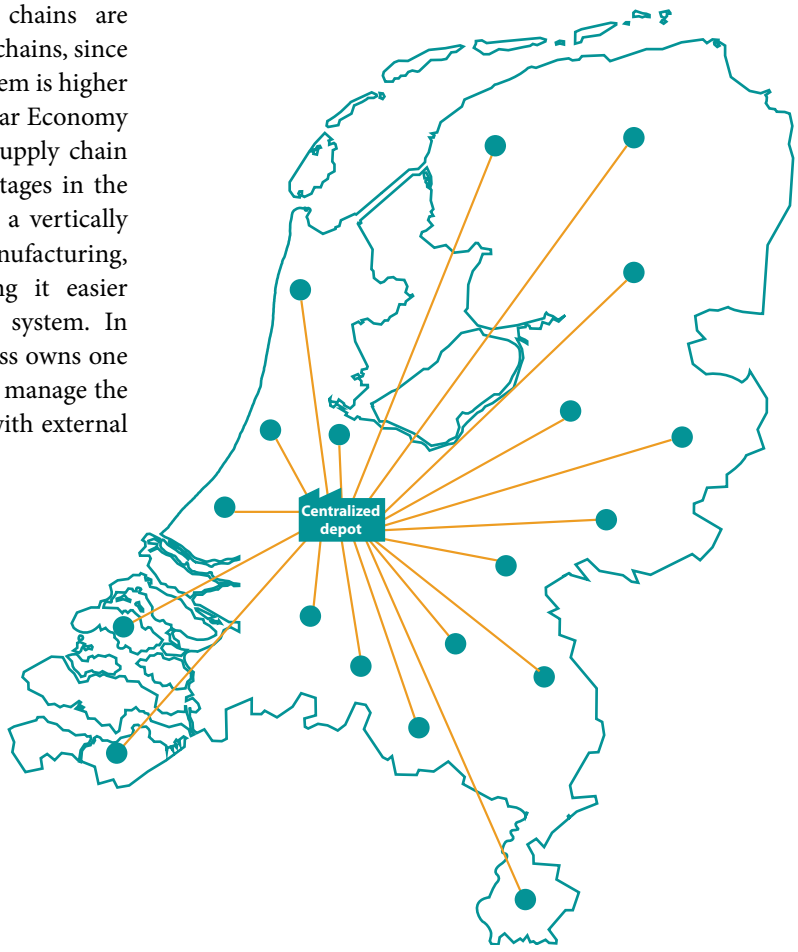


Figure 28 - Star network for national supply chain

In case of an international supply chain, such a star network is less viable, due to the increased transport distances between locations. Alternatively, the multi-depot system, as described by Carrasco-Callego et al. (2012) is more viable. An example illustration of a multi-depot system is given for western Europe in Figure 29. Such a system can ensure shorter transport distances through decentralized depots for reconditioning activities, such as refilling and cleaning. In this system, these decentralized depots can act as a capillary network, thereby reducing transport (Circular Economy Portugal, 2021b). The main depot is the manufacturing location of the product. This product is shipped in bulk to the decentralized depots where the reusable packaging can be filled. This way the international supply chain becomes a network of smaller local supply chains. Such a multi-depot network across countries asks for cross-country collaboration and standardisation of packaging and infrastructure.

5.2.2 Collaboration and pooling

Collaboration and pooling are factors that can positively influence the economic viability of reuse systems. Through collaboration and pooling economies of scale of reusable packaging systems can be reached (Rethink Plastic Alliance, 2021). To indicate, companies can share the same packaging in a pooling system and/or share the same logistics and washing lines. The use of pooling systems requires a degree of standardisation, as can be seen in pooling system for transit packaging such as standardised dimensions for pallets in Europe as well as in primary packaging such as beer bottles (Coelho et al., 2020a). The topics of standardisation will be separately discussed in subsection 5.2.3 on the next page. Benefits of setting up a pooling systems are the reduced investments and operating costs, as they can be shared across participants in the system. Furthermore, pooling systems can smoothen out peaks and lows in demand (WRAP, 2010) and reduce inventory costs (Coelho et al., 2020a).

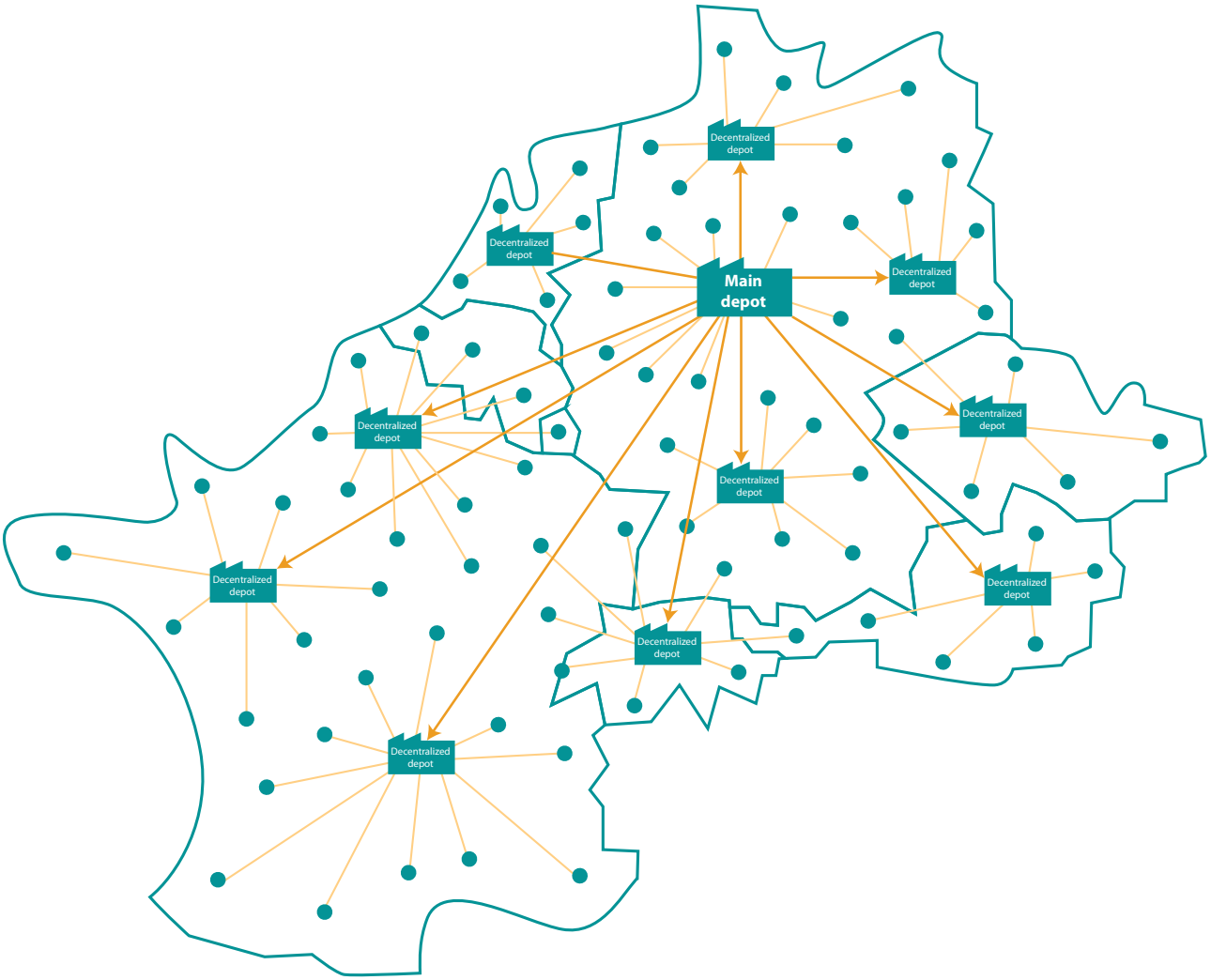


Figure 29 - Multi-depot network for international supply chain

5.2.3 Standardisation & harmonisation

For FMCGs, packaging is considered to be important for brand equity (Greenwood et al., 2021). Therefore, brands might be hesitant to harmonise and standardise their packaging. However, standardisation and harmonisation of packaging does not necessarily have to mean that all of the packaging is the exact same. To indicate, reusable packaging can still have a different look and feel from one brand to another while following the same dimension requirements in order to fit the same logistics and washing systems. With standardised packaging, there is less variety in packaging formats in terms of shape, volume, weight and lid size (Coelho et al., 2020b). An example illustration of three standardised packaging formats can be found in Figure 30.

Differentiation can be applied through colour, labels prints, embossing, debossing and finishes. Differentiation can also be done through non-material means, such as digital experiences. Standardised packaging facilitates reverse logistics, cleaning processes and machinery (Coelho et al., 2020b). Because of standardised packaging, machinery do not need to be reset as a result of different packaging dimensions, which makes handling more efficient. Even more specific designs that could not be exchanged for reuse between brands, could still be washed and transported using the same washing and logistics system thanks to their standardized dimensions and overall shape (World Economic Forum, 2021d). Furthermore, standardisation can aid in reducing the complexity of packaging materials, which could enhance the recyclability of packaging formats and therefore the overall environmental impact of packaging formats (Coelho et al., 2020b). Moreover, standardisation of reusable packaging systems can reduce confusion and increase convenience for consumers, for example by reducing the number of different systems they have to interact with (Rethink Plastic Alliance, 2021).

5.2.4 Monitoring and tracking

Monitoring and tracking of reusable packaging aid in the successful management of the return logistics. When the movements of the packaging are tracked it becomes easier for operators to predict and foster the return of the packaging into the supply chain (Rethink Plastic Alliance, 2021). The importance of monitoring reusable containers has long been acknowledged, for example by McKerrow (1996) who concluded that reusable containers work best when the containers are monitored from the beginning to the end of distribution process. If the logistics of reusable packaging are not properly managed the operational cost can become a challenge. Therefore, the system needs monitoring and tracking to enable efficient allocation of reusable packaging. Efficient allocation means getting the right number of right kinds of empty packaging to the right place at the right time. Inefficient allocation and tracking increases the number of reusable packaging needed to keep the system running, and thus drive up the total cost of the system. Moreover, monitoring and tracking can decrease the reusable packaging's cycle time as packaging is more visible and trackable (Mahmoudi & Parviziomran, 2020). Cycle time is further discussed in subsection 5.2.8.

Several technologies can be applied to monitor and track reusable packaging. For example, radio-frequency identification (RFID) chips can be added to the packaging, allowing for remote reading and automated handling (Coelho et al., 2020a). Maleki and Meiser (2011) mention five different technologies that can improve identification and tracking in supply chains: barcode, RFID, Wi-Fi and global positioning system (GPS). The authors found that barcode systems are cheaper compared to other systems. However, disadvantages are that barcodes must be individually and manually scanned and need to be visible at all times, so any damage to the reusable packaging can make it unreadable. RFID tags can be read faster and automatically, do not need to be visible to be read and can deal with rough environments better.

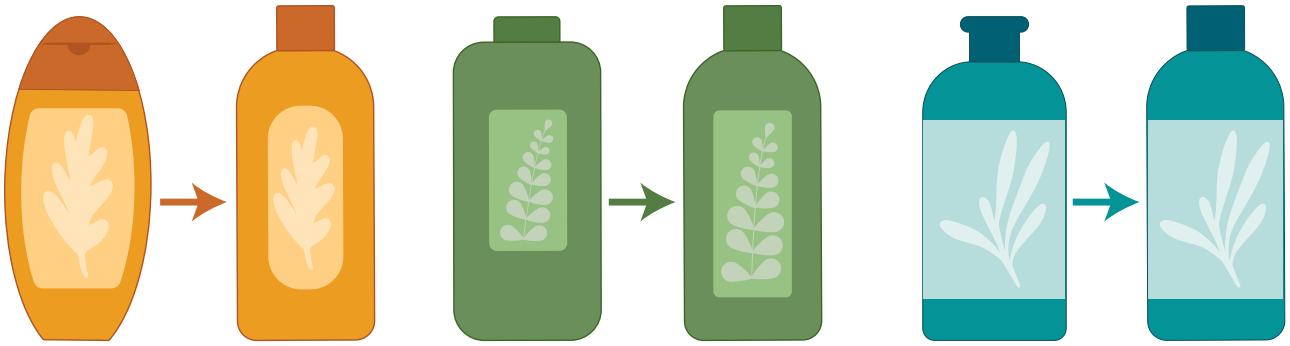


Figure 30 - Standardisation of three packaging formats in terms of dimensions and overall shape

5.2.5 Distribution channel

To explore the differences between traditional retail and e-commerce and the consequences this difference might have for the design of primary reusable packaging this subsection dives deeper into the two distribution channels. Brick-and-mortar businesses are considered to be traditional retail. These are businesses that have a physical presence and offer face-to-face customer experiences (Sommar & Mellander, 2018). The type of distribution channel influences the (reverse) logistics of a reusable system, as it determines from which locations items are shipped and from which locations items are collected. The distinction between traditional retail and e-commerce is sometimes blurred, as many traditional stores also offer e-commerce options. This is called omni-channel distribution. This increases the complexity and variety of logistics solutions.

One of the differences between e-commerce and traditional retail is that the e-commerce supply chain needs to manage order fulfilment on an item level, which is in traditional retail overseen by the consumers themselves (Sommar & Mellander, 2018). As a result of individual item fulfilment in e-commerce supply chains, items are handled more frequently as compared items in traditional retail. Another difference is that the e-commerce supply chain often needs to manage the last mile transportations to people's home whereas in traditional retail this is also overseen by the consumers themselves.

These differences do not seem to influence the design of the primary reusable packaging. For example, the company Loop from Terracycle started with an online delivery and collection system of durable reusable packaging. They offer products from well-known brands in durable stainless steel containers and bottles. Now, they are expanding some of their products to traditional retail with a "buy anywhere, return anywhere" model (Quinn, 2021). This means the primary packaging in store does not differ from the primary reusable packaging online. This makes sense as differentiation would prevent the possibility of an omni-channel strategy. So, in a lot of cases differentiating the primary packaging of products between e-commerce and traditional retail is undesirable as it prevents omni-channel integration.

The distribution channel does determine which reuse model is most suitable. Refill at home works particularly well for e-commerce as refills do not need to compete on the shelves with single-use packaging and refills can be delivered in compact forms that can fit through people's letterboxes. Refill on the go works particularly well for traditional retail, as refill on the go models need a physical dispensing point, which can be placed in a traditional retail store.

5.2.6 Reuse cycles

Another factor related to the logistics of reusable packaging systems is reuse cycles, which is the number of cycles, rotations, circulations or trips that a container will complete in its lifetime. The number of reuse cycles made by reusable packaging in its lifetime is a critical factor as it determines the allocation of the impacts for production of the reusable packaging to each reuse cycle. Typically, production of reusable packaging has a high environmental burden, due to the desired quality and durability of the packaging. The more reuse cycles, the lower the environmental burden per cycle (WRAP, 2010). This is also mentioned by Albrecht et al. (2011) who state the more reusable packaging is circulated, the higher the environmental benefit will be as it prevents the need for new packaging. Therefore, low reuse cycles for reusable packaging tend to favour single-trip packaging, and high number of reuse cycles tend to favour reusable packaging (WRAP, 2010). The minimum amount if reuse cycles a reusable packaging has to make in order to be economically and environmentally viable can only be determined case by case, as many variables are involved. Therefore it is not possible to make generalizations about this. Some studies have investigated the maximum number of packaging formats. For example, according to Geyer et al. (2007) of a glass bottle 25 cycles (Geyer et al., 2007).

The number of reuse cycles a reusable packaging will complete in its lifetime is dependent on the following factors:

- ***Return rates*** – The higher the return rates, the more reusable packaging gets returned for another reuse cycle.
- ***Durability of the reusable packaging*** – The durability of the reusable packaging is an important factor, as it determines the serviceable lifetime of the packaging before it gets rejected by the consumer or producer. The number of uses before a packaging gets rejected must always be higher than the break-even number of uses for the reusable packaging system to be viable (Greenwood et al., 2021). To illustrate, if a container has to be used five times in order to break even with single-use alternatives, but the durability of the container last only three reuse cycles, the system will most likely become environmentally and economically unviable.
- ***Cycle time*** – The lower the cycle time, the more reuse cycles a reusable packaging can make in a given time period.
- ***Damages and losses*** – Damages and losses of reusable packaging prevents packaging from making another reuse cycle.

5.2.7 Return rates

The return rate is the average rate of return of reusable packaging after each trip, usually expressed as a percentage (WRAP, 2010). Although classified under logistics and distribution, the return rate is a key factor that affects the economics as well as the environmental impact of a reusable packaging system (Coelho et al., 2020a). Return rates should be as high as possible to prevent losses. High return rates ensure that the system can run smoothly and that the container pool stays intact. Return rates can be incentivised through reminders, deposit return schemes, discount systems and reward systems. Return rates are also positively affected by return opportunities. If reuse infrastructure is widely accessible, return opportunities will go up. In the case of return on the go models, when the consumer can return the empty packaging at a variety of drop-off points, the return rate can go up due to the increased convenience of returning. In the case of return from home models, when the consumer can schedule a collection time whenever it suits him, return rates can go up due to the increased convenience of collecting.

5.2.8 Cycle time

Another factor influencing the logistics and distribution of reusable packaging systems is the cycle time. The cycle time is the average time taken for the reusable to complete the loop from supplier to consumer (Mollenkopf et al., 2005). It is the time it takes for a reusable to go through the whole distribution cycle. This includes time taken for return logistics and activities such as sorting, cleaning, maintaining and filling. Furthermore, cycle time includes the time the reusable is kept by the customer. To indicate, the amount of time an empty reusable is stored in someone's home before returning it differs among consumers. According to Mollenkopf et al. (2005) a short cycle time is preferred as the shorter the cycle time, the fewer reusable packaging have to be purchased to keep the system running, which lowers the initial investment costs for the reusable packaging pool.

5.2.9 Size of reusable packaging pool

The last factor in the logistics & distribution category is the size of the reusable packaging pool. To be able to support a reusable packaging system based on sequential reuse, the total number of containers in the pool is a critical factor. The number of containers in the pool needs to be significantly higher than the number of containers required for immediate product supply at a point in time (WRAP, 2010). There are several reasons for this:

- The pool size needs to be bigger to accommodate to the cycle time. The cycle time, as mentioned previously, is the average time taken for the reusable to complete the loop from supplier to consumer
- The pool size needs to be adapted to sales volumes and fluctuations in peak volumes, due to for instance seasonality. For example, beer bottle producers experience a peak in their sales volumes in certain situations, such as during the summer when the weather is good, during holidays such as Christmas and during events such as the FIFA world cup.
- The pool size needs to accommodate to the return rate, as not 100% of the packaging will be returned. Therefore, the pool size needs to be big enough to compensate for that.
- The pool size needs to compensate of damages and losses in the system as reusables can get damaged during transport or use.

A simplified sample calculation to determine the size of a reusable packaging pool is illustrated by a scenario in **Appendix B: Scenerio for pool size calculation.**

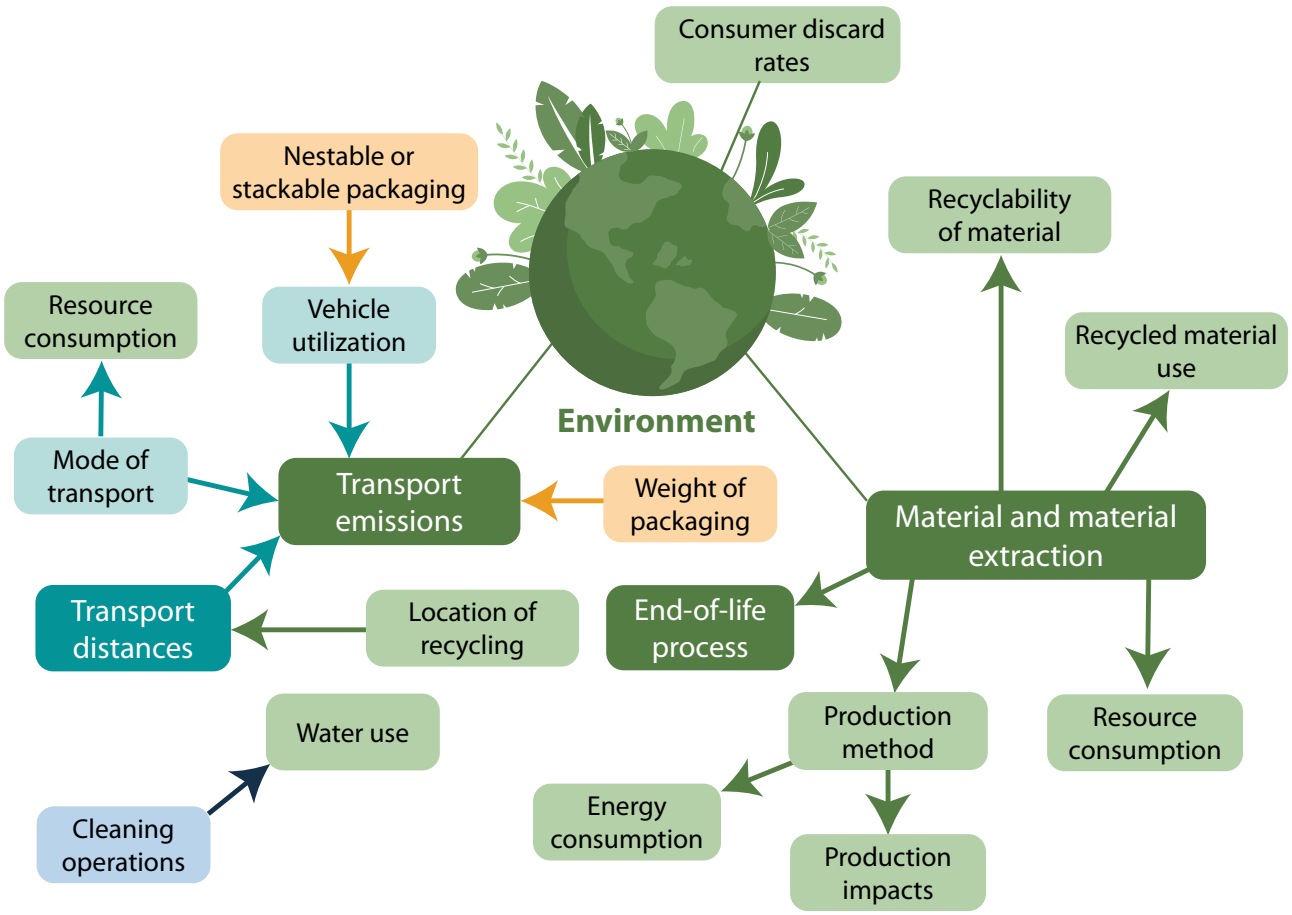


Figure 31 - Overview environmental factors

5.3 Environment

Environmental factors influence the environmental impact of reusable packaging systems (see Figure 31). Environmental impact is the positive or negative effect that the reuse provider's activities, products or services have on the environment. The key environmental trade-off between a single-use system and a reusable system is the impacts associated with materials production and disposal on the one hand, and the impacts of increased transport on the other hand (Coelho et al., 2020a).

5.3.1 Material choice and production impacts

The choice of packaging material deeply influences the environmental impact of a reuse system. The choice of packaging material influences the end-of-life process, such as the recyclability of the reusable packaging and also the amount of recycled material that can be integrated in the reusable packaging.

Production impacts – Materials with higher production emissions generally require a higher number of reuse cycles in order to environmentally and economically break even with single-use alternatives (Coelho et al., 2020b). Therefore, the overall impact of all materials heavily depends on the number of reuse cycles: the more reuse cycles the less impact per cycle because impacts can be divided over many reuse cycles. The production of glass, stainless steel and aluminium is more energy intensive than the production of plastic packaging. Therefore, it can be expected that packaging made out of glass, stainless steel or aluminium needs to be used considerably more times to environmentally break-even with single-use alternatives than reusable plastic.

Materials and recyclability – Every material has its benefits and disadvantages, which will be briefly discussed now. Benefits of glass are that it is heat resistant and therefore very suitable for industrial washing machines, that it has excellent barrier properties, that is almost inert and highly scratch-resistant (Ten Klooster et al., 2008), that it can be endlessly recycled without loss of functional properties and that it can incorporate recycled content. Disadvantages are that it is heavy weight, which results in higher transportation emissions and makes returning of packaging less convenient for the consumer. Benefits of stainless steel and aluminium are that they are heat resistant, that they have excellent barrier properties, that they are corrosion resistant, that they are inert and that they are generally lighter than glass (Coelho et al., 2020b). Moreover, both materials are highly recyclable. Stainless steel is more scratch resistant than aluminium and is generally brighter and shinier than aluminium. Benefits of plastics are that they are lightweight and that they

offer many design options. Plastics lend themselves well for complex shape design. A disadvantage of plastics is that recycling of plastics often results in downcycling of plastics. To indicate, some recycled plastics are not food safe or are of inferior quality than virgin plastics.

Recycled material use – Incorporating recycled materials into the packaging design may significantly influence the relative environmental performance of a packaging as it decreases environmental impacts. Packaging that incorporates recycled content will have lower production emissions compared to packaging manufactured using only virgin material. This is because upstream processes involved in the production of packaging, like the extraction of raw materials can be avoided (Coelho et al., 2020b). The reduced environmental burden of incorporating recycled content in the packaging usually outweighs the environmental burdens associated with the recovery of material (WRAP, 2010). In general, the higher the percentage of recycled content of a packaging, the lower the environmental burden of production of that packaging becomes. Furthermore, a reusable packaging that can be recycled prevents the extraction of virgin material.

5.3.2 End-of-life process

The end-of-life process affects the environmental impact of reusable packaging. According to Coelho et al. (2020b) end-of-life management refers to the ways in which waste from packaging is processed. In the packaging industry, end-of-life treatment usually includes recycling, incineration or landfilling. Given the ranking on the R-ladder (see subsection 2.3.2), recycling is preferred over incineration and landfilling. Of the latter incineration is preferred over landfilling.

5.3.3 Transport and transport emissions

Transport distance is a highly significant factor in defining the environmental impact of a reusable packaging system. It is a very important factor when comparing reusable packaging systems with single-use systems. This is because the return trip of reusable packaging increases the number of kilometres required for the system to operate (WRAP, 2010). Coelho et al. (2020b) analysed several studies on the environmental impact of reusable packaging and found that in most studies where reusable packaging showed negative results this was because of the transport distance.

Transport distance - For primary reusable packaging the total journey distance is doubled compared to single-use packaging. Therefore, the importance of journey distance is far more significant for reusable packaging than for single-use packaging. Remote customers can make return environmentally as well as economically non-viable. In general, longer journey distances tend to favour single trip packaging and shorter journey distances tend to favour reusable packaging (WRAP, 2010). It is however impossible to make generalisations about the exact journey distance that will favour reuse over single-use due to the many other factors involved.

Vehicle utilization – Contrary to transit packaging such as crates, who often are designed to nest or to fold down, primary packaging usually is not. So a lot of the times the volume of the return journey cannot be reduced as the same amount of space is used on the outward journey and return journey. Moreover, due to the required durability and to withstand the demands of multiple trips, reusable packaging is usually heavier and occupies a greater volume than single-use packaging (WRAP, 2010). This increases fuel usage and related emissions.

Mode of transport – The energy consumed and emissions per transport mode vary considerably. Rail and water transport are less impactful in terms of CO2 emissions than road and air transport as they are more energy-efficient per ton-km. Air transport has the highest emissions, followed by road transport, water transport and rail transport (Coelho et al., 2020b). However, this factor is less significant because when comparing reuse to single-use the transportation mode is usually assumed to be the same for both systems (WRAP, 2010).

5.3.4 Cleaning and water use

Another factor impacting the environmental impact of a reuse system is water use and cleaning operations. The amount of water used throughout a container's life cycle include water use in production, manufacturing and cleaning activities. Water used during cleaning activities is especially relevant as this is unique to reuse models (World Economic Forum, 2021d). The dishwasher process is preferred, not only as it ensures the packaging is cleaned according to hygiene standards but also to lower the impacts of water use, as dishwashers tend to be more water efficient than hand washing (Coelho et al., 2020b).

5.3.5 Consumer discard rates

The last factor in the environment category is the improper disposal or discard of reusable packaging by the consumer. This especially affects exclusive reuse models, as in exclusive reuse models the owner has the responsibility of disposing the packaging. However this also affects sequential reuse models, if people simply decide to not return the packaging and dispose of it in the wrong way. Reusable packaging is more durable, and often more material is needed in the production phase as compared to single-use packaging. Therefore, a reusable packaging only becomes environmentally attractive after several use cycles to compensate for the increased emissions during production. However, when a consumer decides to dispose of the packaging before the required amount of use cycles to become environmentally viable is met, the reusable packaging system could have a higher environmental impact than a single-use alternative system.

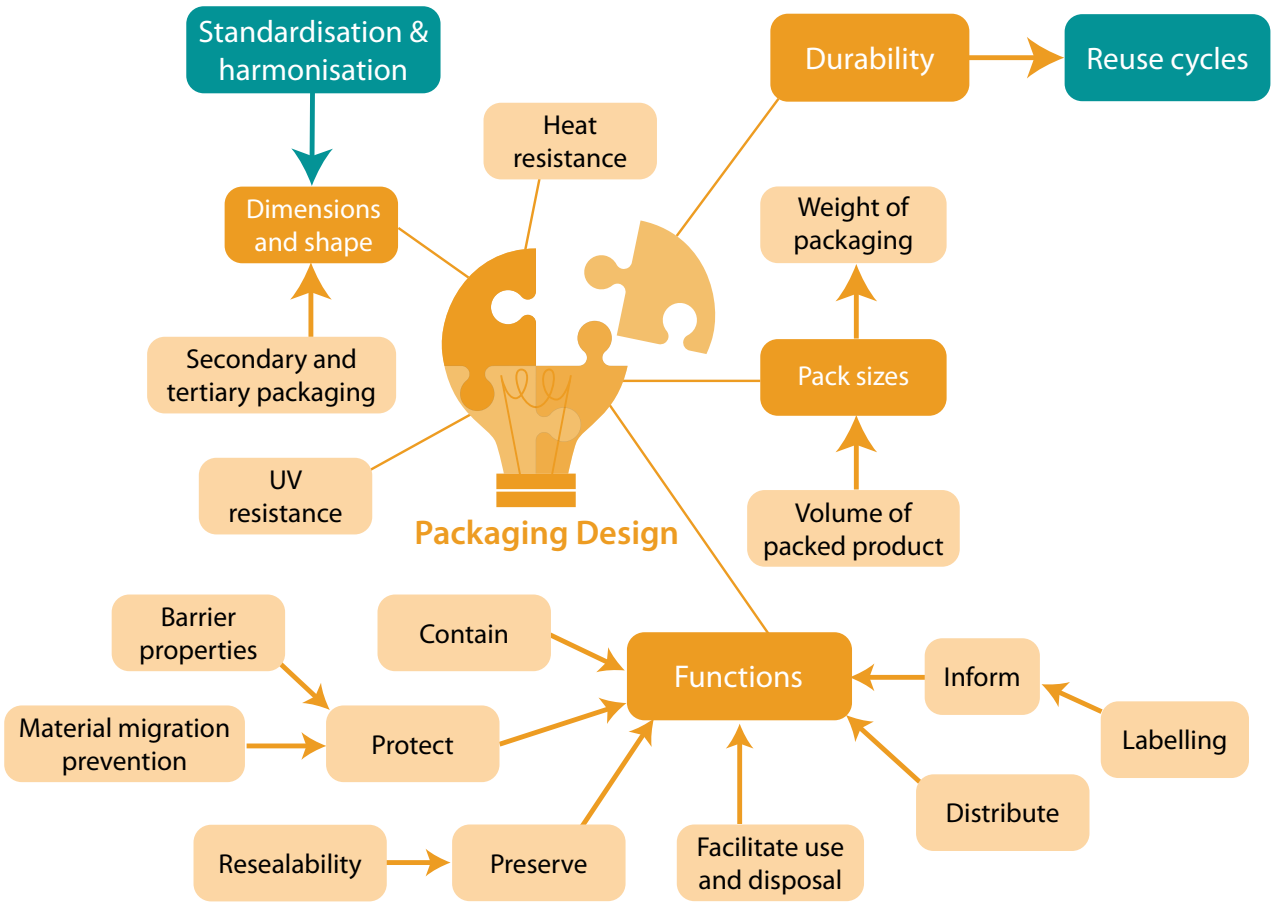


Figure 32 - Overview packaging design factors

5.4 Packaging Design

Packaging design factors play a role in the physical design of the reusable packaging and help determine the required features of the packaging (see Figure 32).

5.4.1 Durability

Durability is one of the most important factors assessing the sustainability and economic viability of reuse systems. According to World Economic Forum (2021b) "durability is the ability of a material to last through multiple use cycles without significant deterioration" (p. 34). Packaging needs to physically as well as chemically durable to withstand the return and washing process without loss if its containment properties (Greenwood et al., 2020). Moreover, the packaging should be resistant against typical use exposures. This means the packaging should prevent water and limescale deposits, and be resistant to scratches, deformations and impacts such as dropping and squeezing the packaging. Additionally the packaging should be UV resistant. For plastics UV resistance is to prevent photo-oxidation. The durability of the packaging heavily influence the amount of reuse cycles, as the durability determines of the packaging is suitable for repeated use. Material choice influences for a large part the durability of the packaging.

5.4.2 Dimensions and shape

By harmonising packaging dimensions across sectors the efficiency of the reverse logistics and washing operations can be optimized as reuse-enabling infrastructure can be shared. To indicate, most industrial cleaning machine designs are based on Euronorm standards (600 x 400 mm). Therefore, conforming the dimensions of the packaging to that standard will make the cleaning process more efficient (PackBack, 2020).

In terms of dimensions, the primary reusable packaging should be compliant with secondary packaging and tertiary packaging. In terms of tertiary packaging, the EPAL 1 Europallet (800 x 1200 mm) and the EPAL 2 Pallet (1200 x 1000 mm) are common pallet sizes in Europe. In terms of secondary packaging, based on the Europallet standardised Euronorm sizing exist for secondary packaging like boxes and crates (Ten Klooster et al., 2008).

Related to the shape of a packaging it is important to consider nestable and/or stackable packaging. Nestable and/or stackable packaging can minimize the costs of logistics as this way space is utilised efficiently during transport and storage. Nestable and stackable packaging can reduce vehicle utilization and therefore reduce environmental impact of transport.

5.4.3 Pack sizes

Another factor related to the design of a packaging which influences the environmental impact of reusable packaging is pack size. When comparing packs of different sizes, larger pack sizes are environmentally favourable over smaller pack sizes. The reason for this is that smaller packs have a larger surface area for a given volume of product than larger packs. Smaller pack sizes are therefore relatively heavier and use more materials (WRAP, 2010). This is also mentioned by Coelho et al. (2020b) who state that for beverages "smaller packaging formats have higher emissions since they require more material per volume of beverage" (p. 38). So generally speaking, the bigger the volume per packaged product, the lower the impact. This means that when developing reusable packaging one should find the right balance between packed volume and pack size.

Another factor related to pack size is the weight of the packaging. Reusable packaging is by design often heavier than single-use packaging (WRAP, 2010). Weight of the packaging influences the environmental impacts of transport. Coelho et al. (2020b) mention packaging weight (next to number of reuse cycles, transport distances, choice of material and recycled content) as one of the important factors to the success of reusable packaging. Therefore, from an environmental perspective, lower weight is preferred.

Most consumers also likely prefer a lower weight. A higher weight of reusable packaging can be a significant barrier to customers, especially in refill on the go and return on the go models, where consumers have to take empty packaging to a refill or drop-off point themselves (Ellen MacArthur Foundation, 2020).

5.4.4 Functions

Another important factor related to the design of the packaging is its functionality. In order for a reusable packaging to match single-use packaging the reusable packaging must be able to perform the same functionalities as single-use packaging over several reuse cycles. Adding extra functionalities could possibly add a competitive advantage over single-use packaging. Adding extra functionalities, such as an insulation layer to keep products warm or cold, is possible because the initial costs of producing the packaging are divided over many reuse cycles. Therefore the packaging can be regarded an asset for the company. The required functions of packaging are described in detail in subsection 2.1.2. In short, the reusable packaging must contain, protect (e.g. by having the appropriate barrier properties and prevent material migration), preserve, distribute the product, provide information and facilitate use and disposal.

Labels are used to provide information. Whereas in single-use packaging applying labels is very straightforward (only once) for reusable packaging the amount of times labels need to be applied differs. In some cases labels can be permanent, when packaging is filled with the same product over and over again. In other cases labels should be washable, when the content of the packaging changes per refill. Therefore, developers need to decide on which information is of permanent relevant and which information is of temporal relevance. To indicate, information related to the reusable packaging itself is of permanent relevance. Furthermore, when the packaging is proprietary to one specific brand, branding elements can also be permanent. Information related to the packaging's content, such as product descriptions, ingredient/nutritional information, or batch numbers is of temporal relevance, as content often changes per reuse cycle. Furthermore, if the packaging is generic and part of a larger container pool managed by different businesses, branding elements should be of temporal nature (World Economic Forum, 2021b).

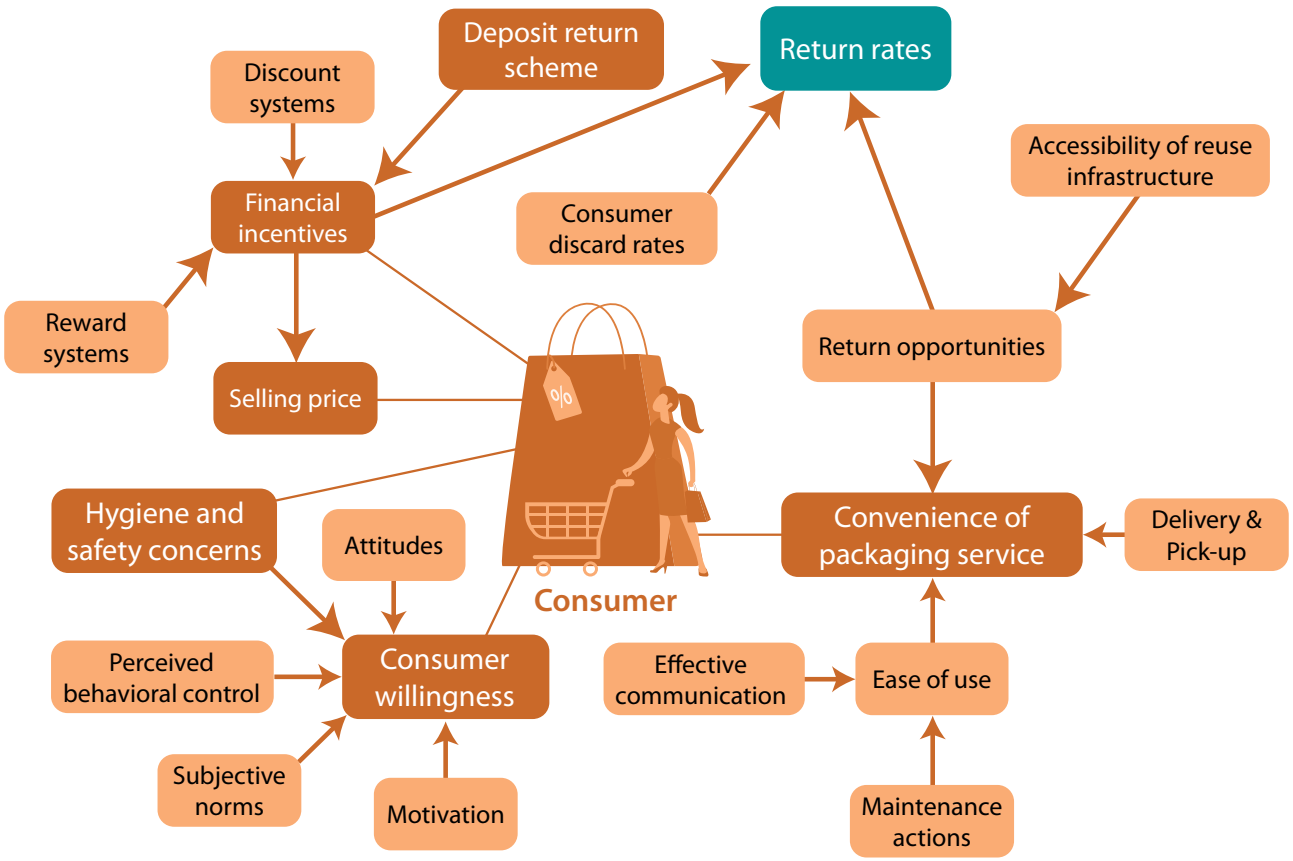


Figure 33 - Overview consumer factors

5.5 Consumer

The consumer factors describe the factors influencing consumer willingness and participation as every reusable packaging system relies strongly on the willingness and ability of consumers to reuse (see Figure 33).

5.5.1 Consumer willingness

In recent years a profound shift in consumer preference in favour of more sustainability-oriented options can be observed, as contributing to a better environment through more sustainable buying behaviour makes consumers feel good about themselves. For example, consumers are insisting on reduced packaging and increasing use of recycled materials. There is reason to believe that these sustainability drivers are here to stay and can accelerate the shift towards reuse (World Economic Forum, 2021d). It is therefore vital to know to what extend people are willing to engage in reuse systems, which reuse model (exclusive vs. sequential reuse) they prefer and which products and packaging they are willing to reuse and how they want to reuse it. The following paragraphs elaborate on these aspects.

According to Greenwood et al. (2021) little research exists on which types of packaging consumers are willing to reuse and even less research has considered which reuse models consumers prefer for different products and packaging. It is of vital importance that consumers are willing to engage with and use reuse systems for such systems to work. There is little to no point in developing reuse systems with low environmental impact if consumers are not willing to engage with the systems.

Intention behaviour gap –The willingness to engage with a reuse system depends on several factors, such as people's attitudes towards reuse, normative beliefs (which is what people think others do or what others think they should do), motivation, perceptions of contamination and so on. Even though people have positive attitudes towards reuse and are motivated to reuse, these intentions are often not translated to behaviour (Greenwood et al., 2021). This is a frequently observed phenomenon in other domains too, which has been termed by researchers as the 'intention-behaviour gap'. In the context of reuse, one important factor according to Greenwood et al. (2021) that could explain this intention-behaviour gap concerning reuse is whether people actually have the opportunity to engage in a reuse system, as reuse systems are currently not the norm.

Greenwood et al. (2021) performed an online survey in the United Kingdom to explore what type of products people are willing to reuse. They used a total of ninety products, ranging from food and drink products, homecare products and personal care products.

Packaging aspects – The study found several packaging aspects that influence whether people are willing to reuse the packaging. The aspects that had a significant influence were the material of the packaging, the packaging format and the closure type. In terms of material, more people were more willing to reuse packaging made from glass (37%) compared to packaging made from rigid and flexible plastic (14.5% and 4.8% respectively), paper (15.3%) or aluminium and tin (16.4%). In terms of packaging format, people were more willing to reuse jars (36%), bottles (20%) and boxes or cartons (23%) compared to wraps (2%), cans (3%), and aerosols (4%). Furthermore, the study found that people were more willing to reuse packaging that was durable, resistant to changes in appearance, and easy to clean. The authors stress the importance of using materials that are resistant to frequent reuse and repeated industrial washing.

The findings of the study suggest that consumer willingness is primarily driven by aspects of the packaging rather than aspects of the product inside. The study did not succeed in identifying factors that influence which method of reuse people prefer for different packaging (e.g. refill at home, refill on the go, return from home, return on the go).

Theory of Planned Behaviour – The study by Ertz et al. (2017) analysed the role of context, motivation and culture on reuse behaviour. Results of the study confirmed that the Theory of Planned Behaviour (TPB) by Ajzen (1991) is an appropriate framework for representing consumer's reusable containers consumption. In the TPB model, the closest antecedent of behaviour is behavioural intention. In turn, behavioural intention is determined by attitude, subjective norms and perceived behavioural control. Perceived behavioural control refers to whether a person perceives the behaviour of interest as easy or difficult. Their findings suggest the importance of context and motivation as predictors for reuse behaviour (see their conceptual behaviour predictor model in Figure 34). Namely, context is an important predictor of perceived behavioural control and attitude. Motivation is influenced by context and influences attitude and intention. Perceived behavioural control has the strongest impact on intentions.

The authors stress the importance of creating situations which facilitate reuse and complicate single-use. In that case, reuse becomes less inconvenient and this will drive up their intentions to consume reusable containers. Legislation is an important element in consumer's contexts. Therefore, enacting laws and regulations which encourage reusable container consumption could have a strong effect in changing consumer behaviour (Ertz et al., 2017)

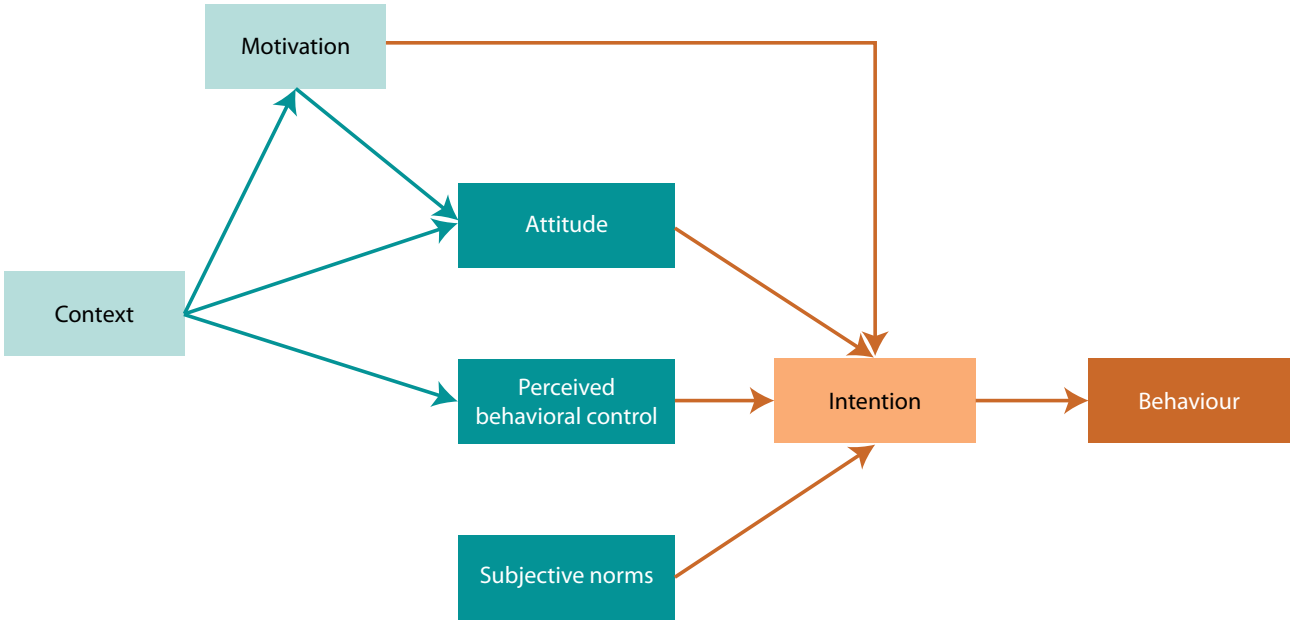


Figure 34 - Conceptual behavioral predictor model adapted from Ertz et al. (2017)

Opportunities for supermarkets – The report by Kramer et al. (2021) describes opportunities for introduction of reusable packaging in Dutch supermarkets based on quantitative consumer research and qualitative research performed by Kantar. The consumer research showed that people are willing to engage in all four reuse models as described by the Ellen MacArthur Foundation: refill on the go, refill at home, return from home and return on the go. Depending on the reuse model different products are seen appropriate:

- ***Refill on the go:*** This model is considered suitable for potatoes, fruits, vegetables, eggs, fresh herbs, pasta, rice, noodles, coffee, tea, cereals, personal care products and cleaning products. Potatoes, vegetables, fruit and fresh herbs are considered most suitable.
- ***Refill at home:*** This model is considered suitable for cleaning products, personal care products, soft drinks and juice and soups, sauces and oil. Cleaning products are considered most suitable.
- ***Return from home:*** This models is considered suitable for many types of products, among which eggs, personal care products, cleaning products, soft drinks and juices, water, pasta, rice, noodles, coffee, tea, potatoes, vegetables, fruits, cereals, dairy, sweets, soups, sauces, oil, salads, ready meals and soft drinks.
- ***Return on the go:*** This model is also considered suitable for many types of products, among which eggs, personal care products, cleaning products, soft drinks and juices, water, pasta, rice, noodles, coffee, tea, potatoes, vegetables, fruits, cereals, dairy, sweets, soups, sauces, oil, salads, ready meals and soft drinks.

In terms of motivation, contributing to a better environment (and the good feeling that reuse gives) is by far the strongest motivation for all models (Kramer et al., 2021). As contributing to a better environment is a strong motivation for all models it is important to keep emphasizing that through communication. Furthermore, communication can increase consumer willingness and participation. For example, by emphasizing that ever more people are making use of this possibility. If a wide-range group of people is shown in shops and advertisements people are more likely to recognize themselves and are less likely to think that reusing is not something for them. Another example of how communication can increase consumer participation is by setting up reminders at home, for example through fridge stickers.

The previously mentioned intention-behaviour gap, as described by Greenwood et al. (2021) is also present in the results presented in the report by Kramer et al. (2021). 86% of the people surveyed belief it is important the amount of disposable packaging is reduced, but only 16% is actually very consciously involved and just 53% are a little bit involved in reducing their use of disposable packaging.

5.5.2 Convenience of packaging service

One factor that strongly affects consumer's willingness to engage in reuse systems is convenience. The pace of adoption for reuse systems will depend strongly on making reuse systems as friction-free as possible, especially for time-stressed customers (World Economic Forum, 2021d). An important barrier to engage in reuse systems is the increased effort which is required by the consumer as compared to single-use packaging. These efforts negatively influence the convenience of a packaging services and include: needing to bring your own packaging, needing to clean in-between uses, needing to keep and store packaging and needing to return it. It is important to note that for most consumers, environment is of secondary importance compared to cost, convenience and functionality (Kunamaneni et al., 2019). Therefore making engaging in reusable packaging systems as convenient as possible is imperative to the success of reusable packaging.

Delivery and pick-up – Delivery and pick-up are factors that can boost the convenience of a packaging service, as the consumer doesn't need to leave his home. Therefore, by giving people the choice to either drop-off empty packaging on the go or to schedule a pick-up from home the convenience of the packaging service can be increased.

Return opportunities – When a consumer has substantial return opportunities the convenience of the packaging service can go up. Return opportunities are influenced by the accessibility of reuse infrastructure. Consumers may not find it easy to deal with multiple non-standardized reuse systems (Circular Economy Portugal, 2021b). Therefore a standardized system with a wide network of drop-off points is preferred to increase convenience. This is also emphasized by Coelho et al. (2020b) who state that "having reusable packaging easily accessible, easy to return and commonly used by a variety of establishments, increases the acceptance and therefore use by consumers" (Coelho et al., 2020b, p 64).

Ease of use – When it is clearly communicated to the consumer what actions he needs to perform the ease of use and therefore the convenience can go up. Maintenance actions such as having to clean the packaging between uses influence the ease of use. When a consumer needs to perform complex or a high amount of actions during the use of the product the ease of use will go down. Solutions to reduce the perceived effort of having to return empty packaging can be to make the packaging small, light, stackable or foldable.

5.5.3 Selling price

The selling price of reusable packaging is another important factor for consumers. According to manufacturers and brands, the price for reusable packaging has to be competitive with single-use, otherwise it is less like that consumers will engage in reuse systems (Coelho et al., 2020b). For most people, doing good for the environment is not enough and therefore a financial encouragement may be important to make consumers switch to reusable packaging (Coelho et al., 2020a). Similarly, Lofthouse et al. (2017) found that consumers have the following perceptions when it comes to the cost of refills: that the refillables are cheaper or that they should be cheaper than the original product. This means that customers expect a price incentive and if this is not delivered customers might be disappointed.

5.5.4 Financial incentives

Financial incentives can stimulate consumers to return and/or refill empty packaging and are therefore an important factor in the continuation of reuse systems. This is confirmed by Rethink Plastic Alliance (2021) who state that reusable packaging is most successful when consumers are given an incentive to return it. This incentive can be in the form of deposit return schemes or discount and reward systems.

Deposit Return Scheme (DRS) – DRS incentives consumers to return packaging after use, increasing the return rate. DRS schemes add a small fee to the price of the packaging, which is reimbursed to consumer once the empty packaging is returned or collected (Coelho et al., 2020b). A deposit should not only cover the costs of replacing the packaging, but should also 'trigger' the consumer to return it and not use it for something else.

The value of the deposit is important. If it is too low, consumers may find it too inconvenient to return the container. If it is too high, consumers may not purchase the packaging at all. Members of the Community of Practice on Reusable Packaging of the Netherlands Institute for Sustainable Packaging (KIDV) have indicated that deposits are one of the bottlenecks of reusable packaging. It is difficult to find the sweet spot: when the deposit is too low, people don't return the packaging, but when the deposit is too high people don't initially buy the product (Community of Practice Meet & Greet, 1 July, 2021).

Discount and reward systems – Another way to encourage users' participation is to offer discounts on future purchases or rewards if the package is returned (Circular Economy Portugal, 2021b). For example, RePack, a Finnish brand offering reusable e-commerce packaging, offers customers who use their packaging discount vouchers for the next purchase when they return the packaging. Another example of applying discounts are progressive discounts for every refill or return done by consumers (Coelho et al., 2020b). An example of a reward system could be savings campaigns in which customers save stamps for a free refill.

5.5.5 Hygiene and safety concerns

The last factor in the consumer category are hygienic and safety concerns. Hygienic and safety concerns can dissuade consumers from participating in reuse systems, especially in the context of COVID-19 and its aftermath (World Economic Forum, 2021d). Reusable packaging is however not new in the consumer goods sector and when properly cleaned and managed it does not pose any risks. The Ellen MacArthur Foundation (2020) emphasizes this by arguing that "safety and hygiene are critical for all packaging and are determined by how the packaging is managed and handled, not whether it is single-use or reusable. There are many examples of how reusable packaging can be used safely and hygienically" (Ellen MacArthur Foundation, 2020, p 77).

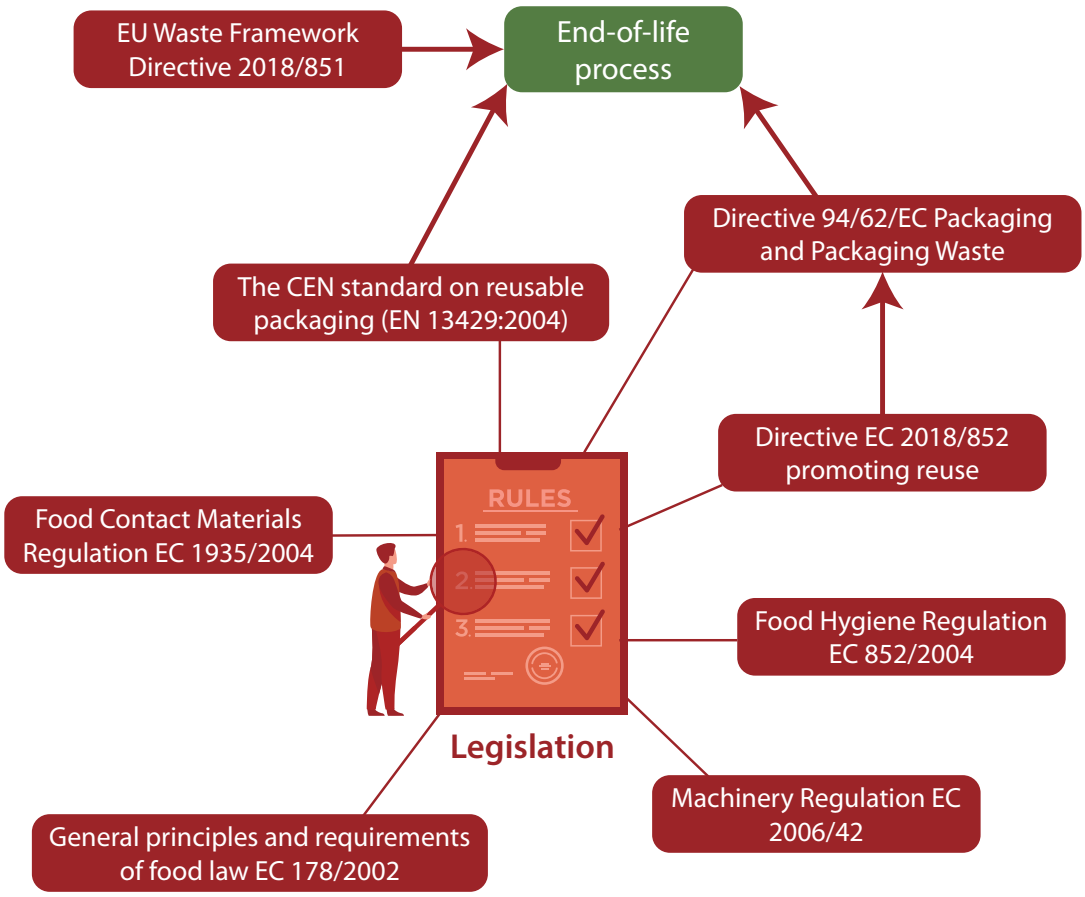


Figure 35 - Overview legal factors

5.6 Legislation

The legal factors describe the role of the public sector and governments in the successful development of reuse systems and existing laws to take into account when developing reuse systems (see Figure 35).

5.6.1 Role of public sector

Not only private organizations will need to invest in new capabilities to make large-scale reuse a reality: public organizations should play a large role as well. A big hurdle for reusable packaging is the lack of both dedicated laws and standards. As a result of that, reusable packaging businesses are constantly having to reinvent the wheel. This is emphasized by several sources. Coelho et al. (2020b) state that legislation plays a key role in ensuring better packaging designs and systems. According to them, the right measures can "help remove market barriers for reusable packaging systems and create a level playing field with single-use packaging" (Coelho et al., 2020b, p61). Kramer et al. (2021) describe that supermarkets would like sector-wide agreements so that risks are shared and that governments can help with this by making certain changes mandatory, by adapting laws and regulations. Several policies have been applied by different countries to incentives reuse over single-use. For example bans on single-use packaging (by Denmark), taxing of single-use packaging systems (by Belgium, Denmark and Finland) or compulsory deposit systems (by Germany) (Coelho et al., 2020a). World Economic Forum (2021d) state that governments have the power to establish effective inducements for pro-sustainability consumer choices and business innovation. Furthermore, they state that governments can facilitate the development of physical reuse infrastructure.

5.6.2 Legislation

According to the World Economic Forum (2021c) there is no specific legislation on the design of reusable packaging. This means that legislation on single-use packaging and products also pertain to reusable packaging. They mention several relevant regulations: regulations with regards to hygiene (Regulation EC 852/2004), (food) safety (Regulation EC 178/2002), (food) contact materials (Regulation EC 1935/2004) and machinery for handling, storing and cleaning (Regulation EC 2006/42).

However, there are initiatives in place to promote reusable packaging such as the European Circular Economy Action Plan, as mentioned in section 2.4. With regards to packaging the plan sets the target of making all packaging reusable or recyclable in an economically viable way by 2030. This plan specifically promotes design for reuse of packaging and to reduce the complexity of packaging

materials used (Circular Economy Portugal, 2021b). Furthermore, The Waste Framework Directive (2018/851) as mentioned in subsection 2.3.1 was adopted where reuse is given a high priority (European Commision, 2019). In addition, Directive 2018/851, amending Directive 94/62/EC on Packaging and Packaging Waste was adopted. Directive 2018/852 state that Member States should take measures to increase the share of environmentally sound reusable packaging in the market that don't compromise food hygiene and safety for consumers. The directive recommends measures such as deposit-return systems, setting qualitative or quantitative targets, economic incentives or targeting a minimum percentage of reusable packaging to be placed on the market.

A European Standard on reusable packaging is in place, namely the CEN standard on reusable packaging (EN 13429:2004). This standard contains a checklist by which the packer or filler can assess 'reusability'. The document specifies the following requirements (EUROPEN, 2006):

- Reusability of the packaging must be a deliberate objective;
- The design of the packaging must enable the principal components to accomplish a number of trips or rotations in normally predictable conditions of use;
- The packaging must be capable of being successfully reconditioned in accordance with the requirements laid down in the standard;
- The packaging must be capable of being refilled or reloaded;
- An appropriate system, necessary to support reuse, must be available in markets onto which the packer/filler is responsible for placing the packed product.

Packaging materials that are withdrawn from the reuse system must be in conformity with one or more of the standards on material recovery (EN 13430:2004), energy recovery (EN 13431:2004), and organic recovery (EN 13432:2000). Major shortcomings of this standard are that it does not contain any information on how often a packaging should be reused nor does it provide a clear technical specification on when a packaging is deemed reusable (EUROPEN, 2006).

Chapter 6
Interviews

This chapter summarizes the findings from the six interviews that were conducted.

6.1 Method

Semi-structured interviews were conducted with relevant players in the FMCG sector to learn from their experiences with reuse and perspectives and barriers for reuse. This form of interviewing was chosen as it allowed for flexibility during the interview session. Participants were chosen with the aim of representing the broad field of packaging and included six members of the NVC and one non-member. Participants worked for companies involved in B2C as well as companies involved in B2B, from consumer goods packaging to transport packaging. The interviews were conducted in August, September and October 2021 through Microsoft Teams meetings, and lasted approximately 60 minutes each. The data was recorded through audio-visual recordings with consent of the interviewees. Interviews were anonymized and transcribed in a summarising manner to capture the main points of the interview.

Interview 1 to 4 are transcribed in English and interviews 5 and 6 are transcribed in Dutch. The summarised transcripts are confidential. Details concerning the interviewees and dates can be found in Table 2.

The semi-structured interviews were coded for qualitative data analysis. In accordance with Kumar (2011), the qualitative data analysis was executed in the following manner described: Firstly, a content analysis of the interview data was conducted to establish the main themes from the respondents' answers. This included labelling relevant phrases and categorizing them into themes. Secondly, to each theme, a key-word code is attached. These themes provide an overview of the main findings of the interviews.

Table 2 - Interview details

Interview	Interviewee	Job description	Organization	Date
Interview 1	Interviewee 1	Team lead packaging innovation	Multinational chemical and consumer goods company	August 25, 2021 and September 7, 2021
Interview 2	Interviewee 2a	Packaging Designer	Multinational paper and cardboard packaging company	October 7, 2021
	Interviewee 2b	Packaging Designer		
Interview 3	Interviewee 3	Packaging development leader	Multinational furniture and home accessories chain	October 8, 2021
Interview 4	Interviewee 4	Founder	Start-up beauty products supplier	October 12, 2021
Interview 5	Interviewee 5	Chief commercial officer	Logistical service provider of standardised reusable transport items	October 12, 2021
Interview 6	Interviewee 6	Packaging and manufacturing expert	Dutch supermarket chain	October 22, 2021

6.2 Results

Responses of the interviews were categorised under four themes, with the following key-words: reuse models, enablers of reusable packaging systems, challenges and barriers of reusable packaging systems and the influence and role of e-commerce.

6.2.1 Reuse models

Refill at home – Respondents indicated that refill at home is one of the most widespread reuse solutions, particularly refill pouches. This type of reuse is very well known and therefore people know what to expect. Furthermore, respondents indicated that refill at home solutions work really well in global supply chains with long transport distances as they don't require take-back mechanisms. One respondent indicated that obtaining the right viscosity with dilutable and dissolvable refill at home concepts can be challenging. Another challenge for concepts where a single-use refill component is placed in a reusable packaging, is to ensure that the refill component cannot be used on its own. Furthermore, another challenge of refill at home concepts based on placing is how to put it on shelf: assembled or not assembled. Overall for all refill at home models it was indicated that people expect a price advantage for refills.

Refill on the go – Respondents indicated that refill stations in store requires an effort (i.e. having to clean your bottle at home, having to bring your bottle back to the store to refill again) of consumers which consumers are not always ready to put in. They require a higher engagement on very much commodity products. Whether or not refill in store will work depends heavily on the market, the target group, the product and which type of store. One respondent had experience with a refill station in a beauty salon. The respondent indicated that with such dedicated environment, refill on the go solutions work better, due to the high "ritualization". The respondent believes that refill on the go is easier for premium brands where consumers feel a sense of belonging, so they are willing to put in extra effort to feel like they are part of a community. Furthermore, when brands have an actual purpose and commitment towards sustainability people will be more willing to put in the effort for reuse. For refill on the go systems, the required floor space is seen as a challenge for implementing refill stations.

6.2.2 Enablers of reusable packaging systems

The following factors mentioned by respondents were categorised under the enablers of reusable packaging systems:

- ***Standardisation and harmonisation*** – The importance of standardisation and harmonisation in enabling reusable packaging systems was mentioned by five respondents. This is believed to be especially relevant for sequential reuse models (return from home and return on the go). Too much differentiation and complexity between packaging formats leads to high changeover times, making the system economically unviable. One respondent mentioned that in order to get to scale there should be packaging that can shared among retailers in a common system. The respondent stresses the importance of collaboration and harmonisation across brands and thinks that is the only way forward for reuse systems to really work. Another respondent indicated that sequential reuse systems should be set up across several countries. These countries should share the same packaging and deposit return system. Such systems require international support and legislation. Another respondent also indicated that harmonisation of packaging needs to be done with care. Especially for beauty packaging, one respondent believes that a shelf where all products are in the exact same packaging will look dreadful to consumers, even with different labels and graphics. Similarly, another respondent indicated that one of the obstacles to standardisation and harmonisation is that brands will be less able to differentiate themselves.
- ***Legislation*** – The importance of legislation in stimulating and enabling reusable packaging systems was mentioned by four respondents. For instance, one respondent indicates that it is the task of politicians to set up policies and regulations stimulating cross brand collaboration for reuse systems. Another respondent indicated that if the government does nothing to promote and enable it, most business will not make the switch.
- ***Collaboration*** – The importance of collaboration in enabling reusable packaging systems was mentioned by four respondents. Collaboration is especially important for sequential reuse systems that need to handle reverse logistics. One respondent indicated that for reverse logistics to run smoothly, collaboration between different parties is crucial as it is hard for a single company to do all the cleaning, sorting and distribution. Another responded indicated that collaboration is "absolutely key". Another respondent indicated that for cross brand collaboration where packaging is shared in a packaging pool among different companies, industry standards are required. In that case, one needs to be really mindful about cross contaminations or migrations and it is difficult to determine which brand or company is responsible when that occurs.
- ***Local scope*** – The importance of a local supply chain scope for sequential reusable packaging systems was mentioned by four respondents. One respondent indicated that for global companies it is really hard to make reuse system work, as every country they serve would need its own collection, cleaning

and refill system. In a single-use system filling of packaging is done at one central location, which is much easier. Similarly, another respondent from a global company indicated that it is not realistic for a reusable packaging to have to go all the way back to their remote production locations to be reused again. Another respondent indicated that for sequential reuse systems you need small geographical areas in which circulation of packaging can take place.

- ***Scale*** – It was indicated that for reuse systems to be economically viable a large scale is needed, especially for sequential reuse systems otherwise the costs of cleaning and refilling per packaging will be too high to be financially attractive. Collaboration, pooling and harmonisation help in achieving scale.
- ***Purchase frequency*** – Two respondents indicated that especially for sequential reuse systems, products with a high purchase frequency are preferred to obtain a decent scale. One respondent indicated that it is very difficult to build up reusable packaging systems for non-frequent flows. The respondent indicated it is a lot easier if daily shopping activities are involved in reuse.
- ***Limited product range*** – One respondent indicated that in order for sequential reuse systems to work a limited product range is preferred. To indicate, if there are a hundred different shampoos in the assortment, it will be very complex to refill all these types of shampoos locally.
- ***Deposit return schemes*** – The importance of deposit return schemes to increase return rates for sequential reusable packaging systems was mentioned by three respondents. One respondent mentioned that bottles with a deposit have much higher return rates than bottles without deposits, which indicates how financially motivated returns are. Another respondent indicated that the determining the value of the deposit is important and can be challenging. Deposits should not only cover the costs of replacing the packaging, but should also 'trigger' the consumer to return it and not to use it for something else.
- *Quality controls* – One respondent indicated that quality control is very important for the return flow of reusable packaging. During quality control the status of the packaging is determined to be either functional or non-functional. The respondent indicated that the many different parties involved should all be able to perform the quality control accurately. Otherwise filling locations will receive back damaged items. If quality controls are not performed accurately, deposits might be paid back in situations where they should not have been paid back.
- *Collapsible and nestable packaging* – One respondent indicated that when sequential reuse packaging is collapsible and nestable the return flows can be reduced, making reverse logistic systems more efficient.
- ***Letter box compatibility*** – It was indicated reusable packaging concepts which are letter box compatible will increase the convenience of delivery. It is highly convenient for people when they do not have to go to pick-up points or to the neighbours to pick-up their orders. Naturally this is not possible for all products, but wherever possible it is worth exploring this option.
- ***Plastics*** – One respondent indicated that plastics could (when used right and for long lived applications) play a key role in reusable packaging concepts just as much as glass and metal based packaging concepts. By using plastics, convenient opening and closing mechanisms as well a very ergonomic shapes can be obtained.

6.2.3 Challenges of reusable packaging systems

The following factors mentioned by respondents were categorised under the challenges of reusable packaging systems:

- ***Convenience*** – One of the biggest challenges of reusable packaging systems mentioned by the respondents is to make it convenient for consumers. Similarly, the inconvenience of reuse systems is seen as a major barrier. This was mentioned by all interviewees. It was indicated that in order for reuse to become mainstream, concepts need to be developed that are easy in use. If reusable packaging concepts do not exceed or at least match-up to the performance of single-use packaging, only extremely sustainably motivated people who are willing to give up some convenience for their beliefs will use it. One respondent mentioned that what is most convenient for the customer is not always as convenient to develop for the business. One respondent named the inconvenient execution of some of the refill at home solutions, where consumers need to pour concentrates from huge sachets into tiny bottle openings. This messy process can totally ruin the user experience. Next to inconvenient product assembly, having to clean bottles at home was also seen as inconvenient, especially for bottles that contained products with surfactants, which will foam all over the place. Futhermore, having to remember to take back and return empty packaging is also mentioned as an inconvenience.
- ***Mainstreaming reuse*** – As mentioned above a big challenge for reuse systems is to become mainstream. A respondent indicated that for reuse to become mainstream and popular, reusable packaging concepts should bring either a price, performance, convenience or environmental benefit compared to single-use alternatives. Preferably several aspects improve compared to single-use alternatives. If one of these aspects stays at the same level, another aspect needs to be at a higher level.

- ***Reverse logistics*** – The reverse logistics of sequential reuse systems are seen as a challenge by several respondents. Collecting and delivering packaging can become quite complex with cleaning and sorting involved. One respondent it is difficult to find companies that can drop off and pick up items at the same time without charging twice. In the Netherlands only Post NL offers this without charging twice, but only above a certain threshold. Therefore for smaller companies it becomes very challenging to set-up reverse logistics.
- ***Durability and appearance*** – Another challenge mentioned by the respondents is that the packaging has to keep on looking good over several use cycles. This is especially important for beauty packaging as people want to see their need of beauty reflected in the packaging.
- ***Funding*** – One respondent, who is the founder of a start-up in reusable packaging indicated that it is difficult to get funding. There is circular funding available but very little is suitable for reuse models.
- ***Hygiene and safety*** – Several respondents indicated the hygienic and safer risks for food products as a barrier for implementing reuse systems. Bulk dispensers are mentioned to be particularly at risk.
- ***Infrastructure*** – One respondent indicated that there is not a lot of reuse-enabling infrastructure in place and that it is difficult to find washing facilities that can handle the type of products they use. Moreover, washing facilities are sometimes located far away.
- ***Misuse*** – One respondent indicated that misuse of the packaging is a challenge for reusable packaging systems. This happens when people start using the packaging for a different purpose and decide not return it.

6.2.4 Influence and role of e-commerce

Respondents indicated that the proportion of products sold via e-commerce channels has risen. One respondent indicated that because of the COVID-19 pandemic consumers' buying behaviour has changed and that home deliveries have increased. Moreover, the respondent indicated that the pandemic has taught retailers to be more flexible. Another respondent also indicated that there was an increase in online sales since the pandemic.

Respondents have not indicated there should be a difference between primary reusable packaging sold online or in store. One respondent indicated that currently they only sell through e-commerce but that they are planning to expand the same assortment to stores as well. Another respondent thinks it is more difficult to test new reusable concepts and ideas via e-commerce than via the traditional stores. The respondent indicated it is more logical to introduce reusable primary packaging concepts in store and afterwards via the e-commerce channel. The same respondent indicated that the benefit of e-commerce is that there is no shelf competition. This means that for e-commerce a nice image of the product on the website suffices and that customers might not necessarily need to be send extravagant packaging. From that perspective, reusable packaging could be different from traditional retail packaging. However, the respondent does not think it is very likely that there will be a separate packaging line for e-commerce, as then the company will have to deal with two separate packaging lines for the same product. This prevents omni-channel integration.

Some reuse models and solutions were deemed especially suitable for e-commerce. Refill at home solutions with solid dilutable concentrates were considered an interesting direction for e-commerce where product leakage is a frequently occurring problem. Moreover, reusable transit packaging was seen as especially interesting for e-commerce.

Part I
Setting the stage

This part introduces the thesis project and insights from literature are combined as a point of departure for this thesis project.

Part II
Research & Analysis

This part combines insights from literature and interviews to obtain understanding of the different reuse models, the major factors involved in reuse systems and barriers for implementing them.

Part III
Development

This part revolves around the development of a decision support tool for reusable packaging. Firstly, the decision support tool's aim, target group, functions and requirements are described. Secondly, the design and development process of the decision support tool is described.

Part IV
Evaluation

This part revolves around the evaluation of the decision support tool for reusable packaging. It describes the two methods used to evaluate the decision support tool.

Part V
Wrap-up

This part wraps up this research project by by discussing the limitations and recommendations in the dicussion and answering the research questions in the conclusion.

Chapter 7
Requirements

The insights from Part II: Research & Analysis need to be reflected into the decision support tool. In Part II, factors influencing the viability and successful development of reuse systems were divided into six categories: Economics, Logistics, Environment, Packaging Design, Consumer and Legislation. Part II illustrates and explains how the factors influence each other inside as well as outside of their own category. The results from the interviews endorse this interconnectedness of factors. Therefore, the key take-away from the research and analysis phase for the development of the decision support tool is that it should follow a holistic approach.

7.1 Aim

The first aim of the tool to provide decision-making support for the development of primary reusable packaging systems for FMCGs, such as food and beverage, personal care and household care products used in daily life, for business-to-consumer (B2C) markets. The solution must give the users the chance to orient themselves as broadly as possible so that they can make an informed decision about whether or not to implement a reuse system and which reuse model is most suitable. The second aim of the tool is to provide users with a point of departure for the development of reuse.

7.2 Target Group

The tool is first and foremost developed for members of the NVC. Therefore, this framework is targeted for companies active throughout the whole packaging supply chain. It should also be relevant for brand owners or marketeers who are wanting to explore the option of switching from single-use packaging systems to reusable packaging systems and want to know the different perspectives and choices involved in the development of reusable packaging. It is also relevant for packaging experts and designers who want to get insight in the design considerations and requirements for the reusable packaging itself. As the decision support tool is aimed for packaging professionals, it assumes basic packaging knowledge of users.

7.3 Functions & Requirements

Functions of the tool and corresponding requirements are formulated to realize the aim of the tool as described in the previous sections. The main functions of the tool are to inform, support, navigate and interact.

Function 1: Inform

- Users should be able to use the tool as a stand-alone document.
- The tool must be pleasant to work with, by striking the right balance between information and presentation.
- The tool should set out and explain the different reuse models both visually and textually.
- The tool should provide users with guidelines for reuse tailored to the four different reuse models (refill at home, refill on the go, return from home and return on the go)
- The tool should distinguish between traditional retail, e-commerce and horeca.
- The tool should give insight in packaging design considerations as well as system design considerations.

Function 2: Support

- The tool should allow users to determine the general viability of reuse for their brand or product.
- The tool should aid users in the choice for exclusive or sequential reuse.
- The tool should aid users in the choice for the different reuse models (exclusive: refill at home or refill on the go, sequential: return from home or return on the go).
- The tool should enable users to determine focus points for development.
- The tool should enable users to determine a point of departure for the development of reusable packaging.

Function 3: Navigation

- The tool should be easy to navigate.
- Users should be able to see at all times where in the decision support tool they are.

Function 4: Interaction

- The tool should be interactive to enable users to document decisions.
- The interface of the tool must make sense to the average user.
- The interactions should be intuitive so that only minimal explanation is required.
- The tool should enable users to revise their decisions, by allowing them to undo certain interactions.

Chapter 8
Development

The development of the decision support tool followed from an iterative design process and took several months to complete. During this design process regular status meetings with a packaging professional from an external FMCG company were held, which allowed for constant feedback in the design process. This chapter discusses the design choices for the final version of the decision support tool.

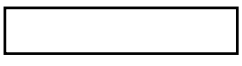
8.1 Format

It is important that the tool is accessible to many users as the tool is going to be shared with the broad network of NVC members. Moreover, as mentioned in the previous chapter, the format of the tool has to accommodate the following functions: to inform, to support, to navigate and to interact. Interactive PDF guide is chosen as format, as this format meets both requirements. It is safe to assume that most people in this day and age have had experience navigating traditional PDF documents. With this in mind, the step to interactive PDFs is considered to be a minor one. Interactive PDFs are easy to circulate via emails and work across multiple platforms and devices such as laptops, desktops, smartphones and tablets. Moreover, interactive PDFs allow readers to respond without the need for additional resources. Lastly, the format also allows for printing which some people might feel more comfortable with.

8.2 Navigation and interaction elements

For intuitive navigation and interaction, widely recognized icons and buttons are used to help users navigate and interact in the decision support tool. The icons and button used in the tool are illustrated and described in Table 3.

Table 3 - Navigation and interaction elements used in the guide

Navigation elements	
	An arrow bar at the top of each page enables users to quickly switch between levels and allows users to see at all times where in the decision support tool they are.
	The universal play icon enables users to navigate to a specific section.
	The universal information icon enables users to locate a section containing extra information.
	This icon enables users to navigate to or locate a section containing an example. Examples are used to complement the main information.
Interaction elements	
	Radio buttons are elements that allow users to choose only one of a predefined set of mutually exclusive options.
	Check boxes are elements that allow users to select one or more options of a limited number of choices.
	Text fields are elements that allow users to write a short text entry.
	Clear form is an element that allows users to reset the radio buttons, check boxes and text fields.

8.3 Structure

Part II: Research & Analysis identified factors that influence the viability and successful development of reuse systems. These factors are reflected and further specified in the decision support guide, which structure is based around the following logic: firstly, prior to the development process, it is important to determine whether reuse is a viable option for a brand and/or product and secondly, it is important to determine which reuse system and corresponding reuse model is most suitable. Therefore this guide is divided into levels, as displayed in Figure 36.

Level 1 and 2 follow a stage-gate inspired approach, as described by Cooper (1990). Level 1 and 2 include "conditional" aspects that describe preferred circumstances for reuse. When the conditions for the general reuse viability are met (Gate 1) one should proceed to Level 2. When the decision for a certain suitable reuse model(s) is made (Gate 2) one should proceed to Level 3 and 4. Levels 3 and 4 include "consideration" aspects that describe aspects to take into account when developing reusable packaging concepts systems. The gates are positioned as follows because as mentioned previously, it is important that users first explore whether reuse is a viable option for their product and/or brand and which reuse system and corresponding reuse model is most suitable for their brand and/or product before diving into the development strategy and design of the reusable packaging and system itself. This is because depending on the reuse model, different considerations are more or less relevant.

Levels 1, 2 and 3 conclude with a worksheet page where users can document their decisions. The worksheet page also serves as a summary of the decisions made in the level. Level 4 is designed to be a combination of worksheets. Although the guide follows a prescriptive route with consecutive levels, users can decide to divert from this because levels can be used stand-alone too. For instance, if a user already knows what reuse model to implement the user can move straight to Levels 3 and 4.

To enable holistic decision making support on the topic of reusable packaging Levels 1, 2 and 3 take four perspectives into account: business and brand, customer and consumer, product and content and environment and sustainability. This is because in order to be viable, reuse needs to perform from the viewpoint of all four perspectives.

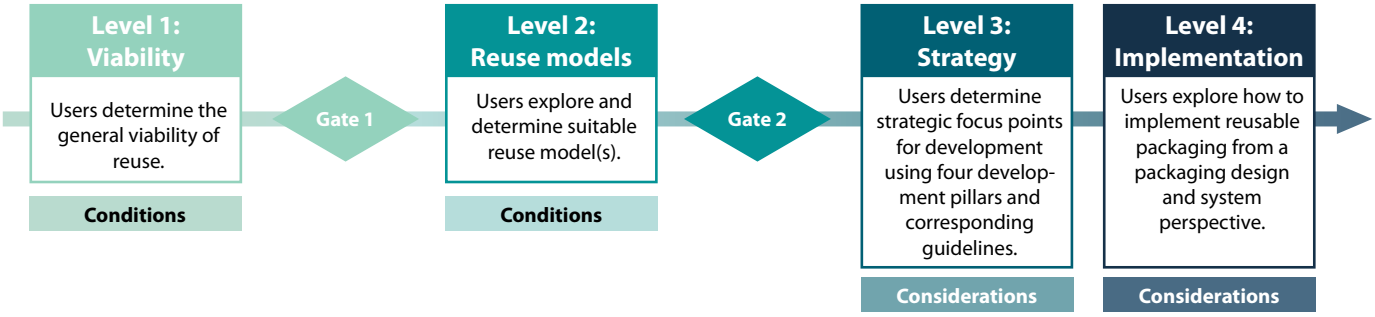


Figure 36 - Level structure of the decision support tool

8.4 Level 1: Viability

The goal of Level 1 is to enable users to determine the general viability of reuse from four different perspectives: business and brand, customer and consumer, product and content and environment and sustainability. Per perspective two main conditional aspects are given, which can be rated on a scale from low to high. The conditional aspects are based upon the literature review and interviews from Part II: Research and Analysis. The two conditional aspects are reflected in a matrix made up of an x-axis and a y-axis with four quadrants. The combined rating of the two aspects determine the general viability of reuse from that particular perspective and can be plotted in one of the quadrants of the matrix. Every perspective has its own page and matrix, see Figure 37.

For the business and brand and the customer and consumer perspective reuse is particularly promising when both conditional aspects are rated high, see Figure 38. For the product and content and the environment and sustainability perspective reuse is particularly promising when aspect X is rated low and aspect Y is rated high, see Figure 39. It is worth noting that these conditional aspects only increase the viability of reuse systems. Therefore, this does not mean that when one of the conditional aspects does not have the ideal ranking, reuse becomes totally unviable. Hence the divisions of "Reuse is particularly promising", "Reuse is reasonably promising" and "Reuse is not very promising". When reuse from a certain perspective is deemed not very promising, it does not mean it is impossible, just that there will be more hurdles to overcome on the way.

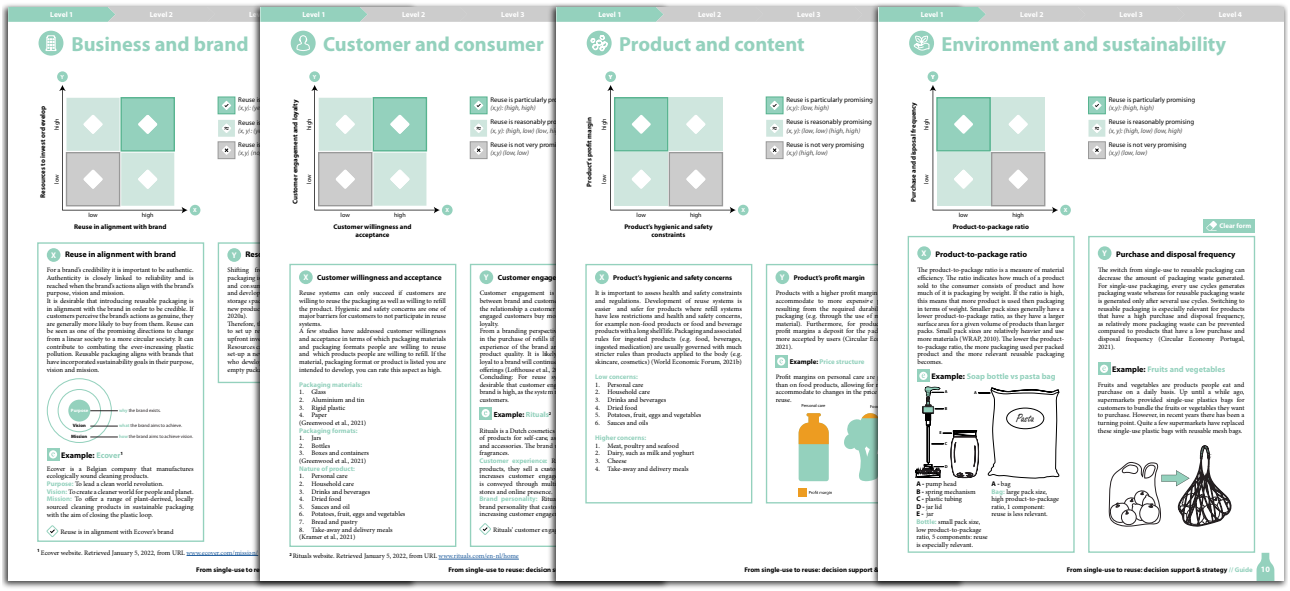


Figure 37 - Level 1 pages showing matrices per perspective

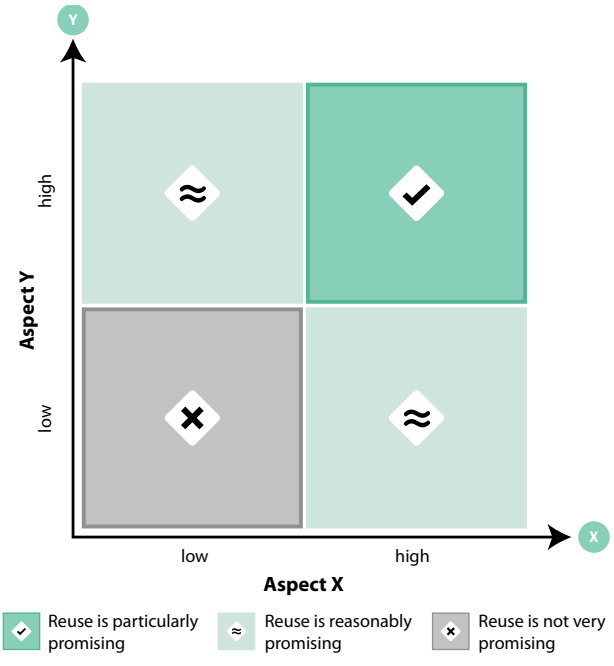


Figure 38 - Matrix for business and brand and the customer and consumer perspective

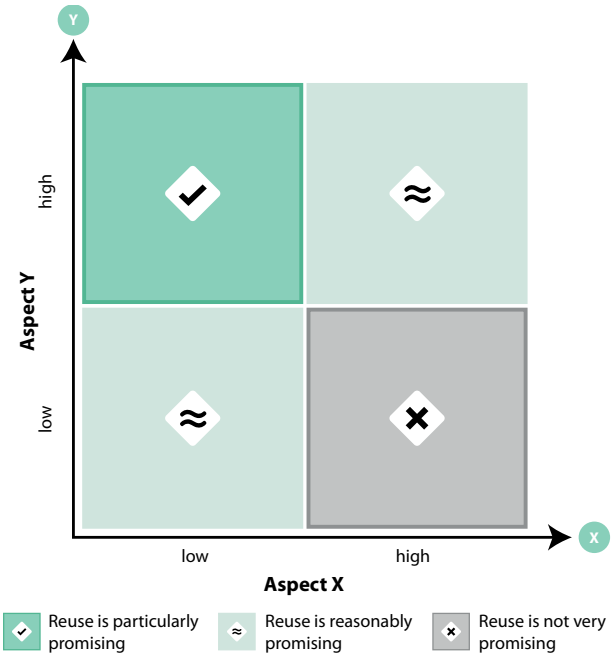


Figure 39 - Matrix for the product and content and the environment and sustainability perspective

8.4.1 Business and brand perspective

The conditional aspects of the business and brand perspective are described in Table 4. Regarding aspect X, when a reuse strategy is highly aligned with the brand's purpose, vision and mission the brand is likely to be perceived as authentic and credible. When customers perceive a brand's actions as genuine they are generally more likely to buy from the brand. Moreover, when brands are authentic in words and deeds, brands can improve customer loyalty. As reuse requires customers to use products for several use cycles it is desirable these customers demonstrate loyalty to the brand. Therefore, it is desirable that reusable packaging is highly aligned with the brand.

Regarding aspect Y, research has indicated that reusable packaging systems, and especially sequential reuse systems require a substantial initial investment, see subsection 5.1.1. Therefore the prime financial condition for reuse is that business have sufficient amount of resources to invest or develop reusable packaging systems.

Table 4 - Conditional aspects of the business and brand perspective

Business and brand perspective		
Axis	**Conditional aspect**	**Ideal ranking**
X	Reuse in alignment with brand	High
Y	Resources to invest or develop	High

8.4.2 Customer and consumer perspective

The conditional aspects of the customer and consumer perspective are described in Table 5. Regarding aspect X, when customer willingness and acceptance is high reuse systems are more likely to succeed. Research has indicated that people are willing to reuse packaging made from glass, aluminium and tin and rigid plastic. Moreover, people are willing to reuse jars, bottles, boxes and containers. In terms of nature of the product, research has shown that people are willing to reuse the following products: personal care, household care, drinks and beverages, dried food, sauces and oil, potatoes, fruit, eggs and vegetables, bread and pastry and take-away and delivery meals, see Chapter 5 subsection 5.5.1.

Regarding aspect Y, highly engaged customers buy more and demonstrate more loyalty. Research has indicated that it is likely that consumers already loyal to a brand will continue to purchase new refillable offerings (Lofthouse et al., 2017). For reuse systems to succeed it is therefore desirable that customer engagement and loyalty of a brand is high, as the system needs frequently recurring customers.

Table 5 - Conditional aspects of the customer and consumer perspective

Customer and consumer perspective		
Axis	**Conditional aspect**	**Ideal ranking**
X	Customer willingness and acceptance	High
Y	Customer engagement and loyalty	High

8.4.3 Product and content perspective

The conditional aspects of the product and content perspective are described in Table 6. Regarding aspect X, in order for reuse systems to be viable it is desirable that the product's hygienic and safety concerns are low. This is because development of reuse systems is easier and safer for products where refill systems have less restrictions and health and safety concerns. Packaging and associated rules for ingested products (e.g. food, beverages, ingested medication) are usually governed with much stricter rules than products applied to the body (e.g. skincare, cosmetics) (World Economic Forum, 2021c).

Regarding aspect Y, in order for reuse systems to be viable it is desirable that the product's profit margin is high. This is because products with a higher profit margin can more easily accommodate to more expensive packaging costs resulting from the required durability for reusable packaging (Circular Economy Portugal, 2021a).

Table 6 - Conditional aspects of the product and content perspective

Product and content perspective		
Axis	**Conditional aspect**	**Ideal ranking**
X	Product's hygienic and safety concerns	Low
Y	Product's profit margin	High

8.4.4 Environment and sustainability perspective

The conditional aspects of the environment and sustainability perspective are described in Table 7. Regarding aspect X, when the product-to-package ratio of the reference single-use packaging is low, reusing the packaging is extra relevant. The product-to packaging ratio indicates how much of a product sold to the consumer consists of product and how much of it is packaging by weight. The higher the ratio, the more product is used compared to the packaging, making the packaging very efficient. The lower the product-to-package ratio, the more packaging used per packed product and the more environmentally attractive reusable packaging for that product becomes as relatively a lot of packaging waste can be prevented by making the packaging reusable.

Regarding aspect Y, the higher the purchase and disposal frequency of the product the more relevant reusable packaging becomes. For single-use packaging, every use cycles generates packaging waste whereas for reusable packaging waste is generated only after several use cycles. The switch from single-use to reusable packaging can decrease the amount of packaging waste generated. Switching to reusable packaging is especially relevant for products that have a high purchase and disposal frequency, as relatively more packaging waste can be prevented compared to products that have a low purchase and disposal frequency. Moreover, respondents from the interviews made clear that a high purchase frequency is desirable to obtain scale of the system, see Chapter 6 subsection 6.2.2.

Table 7 - Conditional aspects of the environment and sustainability perspective

Environment and sustainability perspective		
Axis	**Conditional aspect**	**Ideal ranking**
X	Product-to-package ratio	Low
Y	Purchase and disposal frequency	High

8.5 Level 2: Reuse models

The goal of Level 2 is to enable users to explore and determine suitable reuse model(s) (refill at home, refill on the go, return from home and return on the go). From Part II: Research & Analysis system preferences of exclusive and sequential reuse systems were drawn up and used in the tool to support decision making around the reuse system choice. A list consisting of two columns is used to show the system preferences per reuse system, see Figure 40. Again these preferences are divided over the business and brand, customer and consumer, product and content and environment and sustainability perspectives to enable a holistic approach. By means of checkboxes people can tick what is most applicable for their situation and can determine the most suitable system by reviewing which side has the most checkmarks. The set-up with a clear division between exclusive and sequential reuse was used to highlight the fact that these systems are separate systems with separate preferences and considerations.

Exclusive reuse

Business and brand

- Global or local supply chain scope ☐
- Horizontally or vertically integrated supply chain ☐
- Reuse infrastructure is unavailable ☐
- Not willing to invest in reuse infrastructure ☐

Customer and consumer

- Customer values ownership of packaging ☐
- Packaging is distinctive feature of offering ☐

Product and content

- Diverse or limited range per product type ☐
- Products with high or low rate of circulation ☐

Environment and sustainability

- Decreasing packaging waste **is less of** a priority ☐
- End-of-life control **is not** a priority ☐

Sequential reuse

Business and brand

- Local supply chain scope ☐
- Vertically integrated supply chain ☐
- Reuse infrastructure is available ☐
- Willing to invest in reuse infrastructure ☐

Customer and consumer

- Customer does not value ownership ☐
- Product is distinctive feature of offering ☐

Product and content

- Limited range per product type ☐
- Products with high rate of circulation ☐

Environment and sustainability

- Decreasing packaging waste **is** a priority ☐
- End-of-life control **is** a priority ☐

Figure 40 - Exclusive vs sequential reuse checklist

The rest of the level shows the differences between the reuse models (refill at home, refill on the go, return from home and return on the go) from the viewpoint of the four perspectives. Every perspective is given its separate page and includes colour coded tables for fast distinction between exclusive and sequential reuse and corresponding reuse models, see Figure 41. By showing the different perspectives the guide aims to make clear that when a reuse model seems suitable from the viewpoint of one perspective, it does not necessarily mean that it is also suitable from the viewpoint of other perspectives. For instance, the business' required effort and investment for refill at home solutions is lowest (a consideration in favour of refill at home from the business and brand perspective), but that the anticipated waste of refill at home solutions is highest (a consideration not in favour of refill at home from the environment and sustainability perspective). By highlighting the differences, users can make a well informed choice for a reuse model and identify the consequences of their choice from the viewpoint of the other perspectives.

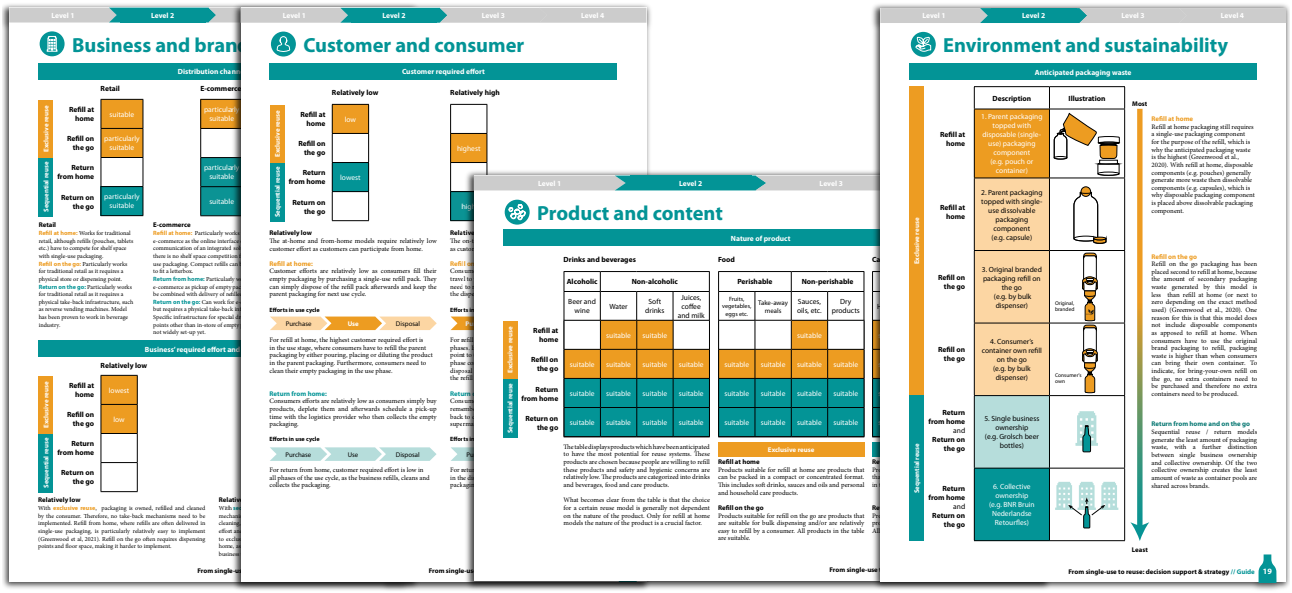


Figure 41 - Level 2 pages showing differences between reuse models per perspective

8.6 Level 3: Strategy

The goal of Level 3 is to enable users to determine strategic focus points for development of the chosen reuse model by using four development pillars and corresponding guidelines. Results from the interviews in Part II: Analysis & Research indicated that in order for reuse to work and become mainstream, reusable packaging concepts should bring either a price, performance, convenience or environmental benefit compared to single-use alternatives. In fact, preferably at least two aspects should improve compared to single-use alternatives. In Level 3 these benefits are reflected into strategic focus points for development and visualised as pillars, see Figure 42. The middle yellow dotted line is the reference line for single-use alternatives and the top yellow dotted line is the target for reuse. In situation *a* on the left of Figure 42, reuse scores the same as single-use. With a same score on price, performance, convenience and sustainability there will be no incentive to switch to a reusable packaging system. In situation *b*, reuse scores better than single-use on price and sustainability, meaning that reusing and refilling packaging is more affordable for consumers and that the system is more sustainable than single-use. With an improvement on two pillars, there is an incentive to switch to a reusable packaging system. In the ideal situation *c*, reuse scores better on all pillars. With an improvement on four pillars there will be a big incentive for customers to switch to a reusable packaging system.

As mentioned previously, in this level users decide on which pillars to focus. Reuse model specific pages will show guidelines per pillar. Required guidelines are given which are vital for the reuse model. These required guidelines should therefore be used to level with single-use alternatives. Optional guidelines are given which can provide a competitive edge over single-use systems. These optional guidelines can therefore be used to improve on a specific pillar. Every pillar consists of sub pillars from which guidelines are drawn up. The pillars with sub pillars can be found in Figure 43. A full overview of the guidelines can be found in the decision support guide.

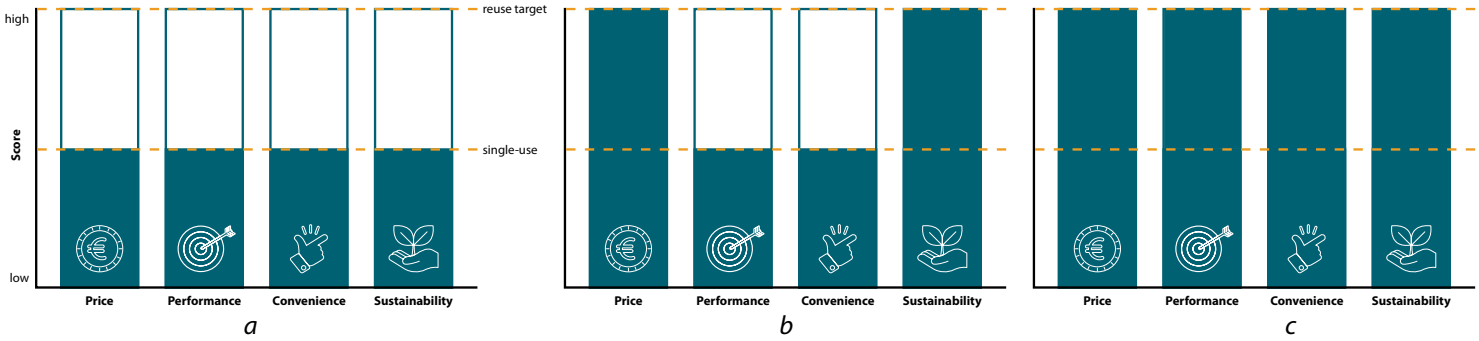


Figure 42 - Strategic development pillars

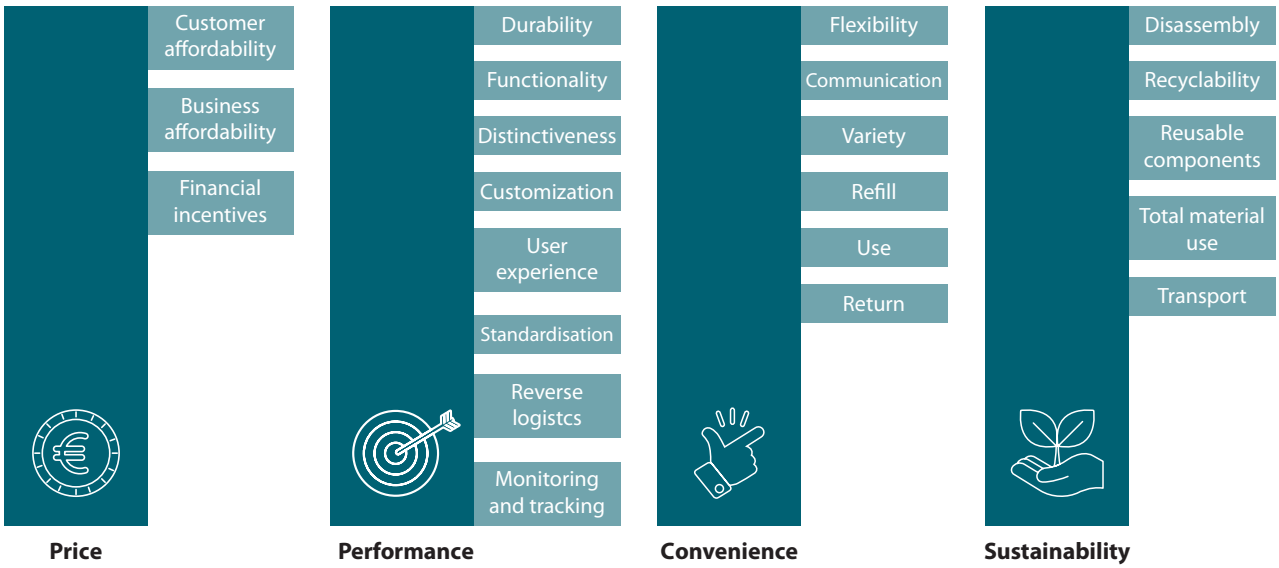


Figure 43 - Strategic development pillars and corresponding sub pillars

8.7 Level 4: Implementation

The goal of Level 4 is to enable users to explore how to implement reusable packaging from a packaging and system perspective. In Level 3 uses have determined on which development pillars to focus their development strategy (price, performance, convenience and sustainability). Level 4 takes the next step and enables users to explore how to implement chosen strategy by looking at reuse from two dimensions: the reusable packaging and the system it operates in. These two dimensions are interdependent, see Figure 44. The design considerations for reusable packaging include four key elements: design, material, labels and technology (World Economic Forum, 2021b). The design considerations associated with reusable systems include the various stages of the product life cycle in the context of a reuse system: production of container, filling and refilling, use, collection/return, transport, storage, cleaning and end-of-life (World Economic Forum, 2021b).

8.7.1 Dimension 1: Reusable packaging

The design considerations per element associated with the reusable packaging design are displayed in a morphological chart like structure. The rows in the X direction show different design considerations for the specific element. The first columns in the Y direction list the elements: design, material, labels and technology. The row of the design element is shown in Figure 45. The full chart can be reviewed in the decision support guide.

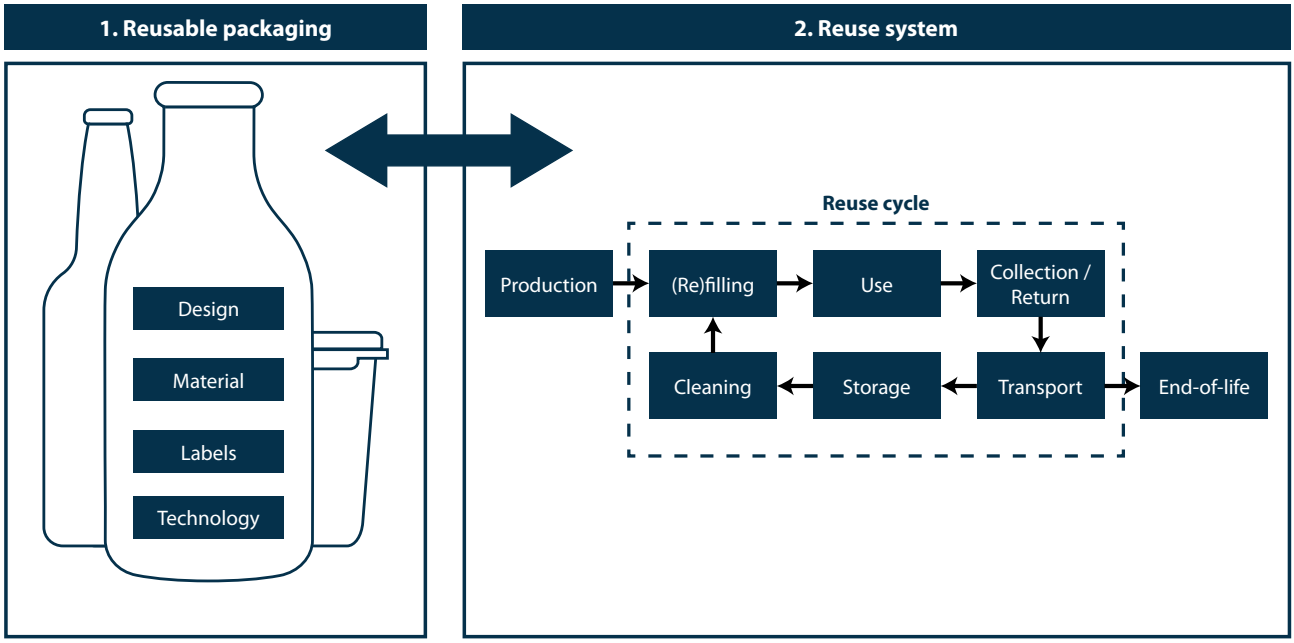


Figure 44 - Reusable packaging and reuse system interdependence

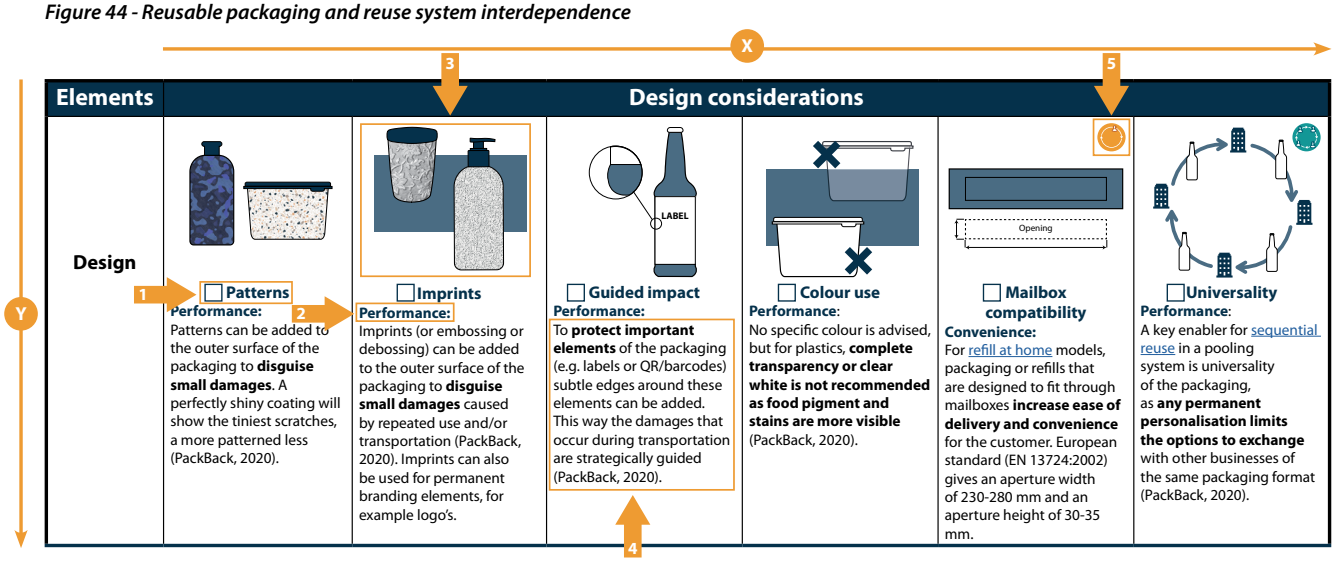


Figure 45 - Design considerations for design element of Dimension 1: Reusable packaging

8.7.2 Dimension 2: Reuse system

The design considerations associated with reusable packaging systems are displayed in the same way as Dimension 1: Reusable packaging. The rows in the X direction show different design considerations for the stage of the reuse system. The first columns in the Y direction list the reuse system stages: production, (re)filling, use, collection/return, transport, storage, cleaning, end-of-life. The rows of the cleaning stage is given in Figure 46. The full chart can be reviewed in the decision support guide.

The charts contains the following cues, see Figure 45 and Figure 46:

1. The design consideration with a check box. Users can check the box when they deem the design consideration relevant.
2. The link of the design consideration with the development pillars (price, performance, convenience and/or sustainability).
3. An illustration for clarification of the design consideration.
4. An explanation of the design consideration.
5. An icon indicating the relevance for one of the two reuse systems: exclusive or sequential reuse.

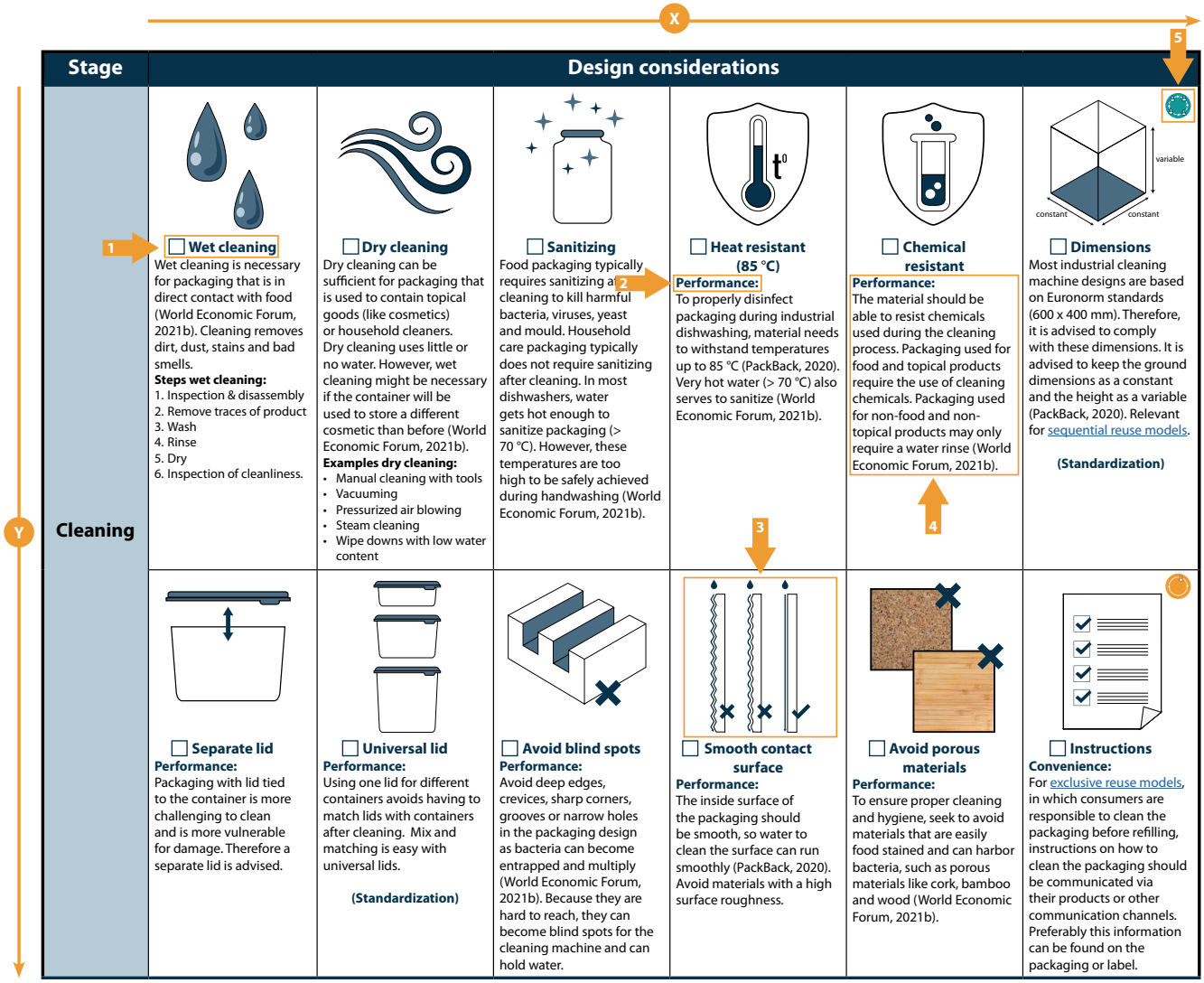


Figure 46 - Design considerations for cleaning stage of Dimension 2: Reuse system

8.7.3 Reusable packaging configurations and systems

The guide concludes with pages of reusable packaging configurations per reuse model (Figure 47) and example pages of reuse systems per reuse model (Figure 48). The research on reusable packaging offerings has indicated that there are different packaging configurations possible per reuse model, see Chapter 4 section 4.3. The aim of the reusable packaging configurations is to give a clear overview of these possibilities to enable users to orientate themselves and choose a configuration for development. The aim of visually showing the reuse systems is to make the different flows per reuse model clearly visible for users. The overview of the reuse systems can be used to find bottlenecks in the system.

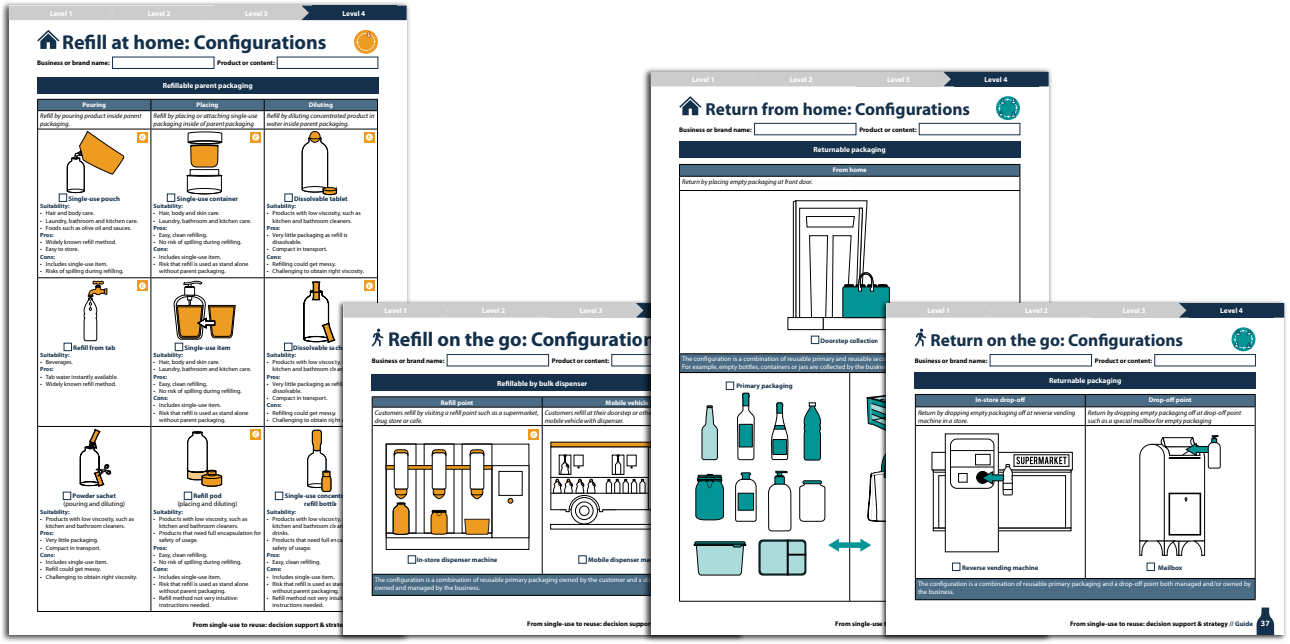


Figure 47 - Reusable packaging configurations per reuse model

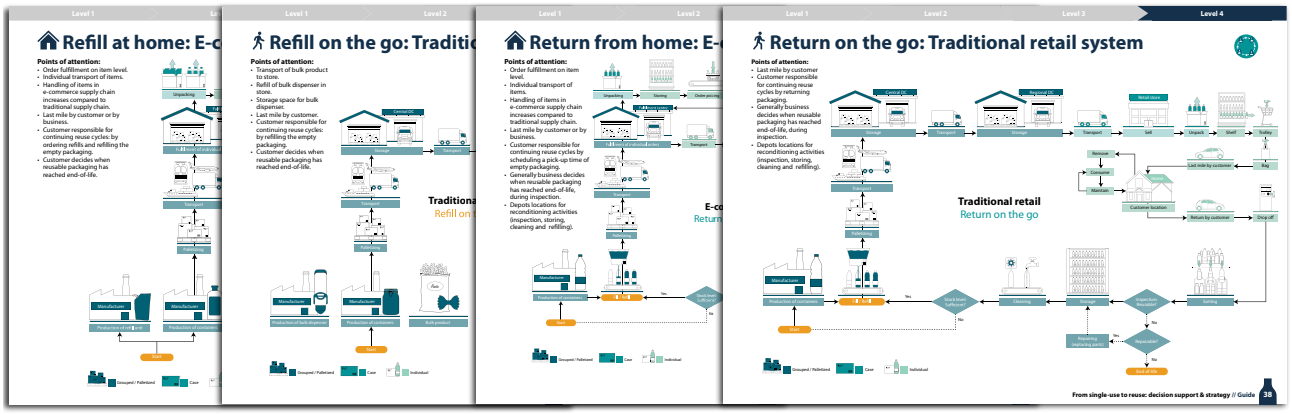


Figure 48 - Reusable packaging systems per reuse model

Part I
Setting the stage

This part introduces the thesis project and insights from literature are combined as a point of departure for this thesis project.

Part II
Research & Analysis

This part combines insights from literature and interviews to obtain understanding of the different reuse models, the major factors involved in reuse systems and barriers for implementing them.

Part III
Development

This part revolves around the development of a decision support tool for reusable packaging. Firstly, the decision support tool's aim, target group, functions and requirements are described. Secondly, the design and development process of the decision support tool is described.

Part IV
Evaluation

This part revolves around the evaluation of the decision support tool for reusable packaging. It describes the two methods used to evaluate the decision support tool.

Part V
Wrap-up

This part wraps up this research project by by discussing the limitations and recommendations in the dicussion and answering the research questions in the conclusion.

Chapter 9
Evaluation

This chapter evaluates the decision support tool by applying two methods for evaluation.

9.1 Methods

Two methods were used to evaluate the decision support tool. The first method used is semi-structured interview. The second method used is a review of student reports on reusable packaging development by applying them to the tool.

9.1.1 Semi-structured interview

A semi-structured interview was conducted with the head of sustainability in marketing from a multinational chemical and consumer goods company through Microsoft Teams and lasted approximately 60 minutes. The data was recorded through audio-visual recordings with consent of the interviewee. The interview was anonymized and transcribed in a summarising manner to capture the main points of the interview. The goal of the interview was to examine whether the decision support tool fulfils the main functions of: inform, support, navigate and interact. Furthermore, the aim was to gather opinions on usability and applicability of the tool.

One week prior to the interview, the decision support tool was send to the respondent accompanied with some questions to support the review process. Because one of the requirements of the decision support tool is that users should be able to use the tool as a stand-alone document the respondent was given a week to work through the document individually. Only little information about the tool was given to the respondent as to check whether the tool is understandable without external guidance.

9.1.2 Master students concepts review

Eight group reports from the course Packaging Design and Management II by master students Industrial Design Engineering of the University of Twente were used to partially evaluate the decision support tool. Students were given the assignment to develop a branded reusable packaging concept for an external client. The client is a packaging company who delivers metal packaging for brands. Students had to develop their concepts for one or more of the reuse models as described by Ellen MacArthur Foundation (2019): refill at home, refill on the go, return from home and return on the go.

It was determined that it was only useful to apply the concepts to Level 1. As students did not use the decision support tool for development, their choices for development are based on different assumptions. Therefore applying their projects to the other levels will result in a review of their projects, not a review of the tool.

9.2 Results interview

At the beginning of the interview it became clear that the respondent had not reviewed the decision support guide prior to the meeting. Therefore the meeting time was used to let the respondent work on the different levels of the decision support tool while sharing her screen. This way she could give direct feedback on the decision support tool and could ask questions to the interviewer in case things were not clear. The answers are summarized into main relevant points and are described in the subsections below.

9.2.1 Overall findings

The following points made are applicable for the overall decision support tool.

- ***Usability:*** Generally people do not like to read a lot at work as there is shortage of time. Therefore things need to be very obvious. The respondent hinted that the tool falls a bit short there as there is a lot of information.
- ***Applicability:*** The respondent believes the decision support tool provides a good overview of the decisions and considerations involved in the development of reusable packaging systems. However, they would need a packaging expert to take the information and make it relevant to their specific products. This means a packaging expert will have to look at it, digest the information and tell marketing executives what they recommend as marketing executives are not going to want to read everything. The respondent indicated

that the guide is perfect for packaging experts that know the brand they are working for and can therefore put suitable pieces together for a specific brand. This guide belongs to the first step of development, and brand marketeers come more into play in the second step of development.

- ***Functions:*** In terms of the different functions of the decision support tool (inform, support, navigate and interact), the inform function stands out. The respondent indicated that the good thing about the decision support tool is that if a businesses is thinking about developing reuse they will find all the options in one PDF. For developers that are in the first exploratory phase of looking into different ideas, the tool would be very helpful. The respondent sees great value of have everything synthesized in one document, so developers do not need to look at a lot of websites or suppliers to see what they are offering. In terms of the navigation function, it works well and runs smoothly. However as there is a lot of text, this might interfere with the navigation of the document.
- ***Recommendations:*** The respondent stressed that she can see that a lot of work has gone into making the tool and the synthesis is highly valuable. The key recommendation is dig into the tool together with a R&D packaging team in a company and figure out with them how this can become a tool that will be really used by them, by configuring it according to their needs and general workflows. The information is already there it just needs to be formatted according to their needs. It would also be nice to see the decision support tool formatted as an online tool where people can go in and make these type of decisions. A lot of things tend to be web based these days and PFDs are normally left for reading.

9.2.2 Findings Level 1

While working through and filling out Level 1 the following points were made:

- ***Explanation boxes:*** Generally, the information in explanation boxes of the X and Y aspects is good. However, the extra information is not always needed for people that work in the industry.
- ***Customer engagement and loyalty aspect:*** It is hard to rate this aspect, as a brand is sold to many customers and customers are different. Some will be highly engaged and loyal, others not. Moreover, as brands are sold in different countries the relationship customers have with a specific brand differs between countries.
- ***Product's profit margin aspect:*** This aspect is not only related to the product but also to the brand. More premium brands with a high brand equity will have a higher profit margin than other brands within the same product category.
- ***Product-to-package ratio:*** The product-to-package ratio of the single-use alternative is an interesting aspect and something she would not have thought about as a key element in determining whether developing a reusable packaging would make sense. It was however unclear that the benchmark for rating the product-to-package ratio is the single-use alternative of the product in mind.
- ***Purchase and disposal frequency:*** The purchase and disposal frequency as an aspect makes sense. However, it has to be defined what is low and what is high and currently there is no benchmark mentioned. For example, the respondent indicated it could be: purchase and disposal frequency compared to food.
- ***Level 2 criteria:*** Currently, the box for Level 2 criteria is very small and on the bottom of the pages which makes the box easy to overlook. Therefore it needs to be more prominent on the page, for instance placed at the top.

9.2.3 Findings Level 2

While working through and filling out Level 2 the following points were made:

- ***Examples:*** The buttons that link to an example are helpful and bring added value in terms of understandability.
- ***Terminology:*** Refill at home and refill on the go terminology is a bit abstract. Instead, refill pouch and refill station were suggested.
- ***Exclusive vs sequential - Global vs local supply chain:*** The choice for local or global supply chain is hard to determine. It is a bit unclear what is meant by local and global supply chain. The respondent indicated that for big companies the supply chain is centralized but at the same time there also local supply chains. Furthermore, reuse systems are normally done in partnership with some other party, which could be a local party. So from that perspective it does not matter what the supply chain is of the main business is. For instance, a business or the government can set up local solutions for the main business and engage with retailers. The respondent agreed with the tool that sequential reuse systems are all about local solutions. Globally they sell the exclusive reuse refill pouches, for which they do not need any infrastructure.
- ***Exclusive vs sequential – Horizontal vs vertically integrated supply chain:*** Hardly any company has a fully vertically integrated supply chain, only partially. What is kind of missing here is the fact that companies would not have to operate the whole reuse system by themselves as there will be partnerships or collaborations, so they do not need to be fully vertically integrated for sequential reuse. So collaborations and partnerships will enable more control over the supply chain without having to own another step in the supply chain. For instance many companies have partnerships with a recycler.

- ***Exclusive vs sequential – Decreasing packaging waste is less of a priority vs priority:*** The respondent does not think anyone is wanting to fill in that decreasing packaging waste is less of a priority or that end-of-life control is not a priority. She believes it is a priority for everyone right now.
- ***Scale:*** For the perspective pages of Level 2 it would be nice if there was a scale as the difference between suitable and particularly suitable is not that clear. The respondent is not sure what the order is.
- ***Customer vs consumer:*** There can be a bit of confusion between these two terms. For the respondent, the customer is actually the retailer where they sell their products. However in the decision support tool the customer is meant to be the person who buys the product and the consumer is the person that uses the product. Therefore from the tool's perspective the customer and consumer are often the same person.

9.2.4 Findings Level 3

While working through and filling out Level 3 the following points were made:

- ***Information:*** There are many factors and guidelines containing a lot of text and information and the respondent highly doubts if people will be prepared to read all of it.

9.2.5 Findings Level 4

While working through and filling out Level 4 the following points were made:

- ***Overviews:*** The overviews containing design considerations are nice yet again there is a lot of information. The respondent gives an example that if the same information was conveyed through a PowerPoint presentation it would be more easy to digest.

9.3 Results students concept review

As mentioned previously, the student group concepts were applied to walk through Level 1 of the decision support tool. Details concerning the student concepts are given in Table 8.

Table 8 - Navigation and interaction elements used in the guide

	Reusable packaging	Product	Brand	Reuse model
Group 1	Can	Dry pet food	Royal Canin	Refill on the go
Group 2	Aerosol can	Deodorant	Nivea	Refill on the go, return on the go
Group 3	Standardised container	Rice	Tilda	Refill on the go
Group 4	Bottle	Contact lens solution	Eyexpert	Return from home
Group 5	Can	Legumes	Bonduelle	Return on the go, return from home
Group 6	Container	Coffee beans	Starbucks	Return on the go
Group 7	Roller stick	Deodorant	AXE	Refill at home
Group 8	Keg	Wine	Bridge Lane Wine	Return from restaurant

9.3.1 Level 1: Viability

Business and brand perspective – The chosen brands of the students were used to review the general viability of reuse for the brands from the business and brand perspective of the decision support tool. The brands were rated on the conditional X and Y aspects, "Reuse in alignment with brand" and "Resources to invest of develop" respectively. The combined results were plotted on the matrix, see Figure 49. These ratings are based on assumptions and information of the brands available online. The ratings per brand will be explained in order of student group numbers:

1. ***Royal Canin*** – Royal Canin is a subsidiary company of Mars, Incorporated which is a multinational manufacturer of pet food, among others. Therefore it is assumed that Royal Canin has sufficient resources to invest or develop, and this aspect is rated highly. Mars is a partner of the Ellen MacArthur Foundation New Plastic Economy initiative. They claim their vision is aligned with the Ellen MacArthur Foundation, which is to support a circular economy where packaging never becomes waste. To advance towards this vision, they aim for 100% of their plastic packaging to be reusable, recyclable or compostable in 2025 (Mars, 2022). Therefore it is concluded that a reuse strategy aligns with the Royal Canin brand, and this aspect is rated highly. Whether brands truly live up to their sustainability goals is out of scope for this evaluation.
2. ***Nivea*** – Nivea is owned by the Beiersdorf Global AG, a multinational company of personal-care products, among others. Therefore it is assumed that Nivea has sufficient resources to invest or develop, and this aspect is rated highly. Beiersdorf has made a plastic pledge in which they set the following targets for 2025: to make 100% of its packaging reusable, refillable or recyclable (Packaging Europe, 2021). According to Nivea, one of their core brand values is to care for and respect the planet. Therefore it is concluded that a reuse strategy aligns with the Nivea brand, and this aspect is rated highly. As mentioned previously, whether brands truly live up to their sustainability goals is out of scope for this evaluation.
3. ***Tilda*** – Tilda is a premium rice products company and part of Ebro Foods, a Spanish food processing company that is the largest producer of rice globally (Ebro Foods, 2022). Therefore it is assumed that Tilda has sufficient resources to invest or develop, and this aspect is rated highly. Tilda claims to be committed to minimising their impact on the environment and are committed to the UK Plastics Pact to 100% recyclable packaging by 2025 (Tilda, 2022). However, no specific goals one reuse were found. Therefore it is concluded that reuse aligns with the Tilda brand only to some extent.
4. ***Eyexpert*** – Eyexpert is a contact lens brand. Not much information on the brand can be found online. It is assumed the brand has limited resources to invest or develop and with no information found on sustainability it is also assumed that reuse is not aligned with the brand.
5. ***Bonduelle*** – Bonduelle is a global company producing processed vegetables. Therefore it is assumed that Bonduelle has sufficient resources to invest or develop, and this aspect is rated highly. Their vision is to make a better future through plant-based food (Bonduelle, 2022). They want to shape a positive economy for the planet, society and people. Bonduelle has signed the European Plastic Pact and strive to achieve 100% recyclable and/or reusable packaging by 2025. Therefore it is concluded that a reuse strategy aligns with the Bonduelle brand, and this aspect is rated highly.

6. ***Starbucks*** – Starbucks is a multinational chain of coffeehouses. Therefore it is assumed that Starbucks has sufficient resources to invest or develop, and this aspect is rated highly. Starbucks is committed to reduce single-use cup waste. One of their areas of focus is to shift away from single-use to reusable packaging (Starbucks, 2022). In 2021, Starbucks reintroduced personal reusable cups across the United States . Therefore it is concluded that a reuse strategy aligns with the Starbucks brand, and this aspect is rated highly.
7. ***AXE*** – AXE is a brand of multinational consumer goods company Unilever. Therefore it is assumed that AXE has sufficient resources to invest or develop, and this aspect is rated highly. Sustainability is not emphasized through AXE's branding. Their vision is about "attraction", to make people smell irresistible (AXE, 2022). Therefore it is concluded that a reuse strategy does not really align with the AXE brand, and this aspect is rated low.
8. ***Bridge Lane Wine*** – Bridge Lane Wine is a eco-conscious small farm-winery. According to their website, their wines are made in small batches (Bridge Lane Wine, 2022). Therefore it is assumed that Bridge Lane Wine does not have a lot of resources to invest or develop, and this aspect is rated low. The grapes for their wines are grown sustainably and they offer their in 4 packaging formats in standardized sizes, namely cans, glass bottles, bag-in-box solutions and kegs. Their vision for packaging is "One format does not fit all. Bridge lane does" (Bridge Lane Wine, 2022). Therefore it is concluded that a reuse strategy would align with the Bridge Lan Wine brand as it is assumed they are willing to investigate sustainable alternative options, and this aspect is rated highly.

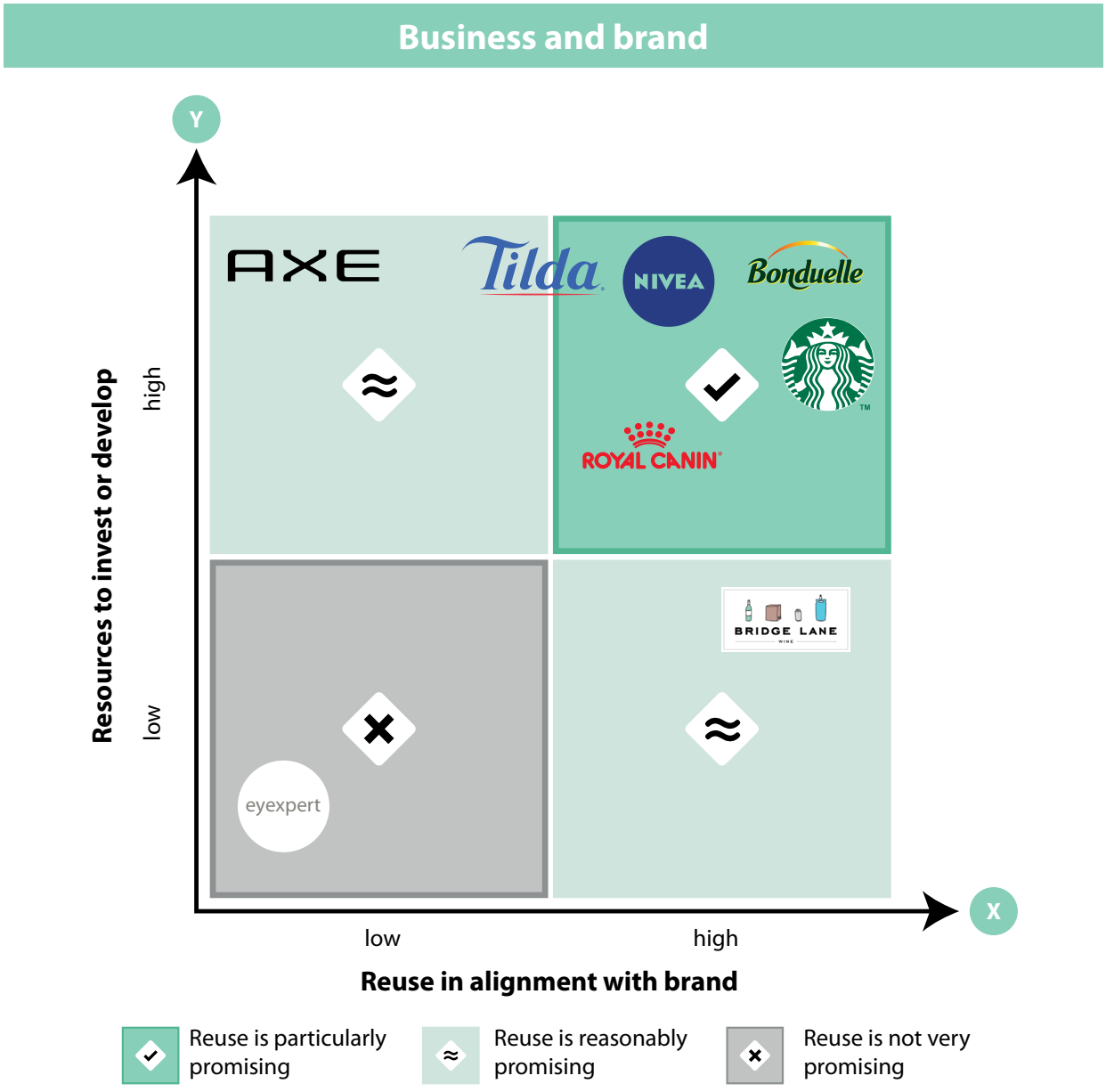


Figure 49 - Brands plotted on business and brand perspective matrix

Customer and consumer perspective – The chosen brands of the students were also used to review the general viability of reuse for the brands from the customer and consumer perspective of the decision support tool. The brands were rated on the conditional X and Y aspects, "Customer willingness and acceptance" and "Customer engagement and loyalty" respectively. The combined results were plotted on the matrix, see Figure 50. Again, these ratings are based on assumptions and information of the brands available online. The ratings per brand will be explained in order of student group numbers:

1. ***Royal Canin, dry pet food*** – Dry pet food, also known as kibble, has low hygienic and safety concerns as it is relatively clean and not very perishable. Therefore it is assumed that customers would be willing to refill pet food, and this aspect is rated highly. Royal Canin is a popular and premium pet food brand that has a wide variety of offerings. Once the kibble is correctly matched to the animal, it is expected that customers will continue to buy the same kibble for their pet for a longer period of time. Therefore the customer engagement and loyalty aspect is rated rather highly.
2. ***Nivea, aerosol can for deodorant*** – Numerous refillable deodorant options are available on the market today, of which many sticks and rollers (Pattemore, 2022) but no aerosol deodorants were found. Aerosols have a harmful impact on the environment, due to chemicals found in many aerosol sprays (VOCs). Therefore reusing aerosol spray cans is questionable, as these chemicals are still needed with every refill. It is assumed that conscious consumers would not buy aerosols in the first place and would therefore also not refill it. It is assumed that customers that do buy aerosols are not really interested in sustainable alternatives and would therefore not engage in a reuse system. Thus, customer willingness and acceptance aspect is rated low. Nivea is a drug store brand and therefore it is sold in a highly competitive environment with other brands and discounts. It is therefore assumed that customer engagement and loyalty is not that high, as especially with personal care products people tend to want to switch brands now and then. The aspect is rated between low and high.
3. ***Tilda, container for rice*** – Rice has a long shelf life and does not require refrigeration and can therefore be considered non-perishable. Hygienic and safety concerns are therefore low and it is expected that customers would be willing to refill rice, and this aspect is rated highly. Tilda is a premium high quality rice brand with a good flavour. It is therefore assumed to be likely that customers once sold on the brand will continue to buy rice from that brand, and therefore the customer engagement and loyalty is rated highly.
4. ***Eyexpert, contact lens solution*** – Contact lens solutions need to be sterile as it will be applied directly on the eyes. It is assumed that hygienic and safety concerns are therefore high and it is expected that consumers are not willing to reuse the packaging. Therefore customer willingness and acceptance aspect is rated low. It is assumed contact lens solutions are routine purchases and that therefore once a customer is satisfied with the brand, he will continues to purchase it. So the customer engagement and loyalty is rated rather high.
5. ***Bonduelle, canned legumes*** – Canned legumes have a long shelf life and do not require refrigeration and can therefore be considered non-perishable. Hygienic and safety concerns are therefore low and it is expected that customers would be willing to refill legumes. Bonduelle is a well-known and trusted brand and it is therefore assumed that customers are rather loyal to the brand, and this aspect is rated high.
6. ***Starbucks, coffee beans*** – Coffee beans have a long shelf life and do not require refrigeration and can therefore be considered non-perishable. Hygienic and safety concerns are therefore low and it is expected that customers would be willing to refill coffee beans. Starbucks is a major coffee chain with a high density of locations, especially in the USA and larger cities in Europe. Starbucks has a dedicated brand universe and it is therefore expected that customer engagement and loyalty is rather high. Therefore this aspect is rated high.

7. ***AXE, deodorant*** – As mentioned previously, numerous refillable deodorant options are available in the market today. Because it is not a food product, hygienic and safety concerns are low and it is therefore expected that certain customers are willing to refill deodorant. The question remains whether AXE customers would be willing to refill their deodorant. The AXE branding is not focused on sustainability and therefore less likely that customers are very environmentally conscious people. Therefore the customer willingness and acceptance is rated between low and high. Similar to Nivea, AXE is a drug store brand and is therefore in a highly competitive environment with other brands and discounts. It is therefore assumed that customer engagement and loyalty is not that high, as with personal care products people tend to want to switch brands now and then. The aspect is rated between low and high.

8. ***Bridge Lane Wine, wine*** – Hygienic and safety concerns of wine are expected to be low and therefore user willingness and acceptance is accepted to be rather high. Similarly, in the Circular Economy Portugal (2021a) report, the user acceptance of wine is rated 4 out of 5, where 1 is low acceptance and 5 is high acceptance. Therefore this aspect is rated high. Bridge Lan Wine is a unique brand with a wine club option. Members get discounts and standard three wine shipments per year (Bridge Lane Wine, 2022). It is expected that a fair

Customer and consumer

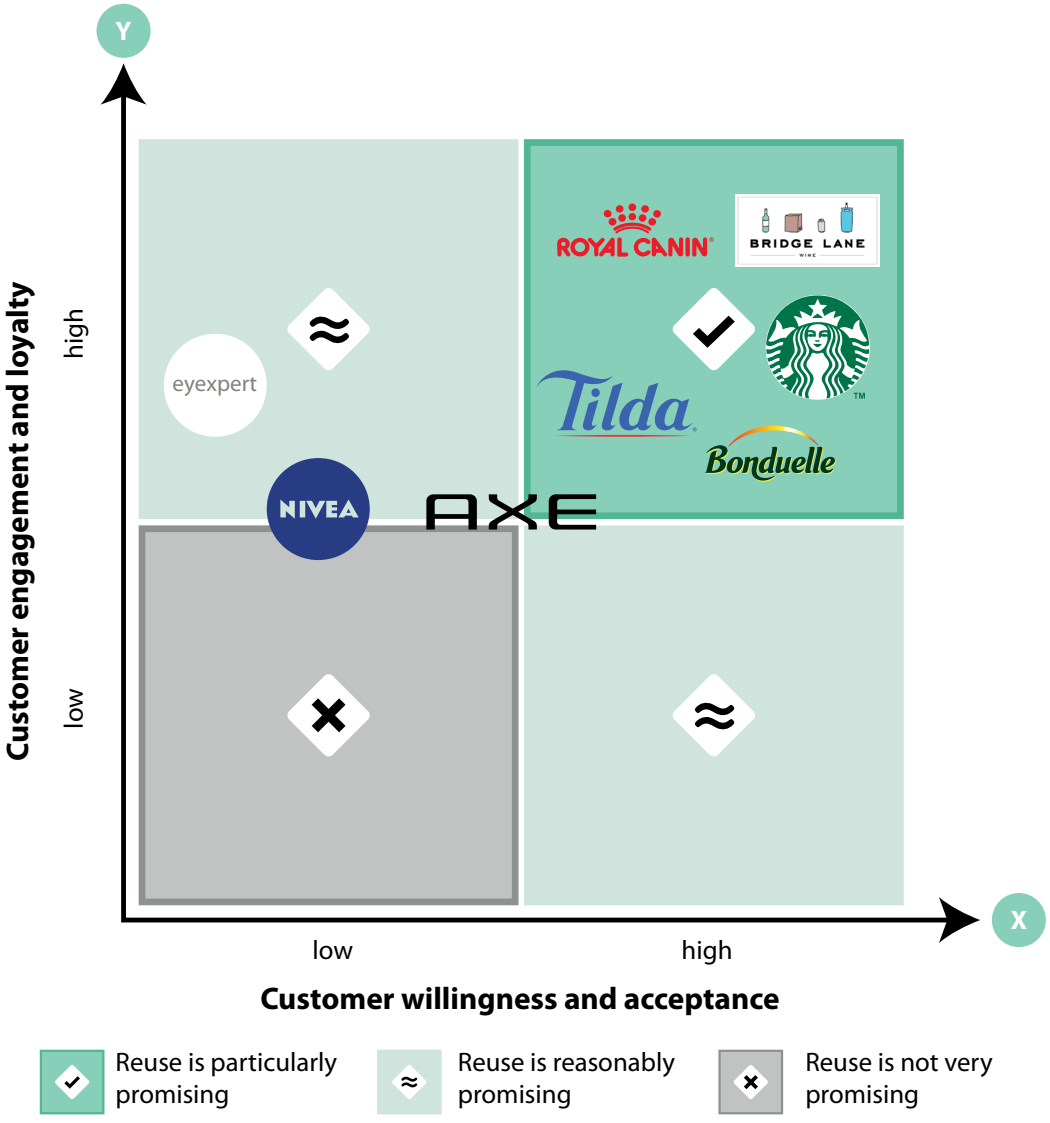


Figure 50 - Brands plotted on customer and consumer perspective matrix

Product and content perspective – The chosen brands and products of the students were also used to review the general viability of reuse for the brands from the product and content perspective of the decision support tool. The brands were rated on the conditional X and Y aspects, "Product's hygienic and safety constraints" and "Product's profit margin" respectively. The combined results were plotted on the matrix, see Figure 51. Again, these ratings are based on assumptions and information of the brands available online. The ratings per brand will be explained in order of student group numbers:

1. ***Royal Canin, dry pet food*** – Dry pet food, also known as kibble, has low hygienic and safety constraints as it is relatively clean and not very perishable. The profit margin on pet food is assumed to be rather high, as it is assumed consumers are prepared to pay for the best quality for their pets.
2. ***Nivea, deodorant*** – Deodorants are applied to the body and therefore have less strict rules then ingested products. Therefore product's hygienic and safety constraints are rated low. Profit margins on cosmetics are relatively high, this is also discussed by Circular Economy Portugal (2021a), who rated the profit margin of cosmetics a 5 out of 5 where 1 was low value-added and 5 high value-added.
3. ***Tilda, rice*** – Rice is an ingested product and therefore have stricter rules than cosmetics. Nevertheless, because it is dry and non-perishable the hygienic and safety constrains are still rather low. Profit margins on Tilda rice are expected to be rather high, as it is a premium brand.
4. ***Eyexpert, contact lens solution*** – Contact lens solutions are applied directly on the eye. As the eye is a very sensitive organ it is therefore expected that the hygienic and safety constraints are rather high. For instance, solutions need to be delivered sterile from the manufacturer and remain sterile until opened. In terms of profit margins, there is a big difference in price between non-premium brands and premium brands. Eyexpert is assumed to be a rather premium brand and therefore it is estimated that the product's profit margin is relatively high.
5. ***Bonduelle, canned legumes*** – Canned legumes are ingested products and therefore have stricter rules than cosmetics. Nevertheless, as they have a long shelf life when sealed properly the hygienic and safety constrains are still rated rather low. Compared to the other products in this evaluation it is expected that the profit margin on canned legumes is relatively low.
6. ***Starbucks, coffee beans*** – Coffee beans are grinded and then ingested and therefore have stricter rules than cosmetic. Nevertheless, because it is dry and non-perishable the hygienic and safety constrains are still rather low. Profit margins on the coffee beans from Starbucks are expected to be rather high, as it is quite a premium brand.
7. ***AXE, deodorant*** – The ratings for the AXE deodorant follow from the same reasoning as number 2 Nivea deodorant.
8. ***Bridge Lane Wine, wine*** – Health and safety constraints for wine are rated low, based on the information by Circular Economy Portugal (2021a) who rated the health and safety constraints and regulations for wine a 5 out of 5, where 1 was very restrictive rules and 5 less restrictive rules. The profit margins of wine was rated high, also based on the information by Circular Economy Portugal (2021a) who rated the profit margin of wine a 5 out of 5 where 1 where 1 was low value-added and 5 high value-added.

Product and content

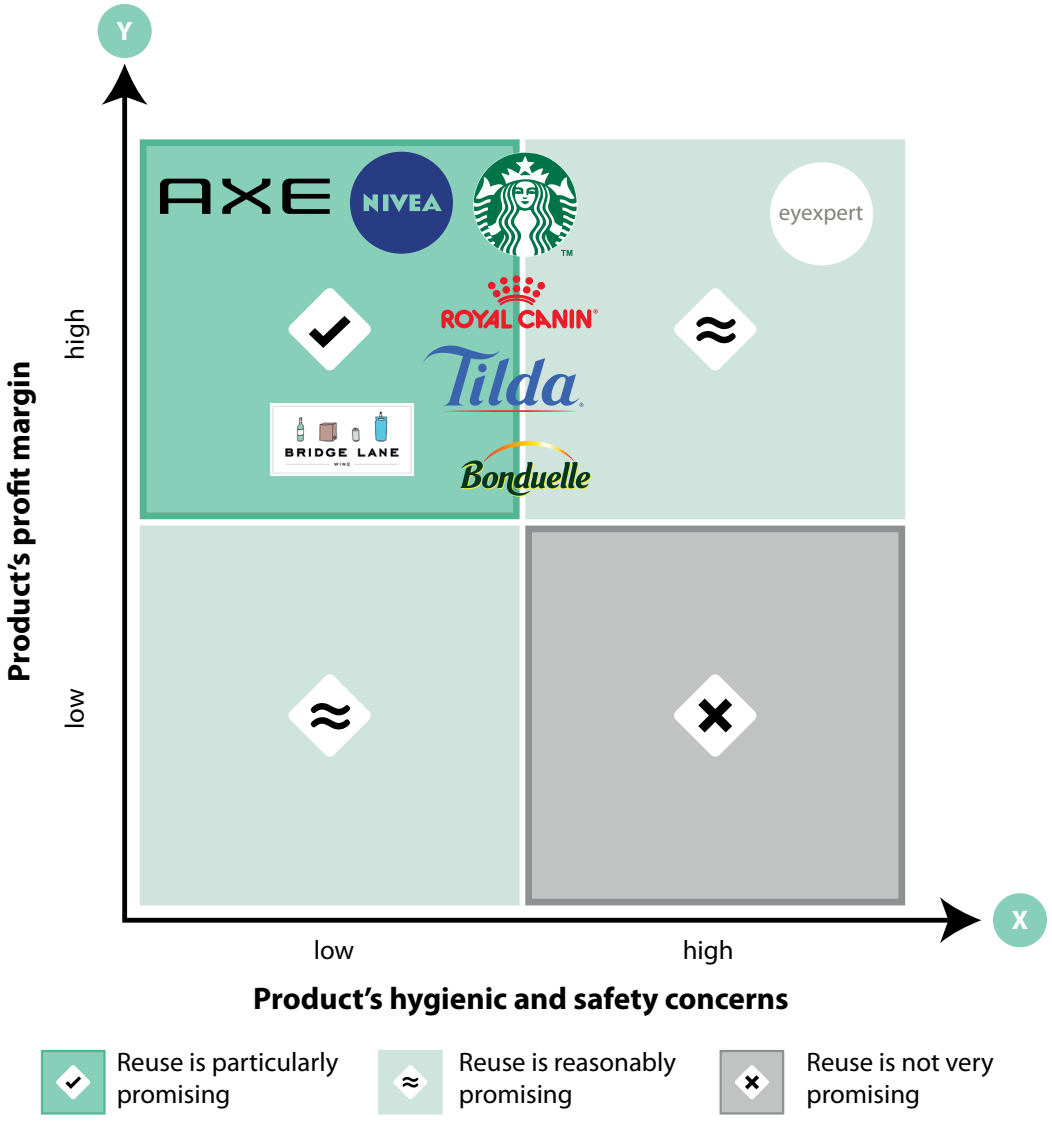


Figure 51 - Brands plotted on product and content perspective matrix

Environment and sustainability perspective – The chosen brands and products of the students were also used to review the general viability of reuse for the brands from the environment and sustainability perspective of the decision support tool. The brands were rated on the conditional X and Y aspects, "Product-to-package ratio" and "Purchase and disposal frequency" respectively. The combined results were plotted on the matrix, see Figure 52. Again, these ratings are based on assumptions and information of the brands available online. The ratings per brand will be explained in order of student group numbers:

1. ***Royal Canin, dry pet food*** – Currently the Royal Canin kibble is packaged in flexible bags in variety of sizes: bags contain around 3 kg to 15 kg of kibble. Therefore product-to-package ratio is rated high as flexible packaging tends to in generally have a higher product-to-package ratio then other packaging formats. Purchase and disposal frequency is rather high as dogs eat this kibble daily and depending on the bag size can empty quite quickly (15 kg takes about a month to finish).
2. ***Nivea, deodorant*** – Product-to-package ratio is rated low for aerosol cans, as quite a lot of packaging is used for a relatively small amount of product. Purchase and disposal frequency is difficult to estimate, as the frequency of use and the amount of product used varies between customers. All in all it is estimated that the purchase and disposal frequency is relatively low compared to food products.
3. ***Tilda, rice*** – Rice is packaged in bags in a variety of sizes: flexible bags of 500 g to 20 kg of rice. Product-to-package ratio is therefore rated high, especially from larger sizes. Purchase and disposal frequency is rather high, as rice is a food product that gets regularly consumed (assumption: daily or weekly) by customers. This is also emphasized by Group 3 who state that "rice is used by consumers regularly and therefore makes a great impact regarding sustainability".
4. ***Eyexpert, contact lens solution*** – Product-to-package ratio is rated low for contact lens solutions, as rather small volumes (about 250 ml) are contained. Purchase and disposal frequency is rated low, as it is estimated that it can take a few months to finish one bottle.
5. ***Bonduelle, canned legumes*** – Product-to-package ratio is rated rather low for canned legumes. Moreover, the amount of kg product packaged is quite small (range of 150 to 400 g). The purchase and disposal frequency is rated high, as it is estimated that for a family of four, depending on the size of the can, two cans are used per meal. When the can is opened its content will generally be completely used in one go, so disposal frequency is quite high.
6. ***Starbucks, coffee beans*** – Product-to-package ratio is rated high for coffee beans, assuming they are typically packed in flexible bags of that contain around 500 g to 1 kg of beans. The purchase and disposal frequency is rated relatively low compared to rice or kibble, as it is assumed that it generally takes longer to finish a bag of coffee beans than to finish a bag of rice or kibble.
7. ***AXE, deodorant*** – Similar to the nivea deodorant, the product-to-package ratio for deodorant is rated high, as quite a lot of packaging is used for a relatively small amount of product. Again purchase and disposal frequency is difficult to estimate, as the frequency of use and the amount of product used varies between customers. All in all it is estimated that the purchase and disposal frequency is relatively low compared to food products.
8. ***Bridge Lane Wine, wine*** – The product-to-package ratio is rated quite low as typically wine is packaged in single-use glass bottles that are quite heavy. The purchase and disposal frequency is rated between low and high, because it really depends on the target group, some people might buy one bottle a week and finish it in the same week (rather high purchase and disposal frequency) whether other people may only buy one bottle of wine a month (rather low purchase and disposal frequency).

9.3.2 Findings Level 1

During the assessment of the brands and associated products of the student groups, a number of things stood out:

- While rating the different aspects it became clear that some type of benchmark is needed to determine the rating relative to that benchmark. For example for the purchase and disposal frequency, when is it considered to be high compared to the benchmark and when is it considered to be low? Additionally, for the product-to-package ratio it might need to be made clear that the benchmark is the single-use packaging.
- The X aspect from the consumer and customer perspective "Customer willingness and acceptance" is assumed to be strongly related to X aspect of "Product's hygienic and safety constraints", as people might not want to refill a product if they believe it is not safe. Therefore one could argue that one of these aspects will suffice, possibly making the other aspect redundant.
- The Y aspect from the consumer and customer perspective "Customer engagement and loyalty" is difficult to rate. Some consumers might be very loyal to the brand, whereas others are not. Therefore this aspect will always remain an assumption or generalization unless businesses have metrics in place to exactly measure customer loyalty.
- The Y aspect product-to-package ratio can be difficult to rate, when the benchmark single-use packaging is available in a variety of formats. This was the case for Tilda.

Environment and sustainability

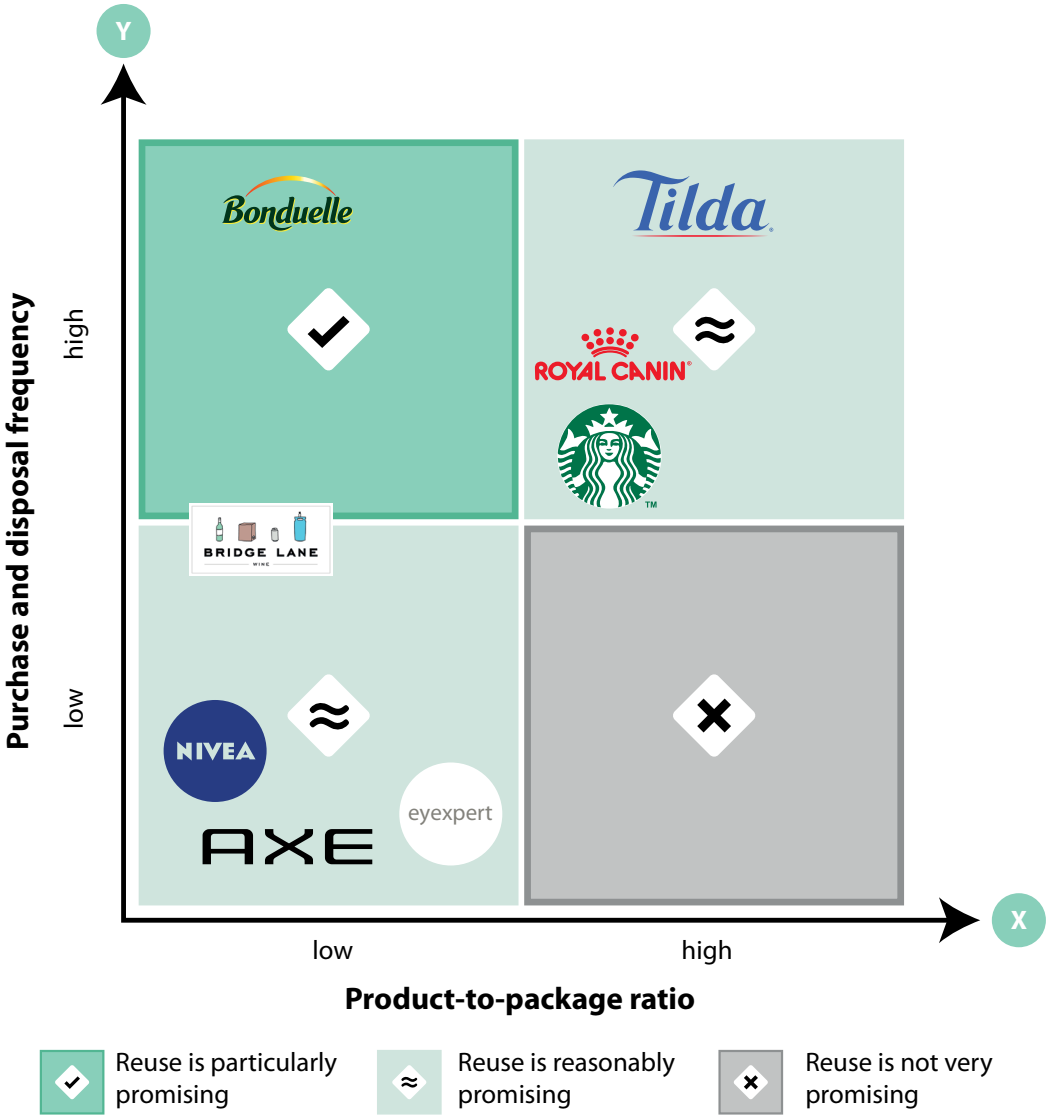


Figure 52 - Brands plotted on environment and sustainability perspective matrix

Part I
Setting the stage

This part introduces the thesis project and insights from literature are combined as a point of departure for this thesis project.

Part II
Research & Analysis

This part combines insights from literature and interviews to obtain understanding of the different reuse models, the major factors involved in reuse systems and barriers for implementing them.

Part III
Development

This part revolves around the development of a decision support tool for reusable packaging. Firstly, the decision support tool's aim, target group, functions and requirements are described. Secondly, the design and development process of the decision support tool is described.

Part IV
Evaluation

This part revolves around the evaluation of the decision support tool for reusable packaging. It describes the two methods used to evaluate the decision support tool.

Part V
Wrap-up

This part wraps up this research project by by discussing the limitations and recommendations in the dicussion and answering the research questions in the conclusion.

Chapter 10
Discussion

The two main aims of this thesis research were: firstly, to determine the preferred conditions and requirements involved in the development of primary reusable packaging concepts and secondly, to translate the results of this research into a decision support tool to guide NVC members in their decision-making process around the development of reusable packaging systems. To achieve the two main aims, an extensive literature review and interviews with relevant players in the FMCG market were conducted and a decision support tool was developed. This chapter discusses the limitations of this thesis research and recommendations for further development of the decision support tool.

10.1 Limitations

This thesis project had several limitations, which will be discussed in the subsections below.

10.1.1 Interviews

During the research phase, six interviews were conducted with relevant players in the FMCG sector. Participants were chosen with the aim of representing the broad field of packaging. Although the representatives came from a variety of different B2C companies (multinationals, start-up and supermarket chain) and one B2B company (logistical service provider) they were all representatives of the business side. As research has indicated that reusable packaging development should follow a holistic approach, it could have been valuable to interview other players that represent the customer, environmental or legislation side. For instance, representatives from waste processors, NGO's or governments. Moreover, the number of interviews was six, which could have been higher to gather more insights.

10.1.2 Evaluation

The evaluation of the decision support tool consisted of two parts: the first part was an online interview and the second part a review of the first level of the tool by the author itself by means of applying student reports to the tool. One of the limitations of the evaluation is that only one interview with one person was conducted. When two or more people would have been used to review the tool, answers and recommendations could have been compared to find differences and similarities between answers, making the evaluation interview results less subjective and more reliable. The one respondent was the head of sustainability in marketing for a multinational chemical and consumer goods company. This meant that her direct packaging knowledge was limited and therefore she was not able to fully assess whether the packaging considerations in the decision support tool were correct or sufficient. Moreover, although the respondent was meant to review the tool before the interview took place, the respondent actually did not do it. Therefore, it is hard to determine when in cases where things were unclear for the respondent this was due to the design of the tool or due to the fact that the tool was not studied thoroughly by the respondent or due to the fact that packaging knowledge of the respondent was limited.

The evaluation of the tool by means of the student reports was only conducted for Level 1. By applying the chosen brands and corresponding products of the students to Level 1 it was possible to evaluate whether it was possible to rate the brands on the X and Y aspects per perspective and plot them on the matrix accordingly. Although this gave some valuable insights, it is by no means a fully objective review, as the reviewer was also the developer of the tool. In hindsight, it might have been better if the students had started designing their concepts using the tool from the beginning of their project. In that case, they could have provided immediate feedback on how the tool works, whether it is user-friendly and if it provides them an added value for development. Unfortunately, this was not possible as at the time the decision support tool was not finished.

10.2 Recommendations

This thesis project provided NVC members with a decision support tool that enables them to make holistic based design decisions about the development of reusable packaging systems and determine a point of departure for reusable packaging development. The decision support tool in its current state has a number of recommendations,

which will be discussed in the subsections below.

10.2.1 Presentation of information

In the current version of the decision support tool, it is very possible that some users may get a bit overwhelmed by the amount of text. The result from the evaluation interview confirms this. This can be partially solved by hiding text in drop-down menus. In that case, when people want more information or clarification about the specific topic, they can click the drop-down menu and read the information that will appear then.

Moreover, in the current version the worksheets in which users can summarize their decisions appear at the end of each level. As a result, people first have to go through a lot of information before they can record their decisions. To increase the ease of use, it might be useful to place the worksheets at the beginning of the level. The worksheets should then be made interactive so that when users would like more information about a decision, they can click on it and then be directed to a page with more information regarding the decision to be made.

10.2.2 Format updates

The current PDF format allows for storage of a lot of information and documentation of decisions. However, communication and information transmission are becoming more and more web based. Therefore, to reduce the threshold for potential users to use the decision support tool, it is worth investigating the option of developing a more simplified online version of the tool with the interactive PDF document as the backbone and reference.

Moreover, during the regular status meetings with a packaging professional from an external FMCG company in the course of the development process, the option of further expanding the decision support tool to a type of game was discussed. The packaging professional indicated that by adding game elements, the tool could be used in a fun and inviting way during workshops with people from different departments of a FMCG company. This way, working on the tool could become more of a group activity. Therefore, future work could focus on how to the information and decisions presented in the tool could be translated into a type of game that can be used during workshops to foster brainstorming and collaboration.

10.2.3 Addition of benchmarks

Results from the evaluation indicated that in some cases in the decision support tool benchmarks should be provided. For instance, the Level I environment and sustainability perspective includes the product-to-package ratio as an aspect to determine whether reuse is a viable option. It discusses that when the product-to-package ratio is very high, the product is packed very efficiently with little packaging material. Therefore, the tool advises that developing a reusable packaging for that product is less relevant. It is however not entirely clear that users are meant to use the single-use packaging of their current product as a benchmark to rate the product-to-package ratio. Similarly, Level 1 includes the purchase and disposal frequency aspect to determine whether reuse is a viable option. Products with a high purchase and disposal frequency are preferred. For this aspect a benchmark should be provided that indicates what frequency can be considered "low" and what frequency can be considered "high". Therefore in future versions benchmarks should be clearly stated per aspect.

10.2.4 Input R&D packaging teams

The decision support tool gives a synthesized but general overview of the factors and considerations involved in reusable packaging development. This means that the tool contains information that is not always relevant for or applicable to every company. To maximize the usability of the tool for specific companies, input and collaboration with company's R&D packaging teams could be useful to configure and format the tool according to their needs and general workflows, so the decision support guide is more tailored to their company.

Chapter 11
Conclusion

This chapter will conclude this thesis project by summarising the key research findings in relation to the research questions.

The following main research question for this thesis project was defined:

What are the preferred conditions and requirements for development of reusable primary packaging systems (for e-commerce) in business-to-consumer markets and how can these be reflected in a decision support tool to guide NVC members in their development process?

The main question was supported by two sub-questions, namely:

1. *To what extent does or should reusable primary packaging for e-commerce differ from reusable primary packaging for traditional retail?*
2. *How can a decision support tool around reusable packaging be created to guide NVC members in the development of reusable packaging?*

By means of an extensive literature review and interviews with relevant players in the market preferred conditions and requirements for reusable primary packaging systems (for e-commerce) in business-to-consumer markets were identified. Furthermore, possible differences between e-commerce primary reusable packaging and traditional retail primary packaging were explored.

Reusable packaging was classified under two systems: exclusive reuse systems, where a consumer consumes individually and keeps, owns and refills the reusable packaging and sequential reuse systems, where a consumer consumes along with multiple successive individuals and the reusable packaging is returned to the business to be cleaned and refilled. Exclusive reuse was further divided into refill at home and refill on the go models and sequential reuse was further divided into return from home and return on the go models.

Regarding the main research question, in order to identify the preferred conditions and requirements of reusable primary packaging systems, factors that play a role in the viability and successful development of reusable packaging systems were identified and classified under six categories: Economics, Logistics, Environment, Packaging Design, Consumer and Legislation. The research made clear that exclusive reuse and sequential reuse systems have many factors in common. However some factors are particularly or only relevant for exclusive reuse systems whereas other factors are particularly or only relevant for sequential reuse systems.

In terms of economics, several factors were identified. Firstly, businesses must be willing to invest resources to develop new packaging designs and/or product lines. The initial investment is especially high for sequential reuse systems as these require take-back mechanisms and infrastructure for cleaning and storing. Therefore, exclusive reuse systems tend to be easier to implement. Secondly, operational costs need to manageable so the system is economically viable. It was identified that collaboration and pooling can reduce the initial investment as well as the operational costs. Thirdly, a high total volume of the market with a high average daily volume is preferred, especially for sequential reuse systems, as these systems need a certain scale to become financially attractive. Linked to that, large sales volumes are preferred. For sequential reuse models, low fluctuations in peak volume are preferred as with high fluctuations in peak volume, it becomes increasingly difficult to predict demand of containers and to determine the right size of the container pool. Lastly damages and losses in the system should be minimal.

In terms of logistics, several factors were identified. Firstly, successful management of the return logistics is critical for sequential reuse systems. The four key logistical activities for return logistics are collection, inspection and sorting, recovery and redistribution. For efficient reverse logistics, supply chains with a local or national scope are preferred over supply chains with

a global or international scope given the numerous transport movements involved in collecting, refilling and redistributing the packaging. Secondly, collaboration and pooling can positively influence the economic viability of reuse systems. Through collaboration and pooling economies of scale can be reached as companies can share the same packaging and/or share the same logistics and washing lines. Thirdly, standardisation and harmonisation of packaging facilitates reverse logistics, cleaning processes and machinery and is therefore of vital importance for sequential reuse systems. Furthermore, standardisation of packaging can reduce the complexity of packaging materials, therefore enhancing the recyclability of packaging formats. Moreover, standardisation of reuse systems can reduce confusion and increase convenience for consumers, as they would have to interact with less different systems. Fourthly, monitoring and tracking of reusable packaging is vital for the successful management of return logistics for sequential reuse systems. Fifthly, the number of reuse cycles is a critical factor as it determines the allocation of the impacts for production of the reusable packaging to each reuse cycle. The more reuse cycles, the lower the environmental burden per cycle, and the more viable reusable packaging systems becomes. Sixthly, the return rate is a key factor that affects the economic as well as environmental viability of reusable packaging systems. Return rates should be as high as possible to prevent losses. High return rates ensure that the system can run smoothly and that the container pool stays intact. Seventhly, cycle time is a factor that influences the logistics and distribution of sequential reusable packaging systems. Cycle time is the time it takes for a reusable to go through the whole distribution cycle. A short cycle time is preferred as the shorter the cycle time, the fewer reusable packaging items have to be purchased to keep the system running, which lowers the initial investment costs of the reusable packaging pool and also lowers the operational costs of the system.

In terms of environment, several factors were identified. Firstly, in order to fulfil its intended reuse cycles the packaging material must be able to withstand impacts associated with the reuse system (e.g. logistics, use and cleaning operations). As mentioned previously, the more reuse cycles the lower the environmental impact of the system. Secondly, incorporating recycled content in the reusable packaging influences the environmental performance. Namely, the higher the percentage of recycled content of a packaging, the lower the environmental burden of production of that packaging becomes. Furthermore, a reusable packaging that can be recycled prevents the extraction of virgin material. Thirdly, transport distance is an important factor in defining the environmental impact. For sequential reusable packaging systems, the total journey distance is doubled compared to single-use packaging systems and therefore short transport distances are vital. Fourthly, in terms of cleaning, dishwasher processes are preferred over hand washing as dishwashers tend to be more water efficient.

In terms of packaging design, several factors were identified. Firstly, the packaging design needs to be physically as well chemically durable to withstand the return and washing process without loss of its containment properties. Secondly, for sequential reuse systems to enable efficient cleaning, the packaging design should conform to the industrial cleaning machines which are based on Euronorm standards. Thirdly, in terms of dimensions, the primary reusable packaging should be compliant with secondary packaging and tertiary packaging. Fourthly, packaging should be nestable and/or stackable to minimize the costs of logistics and space needed for storage. Fifthly, a low weight of the packaging is preferred as it lowers transportation impacts. Furthermore, a low weight makes returning the packaging more convenient for customers in refill on the go and return on the go model. Sixthly, in order for a reusable packaging to match single-use packaging the reusable packaging must be able to perform the same functionalities as single-use packaging over several reuse cycles.

In terms of consumer, several factors were identified. First of all, consumers must be willing to refill the product and reuse the packaging. Research indicated that consumers are willing to reuse packaging made of glass, rigid plastics and metals such as aluminium and tin. Research in terms of which products consumers are willing to refills suggest that consumers are mainly willing to refill products that have little associated hygiene risks, such as beverages, non-perishable foods and personal and household care products. Secondly, a factor that strongly affects consumer's willingness to engage in reuse systems is convenience. Therefore, reuse systems need to be as convenient as possible by offering for instance delivery and pick-up, providing enough return opportunities and/or ensuring ease of use of the reusable packaging. Thirdly, the selling price of reusable packaging has to be competitive with single-use, otherwise it is less likely that consumers will engage in reuse systems as feeling good by contributing to a better environment is not enough for consumers. Fourthly, in order to stimulate return and refill rates financial incentives should be put in place. This incentive can be in the form of a deposit return scheme or discount and reward systems.

Finally, in terms of legislation, several factors were identified. Public organisations should play a vital role in stimulating reusable packaging systems through policy, legislation and funding. Moreover, public organisations and governments can facilitate the development of physical reuse infrastructure. However, a big hurdle for businesses in the development reusable packaging is the

lack of both dedicated laws and standards and therefore these should be established.

From the six interviews conducted with relevant players in the FMCG market enablers of reusable packaging systems and challenges and barriers of reusable packaging systems were identified that greatly overlap the reuse factors as classified under the different categories. For instance, important enablers were: standardisation and harmonisation of packaging design and systems, collaboration between different parties and reuse stimulating legislation. Important challenges were: inconvenience of the packaging service, managing reverse logistics, ensuring high durability of the packaging and mainstreaming reuse.

In terms of the first sub question, "To what extent does or should reusable primary packaging for e-commerce differ from reusable primary packaging for traditional retail?" no differences on the primary packaging design level were found. As many businesses have an omni-channel strategy, differentiating the primary packaging of products between e-commerce and traditional retail is undesirable as it prevents omni-channel integration. Results from interviews indicated that e-commerce does offer new opportunities for branding and communicating product information. E-commerce reduces the need of containing products in extravagant packaging as the products can be visually communicated on the website. However, it is deemed very unlikely by respondents that a separate packaging line for e-commerce will be developed, as then businesses will have to deal with two separate packaging lines for the same product.

The findings in the literature correspond to the interviews, which means a complete and thorough research was carried out that provided a strong base for the development of the decision support tool for reusable packaging.

In terms of the second research question, "How can a decision support tool around reusable packaging be created to guide NVC members in the development of reusable packaging?" the development of the decision support tool followed from an iterative design process, which included regular status update meetings with a packaging professional from an external FMCG company. The results from research indicated that the development of reusable packaging required a holistic approach. Therefore, the factors influencing the viability of reusable packaging were reflected in the decision-support system by approaching decisions from four perspectives: business and brand, customer and consumer, product and content and environment and sustainability. Furthermore, the guide is split up in to four levels of reusable packaging development. In Level 1, users determine the general viability of reuse for their brand and/or product. In Level 2 users determine suitable reuse model(s). In Level 3 users determine strategic focus points for development. In Level 4 users explore how to implement reusable packaging from a packaging and system perspective.

Results from the evaluation indicated that the decision support tool provides a good overview of the decisions and considerations involved in the development of reusable packaging systems. However, due to its high information density, the tool is not very accessible. Nevertheless, it was found that the decision support tool is very suitable for packaging experts. The value of the decision support tool lies in the fact that the information around reusable packaging development is synthesized in one place.

Key recommendations for the decision support tool are to investigate the option of developing a more simplified online version of the tool and to collaborate with R&D packaging teams from specific companies to configure and format the tool according to their needs and general workflows to maximise the usability.

All in all this master thesis project has contributed to the field of reusable packaging development by structuring and merging the myriad of information available on reusable packaging in one place. The decision support tool enables packaging developers to make holistic based decisions and determine a point of departure for reusable packaging development.

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Appendices

This chapter includes two appendices:

- **Appendix A: Additional reverse logistics systems**
- **Appendix B: Scenerio for pool size calculation**

Appendix A

Additional reverse logistics systems

Switch pool system

In a switch pool system every participant has his own portion of containers, for which he is responsible. This means that each participant is responsible for cleaning, control, maintenance and storage of the containers. Kroon & Vrijens (1995) distinguish two variants of switch-pool systems: namely a sender-recipient and a sender-carrier-recipient system. Figure 55 provides an overview of the characteristics of switch pool systems.

In the sender-recipient variant, only the sender and recipient have a portion of containers. The sender has the responsibility of managing the return flow of containers. Delivery and return are two separate opposite streams; the carrier either delivers full containers from the sender to recipient (1), or picks up empty containers from the recipient to the sender (2). Thus, a transfer of containers only takes place when the goods are delivered to the recipient. In the long run, the sender has to guarantee that the number of returned containers equals the number of containers send out.

In the sender-carrier-recipient variant, the carrier also has a portion of containers. This makes management and administration of the containers easier for the sender because the carrier replaces containers with empty ones each time a load is picked up. This means a switch takes place at every exchange of containers. So, when picking up a full container load from the sender, the carrier gives the sender a corresponding number of empty containers and goes on to deliver the full containers to the recipient (1). Upon delivery, the full containers are exchanged with the recipient's empty ones and transported back to the sender (2) where the process starts again.

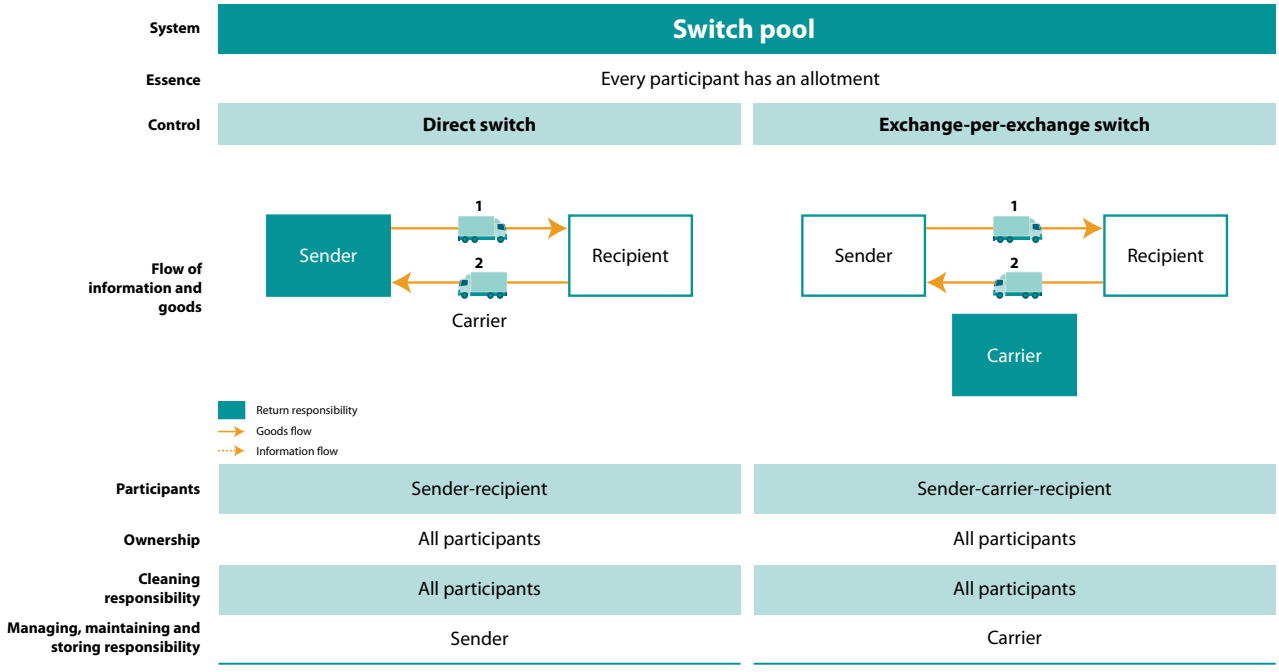

Figure 55 - Characteristics of switch pool systems developed from Kroon & Vrijens (1995)

Systems without return logistics

Similar to the transfer and deposit system, in a system without return logistics the containers are also owned by a central agency. The essence of this system is that the sender rents the containers from the agency and returns them when he no longer needs them. The information and goods flow related to this system are represented in Figure 56. First, the sender notifies the agency of the fact that he wants to use returnable containers (1). Then, the desired number of containers are distributed to the sender (2). The sender packs the goods in the container and sends the goods to the recipient (3). The sender organizes a pick-up from the recipient when the containers are empty (4). In this system, the sender is responsible for all activities involving containers, such as return logistics, cleaning, control, maintenance and storage. A benefit of this system is that the sender can decrease his fixed costs; the sender does not need to invest in a container pool but can simply rent varying numbers of containers depending on the demand.

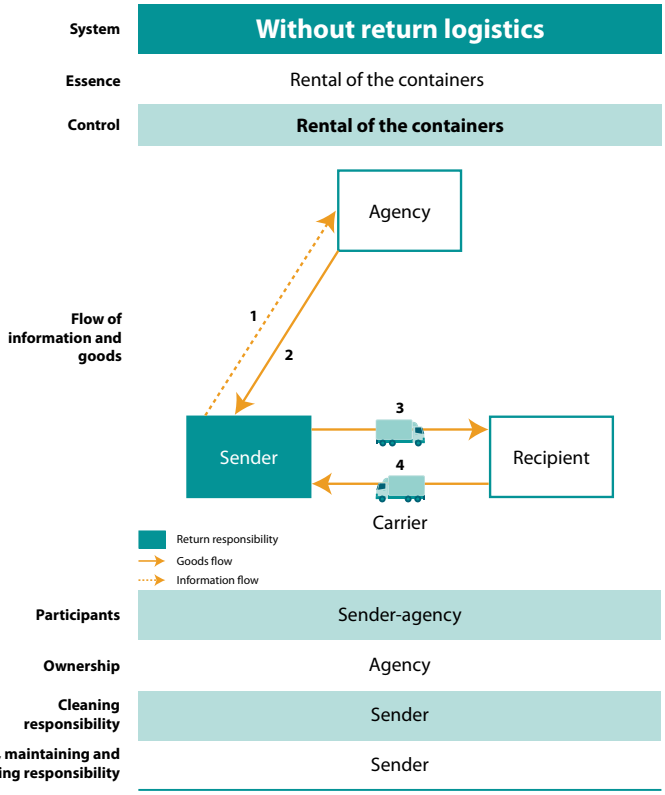

Figure 56 - Characteristics of systems without return logistics developed from Kroon & Vrijens (1995)

Appendix B

Scenario for pool size calculation

How to determine the pool size can be best illustrated by a scenario, comparing a single-trip packaging system to a multiple trip reusable packaging system. For example, a company needs to make 2,000 product deliveries to their customers each week and deliveries operate 50 weeks of the year. In the case of single-trip packaging this would mean that 50 x 2,000 = 100,000 packaging units would be required annually, see Table 10.

In the case of multiple-trip packaging the calculation for the pool size is less straightforward. One needs to take into account the cycle time, return rates and damages and losses. Let's say the time for a reusable packaging to go through the whole distribution cycle (cycle time) is 10 weeks. This means it takes 10 weeks for the reusable to complete the loop from supplier to consumer and back. With a cycle time of 10 weeks, and delivery operations being 50 weeks a year, each reusable will make 5 reuse cycles per year.

If there were was a 100% return rate and no damages and losses, 20,000 reusables would be required for the system to function: as the loop is closed every 10 weeks, 10 x 2000 = 20,000 reusables are needed. This means that in week 11, the containers from week 1 are back and ready to be reused again. However, a 100% return rate and no damages and losses is not realistic. The challenging part for the required container pool size is determining the actual customer return rate and the percentage of products that gets lost or damaged . Let's say there is an overall return rate of 70%, including damages and losses. This means that every reuse cycle, 600 (30% of 2,000 delivered reusables) will either not be returned by the customers or are either damaged or lost. The loss of 600 reusables needs to be compensated for from week 11 onwards, by bringing extra containers in the container pool. In that scenario, 44,000 reusable packaging units would be required annually, see Table 10. This is less than half of the packaging required in a single-use scenario.

Table 10 - Scenario illustrating pool size requirements for single-trip and reusable packaging over 50 week period

Week	Single-trip packaging		Reusable packaging with 70% return rate	
	Number required per week	Number required cumulative	Number required per week	Number required cumulative
1	2,000	2,000	2,000	2,000
2	2,000	4,000	2,000	4,000
3	2,000	6,000	2,000	6,000
4	2,000	8,000	2,000	8,000
5	2,000	10,000	2,000	10,000
6	2,000	12,000	2,000	12,000
7	2,000	14,000	2,000	14,000
8	2,000	16,000	2,000	16,000
9	2,000	18,000	2,000	18,000
10	2,000	20,000	2,000	20,000
11	2,000	22,000	600	20,600
12	2,000	24,000	600	21,200
20	2,000	40,000	600	26,000
30	2,000	60,000	600	32,000
50	2,000	**100,000**	600	**44,000**