Guiding Unilever towards EU's Packaging and Packaging Waste Regulation compliance for 2030

Portfolio assessment, a strategic framework and process development

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Preface

Dear reader,

A year ago, I envisioned my ideal graduation project. I did not yet know exactly what it would be, but I was certain of two things: I wanted it to have a sustainable purpose, and I wanted to collaborate with a company. At the top of my list was Unilever, a brand I admired for both its mission and impact. The opportunity to learn from such a large and experienced company was something I could only dream of.

Now, a year later, I find myself writing the preface to what has been an incredible thesis project, one that aligns with my ambitions and has allowed me to work with the company I once aspired to join. To any student reading this who is struggling to define their thesis project, I can only say: do not give up. Challenges are unavoidable, but I am incredibly grateful to have pursued something I love, even though there were some tough hurdles along the way.

Throughout my six years at Industrial Design Engineering at TU Delft, I have learned that once a design is introduced into the world, its impact can be difficult to predict. How will consumers interact with it? Will it function as intended? What unintended consequences might arise? I also realised how important it is to consider the end-of-life of a design. Since the impact is often not immediately visible, it is easy to overlook, but its long-term consequences are undeniable. This understanding led me to develop a passion for strategic and sustainable design, focusing on creating solutions with the bigger picture in mind.

This thesis has given me the opportunity to further explore recyclability through real packaging cases while stepping into the realities of a company. With new Packaging and Packaging Waste Regulations coming into effect in 2030 across the EU, it is essential for businesses to prioritise these changes and adapt accordingly. More than that, I believe it is an opportunity to go beyond compliance and set an example for others. My research has resulted in roadmaps, a design process template, a handbook, and a data-driven decision tool proposal, resources that I hope will support Unilever, and potentially other companies, in transitioning to a more sustainable future.

First and foremost, I would like to thank Marije Luijendijk, my Unilever supervisor, for believing in me and transforming her internship search into a graduation project opportunity. Beyond that, I am grateful for our weekly discussions, the chance to join her meetings, and the insights she shared throughout the process. Her experience helped me see things from new perspectives, and her dedication to raising awareness has truly inspired me.

I would also like to thank the R&D packaging team at Unilever for making me feel welcome and for their support throughout my research. It was an great experience to get a glimpse inside such a team and to learn from so many knowledgeable individuals. The same goes for all the other stakeholders I spoke to, across marketing, supply chain, recycling, and more. I was amazed by how many people took the time to help me, and I thoroughly enjoyed our conversations and the interviews, which provided me with invaluable insights and knowledge.

Last but certainly not least, I want to thank my IDE supervisors, Pien and Shahrokh. Your guidance and support have been invaluable, even when the start of this project was a little bumpy. Pien, your industry perspective, connections, and drive for sustainable impact pushed me to dig deeper and think outside the box. You challenged me to consider new possibilities and directions, and while not everything made it into the final project, our discussions have shaped how I approach collaborative impact, something I will carry forward. Shahrokh, I appreciate your belief in me, your involvement, and the time you dedicated to providing feedback. Your academic guidance encouraged me to think more critically. I have thoroughly enjoyed all our meetings as they were not only insightful, but also contained some coffee and fun conversations. Your patience and support helped me navigate the challenges I faced, and I hope to make you both proud with my final deliverables, perhaps even contributing to further research.

The completion of this thesis also marks the end of my journey at TU Delft. These years have been filled with learning, growth, and experiences I will always cherish. I have made lifelong friends, explored countless opportunities beyond my studies, and developed a passion for design that continues to grow. Now, it is time for a well-earned break, and the search for a ‘grown-up’ job. Who knows, maybe my path will cross with IDE again in the future.

To all readers, I hope you enjoy my thesis!

Tessa Bronsky
Delft, February 2025

Executive summary

The Packaging and Packaging Waste Regulation (PPWR) 2030 and the EU Circular Economy agenda are set to significantly impact businesses, particularly within the Fast-Moving Consumer Goods (FMCG) packaging sector. This thesis explores how businesses can proactively adapt by integrating recyclability into packaging design, improving stakeholder alignment, and navigating compliance challenges.

A market analysis highlighted the need to combine sustainability goals with technological innovation. The literature review identified key enablers for a sustainable transition, such as bridging knowledge gaps, dynamic capabilities, and stakeholder coordination, forming the basis of an initial framework.

To refine this framework, the research focused on three packaging case studies—examining both paper and plastic recycling. The analysis identified sortability in recycling streams and material contamination as key factors affecting recycled plastic quality (PCR). The primary recommendation is to design for mono-materials or ensure components can be mechanically separated during recycling.

Insights from 13 stakeholder interviews uncovered challenges, including actual recyclability, economic viability, uncertainty, and trade-offs. The study emphasised the importance of designing for multiple recycling infrastructures and streamlining packaging formats. Furthermore, it highlighted the need for stronger cross-stakeholder alignment to create win-win solutions and improve efficiency. A major barrier identified was regulatory uncertainty and technical verification under PPWR, complicating long-term strategic planning. Addressing this requires clear priorities and an urgent, structured approach within companies.

To address these challenges, this research delivers four key design solutions:

- A tactical and strategic roadmap: providing a long-term vision for PPWR-compliant packaging, guiding companies from documenting recyclability cases to implementing an automated decision-support tool that anticipates regulatory changes.
- A design process template: outlining key steps, evaluations, and complexity factors, ensuring structured decision-making and cross-stakeholder alignment.
- An accompanying handbook: offering practical guidance on packaging design for recyclability, tailored to FMCG needs.
- A proposal for a data-driven decision tool: enabling real-time assessment of packaging against recyclability criteria and upcoming regulations.

These solutions were co-developed and validated through sessions with packaging designers, marketing, and supply chain experts, as well as a validation session with R&D, ensuring practical feasibility.

This research contributes to academic literature by establishing a strategic framework for PPWR compliance and a structured design process for recyclable packaging. For practitioners, it provides an actionable pathway to prepare for 2030 and beyond, supporting the shift towards a circular economy and a more sustainable future.

Glossary

Abbreviations

AI - Artificial Intelligence

DfR - Design for Recycling

EU - European Union

EPR - Extended Producer Responsibility

FMCG - Fast Moving Consumer Goods

IML - In-Mould-Label

NIR - Near Infrared

PCR - Post Consumer Recycled Content

PPWD - Packaging and Packaging Waste Directive

PPWR - Packaging and Packaging Waste Regulations

R&D - Research and Development

SDG - Sustainable Development Goals

SWOT - Strength, Weaknesses, Opportunities, Threats

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Introduction

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1. Introduction

1.1.1 Sustainability

In recent decades, there has been a growing focus on sustainability, driven by the increasing recognition of its importance for the future of our planet. Ozili (2022) defines sustainability as “a philosophy, approach or practice that guides the use of today’s resources in an efficient manner to ensure that resources are available and sufficient to meet today’s needs and the needs of future generations”. It is grounded in three key pillars: environmental, social, and economic. Nowadays the governmental and technological pillars are added in some situations (Ozili, 2022). The concept of sustainability emerged due to the exhaustion of raw materials and resources caused by among others industrialisation. This has led to rising global temperatures, pollution, increasing sea levels, and the degradation of land. These changes also affect human health, for example, by increasing air pollution or causing food shortages. To address these issues, international commitments such as the UN Sustainable Development Goals and the Paris Agreement have been established to promote a more sustainable and healthier planet [1][2]. However, progress remains slow, and there is uncertainty about the long-term effects of current measures on sustainability and innovations.

The drive for sustainability also presents significant challenges. Consumer resistance to change, coupled with the high costs of transitioning, poses a large barrier for organisations and individuals. The lack of expertise and the uncertainty of long-term outcomes further complicate the shift towards sustainable practices. Structural challenges, such as fragmented recycling systems, growing consumerism, regulatory obstacles, and a lack of standardisation, intensify the difficulty of making meaningful progress. At the individual level, lack of education and awareness hinder the adoption of sustainable habits, making it difficult to change deep-rooted consumer behaviours (Afif et al., 2021).

Despite these challenges, aligning with sustainability goals offers many advantages. On a societal level, sustainability promotes fairness, equality, health, and an improved quality of life. For organisations, adopting sustainable practices can provide a competitive edge, enhance brand reputation, and foster long-term resilience (Jacobo-Hernandez et al., 2021). New markets can be shaped, creating business opportunities with new technologies (Ekins & Zenghelis, 2021).

Sustainability has increasingly become a priority in both governmental policy and corporate strategy, especially within the European Union (EU), where ambitious regulations aim to drive greener practices across industries. A central element of these efforts is the EU’s Green Deal (see Figure 1), an overarching policy that seeks to make Europe climate-neutral by 2050. These regulations have significant implications for companies operating within the EU, particularly in the fast-moving consumer goods (FMCG) sector, where packaging plays a critical role [3]. In December 2024, the EU council officially adopted the PPWR [4].

Within this framework, the current Packaging and Packaging Waste Directive (PPWD) is being updated to the more strict Packaging and Packaging Waste Regulation (PPWR), which is set to become mandatory by 2030. The PPWD is a directive which means that it sets goals that all EU member states must achieve, but it allows each country to decide how to implement these goals through national laws. The PPWR is a regulation that is directly applicable and enforceable in all EU member states. This ensures harmonisation across the EU. The PPWR should also

stimulate the circular economy as part of the new circular economy action plan. [5][6]

1.1.2 Introduction to PPWR

The EU's new regulations demand that all packaging must be either recyclable or reusable by 2030, an ambitious goal given that packaging currently follows several end-of-life pathways: landfill, incineration, and recycling. Within the EU, packaging waste accounts for approximately 36% of municipal solid waste (Niero, 2023). Moreover, the packaging sector remains the largest consumer of plastics, accounting for about 40% of the global plastic output and consuming over 40.5% of all plastics produced in the EU. Unfortunately, over 23% of this plastic ends up in landfills, highlighting the pressing need for improvements in waste management (Ding & Zhu, 2023).

As mentioned previously, the PPWR are a set of regulations to help stimulate the circular economy, harmonize regulations within the EU and prevent waste for a more neutral climate. This set of regulations is currently still under development, however this section will give an overview of what we currently know. This "current knowledge" will be the basis for this research project, however still keeping in mind the possibility of regulation changes.

By 2030, packaging that is less than 70% recyclable will be prohibited [8]. Packaging will be graded on recycling performance of which A most probably stands for 95%, B for 80% and C for 70%. A score below a C will be considered non-recyclable and be prohibited from the market from 2030. From 2038 only scores A and B will be allowed on the market. Packaging should be recyclable at scale from 2035, however the exact definition is currently undefined. A packaging is considered recyclable if it complies with design for recycling guidelines, is effectively and efficiently separated, can be sorted without affecting the waste streams, can be

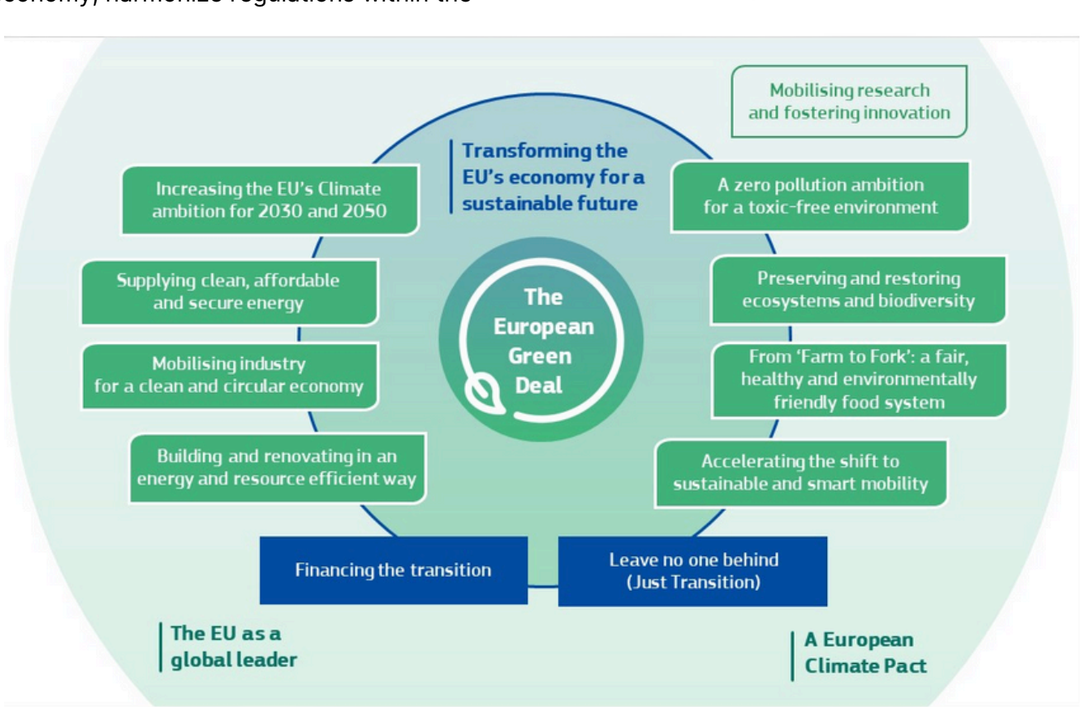

Figure 1: Europe's Green Deal [7]

recycled to sufficient quality and can be efficiently collected, sorted and recycled at scale in member states. As of 2030 packaging should also be scaled down to its minimum size and contain a minimum amount of recycled content. The PPWR also gives new regulations for biodegradable packaging waste, new packaging prevention targets, harmonized deposit return schemes and reuse and refill obligations. This research project focuses mostly on the design for recycling targets and the minimum recycled content targets, however still keeping the other regulations in mind. Figure 2 below visualises the current timeline for PPWR [9].

2024
PPWR entry into force - regulations will be finalized and step into force

2030
Packaging must be designed for recycling, recycled content targets & material minimization into force, first wave of reuse targets

2035
Packaging must be recycled at scale - collected, sorted and recycled at a high rate

2038
The lowest packaging recycling grade, grade C, will be banned

2040
Higher recycled content proportion requirements, second wave of reuse targets

Figure 2: PPWR timeline [10]

1.1.3 Unilever and sustainability

Unilever, as a leading FMCG company with a portfolio of over 400 brands across five primary markets, beauty & wellbeing, personal care, home care, nutrition and ice cream, is directly impacted by these evolving regulations. With a large network of suppliers, Unilever relies on packaging to enhance product appeal, extend shelf life, and communicate essential information to consumers (Iglesias & Mingione, 2022). However, the environmental impact of these packaging designs is considerable, as research suggests that around 80% of a product's environmental footprint is determined at the design stage (Versino et al., 2023). The image below gives an overview of Unilever's categories and their turnover.

Figure 3: Unilever categories and turnover [11]

Unilever's current strategy follows their growth action plan which focuses on three pillars: faster growth, productivity & simplicity and performance culture. Faster growth should be accomplished through brand superiority, innovation and investment in their power brands. Productivity & simplicity means building back gross margin, a focus on sustainability goals and driving benefits of the category focused organisation. Lastly, performance culture means driving and rewarding performance.

When it comes to sustainability, Unilever focuses on four specific pillars: climate, nature, plastics and livelihoods. Diving deeper into the plastics pillar, their goals are to reduce plastic footprint by 30% by 2026 and 40% by 2028 compared to 2018, to have

100% reusable, recyclable or compostable packaging by 2030 for rigids and by 2035 for flexibles (currently 53% actual recyclability), to use 25% recycled plastic in their packaging by 2025 (currently 22%) and to collect and process more plastic packaging than they sell by 2025 [12]. Unilever intends to be a leader when it comes to sustainability through collaboration and policy advocacy, through clear roadmaps and through capital allocation [13][14].

For Unilever, aligning with the PPWR presents both a challenge and an opportunity: while it necessitates significant adjustments in design and materials, it could also offer a competitive advantage by fostering a sustainable brand image, reducing long-term waste management costs, and ensuring compliance with anticipated regulations.

1.2 Problem statement

Despite recent advancements in sustainable practices, FMCG companies like Unilever, still face challenges in aligning packaging with the EU's 2030 PPWR requirements. Specifically, achieving the objectives of full recyclability and reusability while maintaining essential packaging functions and consumer appeal is complex. Current packaging practices often fail to meet these standards, for example due to issues in coordination and knowledge gaps. To transition packs to become recyclable, key stakeholders like suppliers, recyclers, and packaging designers should be aligned, educated and they should collaborate effectively to identify and implement recyclable packaging solutions. However, misalignment and inefficiencies in this process can delay decision-making and slow progress toward sustainability goals. Furthermore, ensuring consumer experience remains good or becomes better when changing packaging is a key requirement for value driven companies like Unilever. (Piller et al., 2011; Ny et al., 2008)

Additionally, companies often lack comprehensive knowledge and tools to evaluate the recyclability of their existing packaging within the PPWR framework. This is currently largely due to the uncertainty of the exact regulations, which will only be published in 2028. A key challenge therefore is the knowledge gap. Furthermore, decision-making on design changes can be difficult when large, uncertain investments will have to be made to transition. Successfully transitioning to sustainable packaging will require engaging with suppliers and recyclers to validate and improve specifications. This transition presents a multi-faceted challenge, as companies must address technical, logistical, and regulatory demands while driving sales and enhancing consumer experience.

1.3 Research objectives and questions

The ultimate goal is to develop and test a framework that supports designers in creating PPWR-compliant recyclable packaging. To achieve this goal, the following main research questions and sub questions guide this research:

How can an organisation like Unilever effectively adapt their packaging recyclability strategy to meet the EU 2030 Packaging and Packaging Waste Regulation (PPWR)?

The sub questions are as follows:

- What internal collaboration factors and organisational processes contribute to successful implementation of sustainable packaging solutions?
- What are the regulatory requirements under the EU 2030 PPWR and how do they impact factors for sustainable packaging design?
- How can partnerships with external stakeholders such as suppliers and recyclers be leveraged to facilitate innovation and ensure compliance within the EU 2030 PPWR?
- What role can designers play in the PPWR transition and how can they help facilitate this process?

1.4 Methodology

This research will be conducted through a case study analysis of a segment of Unilever's current product portfolio. It starts with the analysis of the current trends in the FMCG packaging market and the challenges associated with recyclability. It will involve a comprehensive review of literature on organizational transformation, the circular economy, recycling practices and sustainable design in packaging.

This research employs a qualitative methodological approach to comprehensively explore and address the challenges associated with recyclable packaging in the FMCG sector. The study is structured around several key components:

Market analysis: an extensive market analysis will be conducted to identify current trends, challenges, and opportunities in the FMCG packaging market. Furthermore the competition will be analysed along with simplified benchmarking. This analysis will provide a foundational understanding of the external environment and the factors influencing packaging practices.

Literature review: a thorough review of existing literature on organizational transformation, the circular economy, recycling practices, and sustainable design in packaging will be undertaken. This review will synthesize current knowledge and identify gaps that this research aims to address.

Case study analysis: an in-depth analysis of current product packaging will be performed for three selected case categories within Unilever's product portfolio. This case study approach will allow for a detailed examination of existing packaging practices and their alignment with PPWR requirements.

Qualitative interviewing: a structured interview protocol will be designed to gather insights from key stakeholders involved in packaging design, including suppliers, recyclers, and designers. These interviews will assess stakeholder perspectives and identify barriers and facilitators to implementing recyclable packaging solutions.

Design phase: the design phase of this research will utilize the Double Diamond method, a structured design process that includes the Discover, Define, Develop, and Deliver phases. This method will guide the systematic exploration and refinement of packaging solutions. Additionally, strategic roadmapping will be employed to create a clear and actionable plan for implementing PPWR-compliant packaging based on gathered insights.

Together, these methods will support the development and validation of a comprehensive framework for recyclable packaging which is used in the design phase. The integration of the Double Diamond method and strategic roadmapping ensures a balanced approach that addresses both the problem space and the solution space, facilitating the creation of effective and recyclable packaging solutions.

1.5 Scope and delimitations

This research focuses exclusively on FMCG packaging in the context of the EU. Specifically the following Unilever product packaging from foods has been used for this research:

Plastic packaging with in-mould labels, with Pot Noodle and Aromat as priority (Figure 4)

Figure 4: Plastic packaging with in-mould label

Composite cans with Aromare as a priority (Figure 5)

Figure 5: Composite cans

Plastic pots with a carton sleeve with the snack pot (Asia Noodles) as a priority (Figure 6).

Figure 6: Plastic pots with a carton sleeve

Assumptions are made throughout this report about the stability of current regulatory trends, acknowledging that some market dynamics and regulations may shift. As the PPWR rules are being released from 2028, assumptions are also being made about the direction these rules will probably take in the literature review.

1.6 Expected results

The expected results of this study include a strategic framework to help Unilever adapt its packaging recyclability strategy to meet the EU 2030 PPWR requirements. The research will identify internal collaboration factors that could contribute to the successful implementation of sustainable packaging solutions. It will also outline the regulatory requirements of the PPWR and their impact on packaging design considerations like material selection and recyclability. Additionally, the study is expected to highlight the importance of external partnerships with suppliers and recyclers, offering insights into how these collaborations can drive innovation and compliance. Consequently, the findings will be based on insights gained from Unilever, and the recommendations will be tailored specifically to the company. Finally, it will define the role of designers in the transition process and provide recommendations for leveraging their expertise to achieve sustainable and compliant packaging solutions. For example through certain tools.

1.7 Structure

The thesis is structured as follows: chapter 2 provides an analysis of the FMCG market, focusing on sustainability trends and competitor activities. Chapter 3 reviews the literature on sustainable design, organisational transformation, the circular economy and recycling practices, concluding with a preliminary design for the theoretical framework. Chapter 4 gives the case study analysis for part of Unilever's product portfolio that reforms and validates the theoretical framework. Chapter 5 outlines the research methodology for the qualitative interviews. Chapter 6 explains the preliminary results coming from the qualitative interviews, focusing on stakeholder perspectives and influences. Chapter 7 details the design methodology, explaining the double diamond method and strategic roadmapping. Chapter 8 provides a validation. Chapter 9 presents the final designs and chapter 10 concludes this thesis report with recommendations, limitations and answers the research questions that were stated in section 1.3. Chapter 11 ends with a personal reflection.

Market analysis

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2. Market analysis

2.1 Fast-Moving Consumer Goods Market

The Fast-Moving Consumer Goods Market (FMCG) is a highly competitive market that serves many different product categories such as food and beverage (largest segment), personal care, health care and home care [15]. It is categorized by a high frequency of purchases, rapid consumption, low profit margins per unit and large sales volumes (Lacy et al., 2019). The market is dominated by major players in the global FMCG industry like Unilever, P&G, Nestlé and Coca-Cola. The FMCG market size was valued at 107.46 billion USD in 2022 and is expected to grow towards 148.51 billion USD by 2031 [16]. Key drivers of this growth include population increase, rising disposable incomes, urbanisation, and evolving consumer preferences, including a heightened demand for convenience and packaged products [16]. However, this consumption model has also been associated with the rise of a 'throwaway society' and overconsumption patterns (Kara et al., 2022).

In addition to economic drivers, technological advancements and digitalisation are reshaping the FMCG sector. Companies are adopting data analytics and AI to enhance supply chain efficiency and improve customer engagement. Digital marketing strategies and e-commerce platforms are also playing a critical role in expanding market reach and meeting evolving consumer expectations (Helen & Selvi, 2023). Consumer behaviour in the FMCG industry is also undergoing a transformation. Modern consumers, particularly Millennials and Gen Z, are demanding greater transparency, ethical sourcing, and sustainable practices from brands. This has led to the rise of eco-friendly product lines, clean-label trends, and corporate social responsibility initiatives (Ellsworth-Krebs et al., 2021; Jain & Hudnurkar, 2023).

In recent years, the concerns for sustainability have influenced the FMCG landscape, especially impacting the packaging. There has been a notable rise in initiatives centred around closed-loop recycling and circular economy practices [17], alongside the implementation of deposit return schemes for beverage containers [18]. Closed-loop recycling aims to maximise value creation over the life cycle of a product (Mishra et al., 2018). Furthermore, the market is witnessing a shift towards reusable and refillable packaging solutions, shown by innovative models such as Loop (2024), a packaging platform that offers reusable and refillable containers. It partners with brands to provide products in durable packaging that can be returned, cleaned, and reused, reducing single-use waste [19]. Furthermore, reuse is already broadly implemented in the industry of beer bottles and in B2B for crates and pallets. The implementation of new reusable systems and its benefits to the environment, is currently however still questionable due to transport distances, logistics, cleaning expenses and other factors (Coelho et al., 2020). Brands must balance sustainability goals with concerns over affordability, product safety, and brand reputation in a competitive market (Ellsworth-Krebs et al., 2021).

This chapter undertakes a comprehensive analysis of the FMCG market, with a particular focus on competitor dynamics and emerging trends. Additionally, a detailed examination of Unilever will be presented, highlighting stakeholder mapping, as stakeholders are important factors to success according to the literature review in chapter 3. This analysis

aims to enhance our understanding of the FMCG market and the strategies that key players and involved stakeholders use, to address its challenges and seize opportunities.

2.2 Competitor analysis

The FMCG industry is a fast-growing and dynamic field, and Unilever operates on a highly competitive FMCG market. In this market there are different types of competitors; branded consumer goods companies, private labels, start-ups and niche and local competitors. Companies like Unilever and P&G follow a 'house of brands' strategy, owning multiple distinct brands that operate independently. For instance, Unilever owns Dove, Ben & Jerry's, and Knorr, yet these brands are perceived as standalone entities rather than as part of a single overarching brand identity. In contrast, other FMCG giants like Coca-Cola and Nestlé adopt a more hybrid approach. While they own multiple brands, they also market products directly under their corporate names, such as Coca-Cola beverages and Nestlé-branded food products. On the other hand, most supermarkets typically follow a 'branded house' model, where all their FMCG products are sold under a unified brand identity, such as Albert Heijn's "Terra" (Yu, 2020). Branded consumer goods companies compete on a higher overall level with Unilever and are for example:

- Procter & Gamble: competing in personal care, laundry care and home care.
- Nestlé: competing in food products, frozen foods and beverages.
- The Kraft Heinz Company: competing in the food sector.
- PepsiCo: competing in beverages, condiments and snack foods.
- Mars: competing in snacks and confectionery.
- Danone: competing in dairy and plant-based alternatives, beverages and nutrition

In addition, private label companies also compete on a more direct level with Unilever's products and are for example retailers like Aldi, Lidl, Albert Heijn, Tesco, Walmart, Carrefour et cetera. As these retailers most often also sell products of Unilever in their stores, they mostly compete by offering cheaper alternatives across the product categories, creating their own lines to target budget-conscious consumers. By creating affordable alternatives across various product categories, these private labels present significant competition. For example, Unilever's premium brand, The Vegetarian Butcher, now faces increasing pressure from cheaper private label options in supermarkets.

Startups, niche brands, and local competitors play an important role in shaping the FMCG landscape by introducing disruptive innovations, catering to specific consumer preferences, and responding quickly to market trends (Närvänen et al., 2020). According to Resin (2022) there is a strong correlation between the implementation of start-ups and the achievement of the UN Sustainable Development Goals (SDG), not only for economic, but also for social, environmental and institutional SDG's. Unlike large consumer goods companies and private labels, these competitors often specialise in addressing niche markets, sustainability, and health-conscious consumer needs, creating unique value propositions that challenge Unilever's established position. Examples of competitors are Oatly; making oat milk a mainstream alternative to dairy products and Beyond Meat; producing plant-based meat substitutes.

In the nutrition space, Unilever faces competition from start-ups driving innovation with plant-based, functional, and health-focused products. Consumer preferences are influenced by trends such as health consciousness, environmental sustainability and ethical consumption, leading to the demand of more organic, eco-friendly and fairtrade products (Autere & Sandness, 2023). Niche competitors, often focusing on clean labels, sustainability, and specialised dietary needs, further challenge Unilever's traditional brands. Local competitors, rooted in regional consumer preferences, also play an important role in shaping the FMCG nutrition market, providing alternatives that align with local culture and values. As the demand for sustainable, health-conscious food products grows, Unilever must continue to innovate and adapt to maintain its market position against these diverse and dynamic players. As start-ups played a large role during the digital transformation, they could again be the drivers of sustainable transition (Resin, 2022)

When examining Unilever's product portfolio for this research more closely, we can map some of the more direct product competitors (see Figure 7 below). This interestingly shows that most of their competitors use the same type of product packaging for the snack pots, however most herbs and spices come in all different sorts of packaging types.

Figure 7: mapping Unilever's products and products alike

Through an extensive desk research, Unilever was compared to several FMCG competitors, namely Nestlé, KraftHeinz, PepsiCo, Mars, Procter & Gamble and Danone, resulting in a strengths, weaknesses, opportunities and threats (SWOT) analysis. The highlights of the desk research can be found below. The SWOT analysis can be seen in table 1 on the next page. What stands out is that Unilever is a frontrunner with regards to the amount of recycled content that is used for creating their new products, with a notable 22%. However the company is lagging behind with regards to the percentage of products that are designed to be recyclable, particularly in the nutrition segment where some improvements are needed. Unilever can address this gap by focusing on mono-material packaging and exploring new sustainable materials to enhance recyclability across all product lines. A limitation of the recycled and recyclable material numbers, is that it reflects the full portfolio of the companies and not specifically the nutrition portfolio. Stricter regulations apply for recyclable and recycled food packaging, therefore the numbers are expected to be lower in the nutrition branch.

All companies face similar threats, namely regulatory pressures, high competition, price volatility in essential resources, and changing consumer preferences (Yenipazarli, 2019). At the same time, these changing consumer preferences present opportunities for Unilever, for example in expanding to the health-conscious and plant-based markets, where there is growing demand for both sustainable packaging and healthier products. Unilever should focus on using its sustainability initiatives as a key differentiator, while continuing to invest in packaging innovations and increasing recycled content. By doing so, it can strengthen its position in the market, stay ahead of regulatory changes, and tap into emerging consumer trends.

Table 1: SWOT analysis of FMCG market on sustainability

	Unilever	Nestlé	KraftHeinz	PEPSICO	P&G	DANONE	MARS
% Recycled content	22%	9.3% [20]	Aim 15%	10%	14%	Aim 30% [21]	1.5%
% Recyclable content	72%	86.6%	87%	98%	78% [22]	84% [23]	61%
Strengths	Refillables Strong partnerships Broad range of initiatives (sustainable living plan, plastic reduction initiatives)	Paper and biodegradable based Broad range of initiatives making Nestlé adaptable	Prototyping innovations, affordability	Innovation in design, leadership in reuse initiatives	Innovation design leadership, sustainability-focused design, partnerships with recycling companies	Focus on health and nutrition, partnerships with recycling companies	Mono material use, sustainable innovation initiatives
Weaknesses	Recyclable content in packaging, supply chain changes, environmental criticism	Social criticism, supply chain transparency	Financial performance concerns	Carbonated drinks, unhealthy perception	Environmental criticism on content of products	“Niche” market segment	Recyclable and recycled content, unhealthy perception
Opportunities	Sustainability as USP, commitment to innovation	Expanding to ready to drink and emerging markets	Expanding to emerging markets	Growth in health and organic food segments	Digital & E-commerce expansion, organic & eco-friendly diversification	Growth in plant-based markets Health supplements	Increasing offerings in health and supplements
Threats	Regulatory pressures, increasing competition	Water scarcity, history, cacao shortages, regulatory changes	Global economic fluctuations, changing consumer preferences	Changing consumer preferences	Smaller eco-friendly start-ups	High substitution rate, smaller eco-friendly start-ups	Raw material shortages, particularly chocolate shortage

The main highlights for each company are outlined below. Each section is completed with a figure giving an impression of the sustainability initiatives per company.

2.2.1 Unilever

Unilever's homepage outlines their sustainability goals and accomplishments. They are transparent in their numbers and are keen to present their new innovations or new steps forward. Examples that show their performance are that their Helmann's mayonnaise bottles are made of 100% recycled plastic [24], they have started initiating paper wrappers for their Knorr bouillon blocks [25], they are moving to refillables in their healthcare and wellness products such as with Dove and with Lifebuoy [26], they are reducing their plastic usage in packaging, using more recycled content in their new packaging and have launched the paper Pot Noodle pots in the United Kingdom [27]. Furthermore, Unilever trialed edible mayonnaise seaweed sachets with Just Eat and Nopla [28]. What makes them stand out is mostly their developments in refillables. Less has been mentioned about packaging designed to be recyclable. Unilever had ambitious goals for 2025 regarding the sustainability in their packaging, however they have stepped away from these goals and set new ones for 2030 and 2035.

2.2.2 Nestlé

Nestlé also has an extensive web page and multiple reports on their sustainability goals and initiatives [29]. They have created their own models to work towards these goals and are also clear in their numbers. Like Unilever, they too have created paper bouillon cubes for their brand Maggi and are using 100% recyclable paper packaging for multiple confectionary brands [30]. They stand out with regards to their creation of edible forks in their Maggi, ready to eat cups and they are piloting with reusable packaging for products like Nesquik [31]. Recently they have also launched compostable capsules for their Nespresso brand, which is a big step. Nespresso already offered recycling services for the aluminium capsules [32]. Nestlé seems to be more widespread in their sustainable initiatives, rather than only focusing on recyclability or reusability. This could make them more flexible to changes in regulations due to new research on environmental consequences.

2.2.3 KraftHeinz

In comparison to Unilever and Nestlé, KraftHeinz is less extensive on their website with regards to sustainability initiatives. On reporting, they are also less visible with numbers. What they however do stand out with, is promoting their current sustainable projects. For example their collaboration with Pulpex to develop paper bottles for their tomato ketchup [33]. This is an interesting approach, as most other competitors opt to keep their project confidential as a competitive advantage gain and the possibility to file for patents. Furthermore, if the project does not succeed, it will be interesting to see the comments of consumers and the market. KraftHeinz has more paper initiatives like their Mac & Cheese box [34]. Furthermore they are moving towards 100% rPET and they are one of the first with 100% recyclable caps for their squeezable sauces [35][36].

2.2.4 PepsiCo

Compared to KraftHeinz, PepsiCo is again one of the competitors that is more extensive on their progress and initiatives. They have the pep+ (PepsiCo positive) initiative that works towards their transformation to a more sustainable company. If we look at recyclability numbers, PepsiCo is one of the best performing companies. They have introduced 100% rPET bottles, which is particularly advantageous given their extensive beverage portfolio. They have introduced paper pots for quaker oatmeal and have started with paper outer bags for their crisps [37][38]. Furthermore they are experimenting with compostable packaging, which they did for their Lays crisps during the Coachella festival [39]. Lastly, PepsiCo is ahead in reuse initiatives, implementing refillable bottles for SodaStream at home [40].

Figure 8: Market research

2.2.5 Procter & Gamble

Procter & Gamble is not a direct competitor if we focus on nutrition, as P&G mainly focuses on home- and personal care. However if we look at Unilever as an FMCG company, P&G might be one of the biggest competitors. When it comes to sustainability, they are quite clear in their goals and accomplishments. P&G stands out with their innovative design solutions; they have for example filed a patent to their new clickable cardboard boxes for Ariel washing detergent and they made 'knifeless-opening' boxes for pampers. In general, P&G has been moving more towards cardboard for their packaging. Furthermore they are focusing on using more recycled content. What also stands out with P&G is that they openly stated not to include compostable or biodegradable packaging in their goals, as they claim that not all consumers will have access to treating this waste properly. They therefore focus more on reuse and recycling of packaging [22].

2.2.6 Danone

Danone offers fresh dairy products, bottled water, early life nutrition and medical nutrition products. In comparison to the other competitors, they compare to KraftHeinz with the amount of information they show about sustainability on their website. However, their specific brands, like Evian, portray more specific information on their sustainability results and initiatives. Danone stands out by their recent evolution of fully removing their label on their packaging and replacing it with in-material labels, resulting in less waste [21]. Evian has recently introduced an in-home dispenser, similar to the SodaStream, which should also reduce the amount of packaging used for their water [41]. Furthermore, Danone has a strong collaboration with Veolia, to improve waste recovery [42].

2.2.7 Mars

Lastly, Mars is included in the competitor analysis. They currently stand out as an FMCG company, as they are innovating and promoting in using mono-materials for their packaging, which is occurring less with the other competitors [43]. Furthermore, they are far in the elimination of problematic plastics and in general the reduction of plastic in packaging. Lastly, they are also moving towards paper substitutions [44][45].

2.2.8 Other initiatives

Other packaging initiatives that are relevant to name are the switch that Pringles has made from composite cans to paper tubes in the United Kingdom [46]. Lidl has adopted a cellulose film for their cheese made from wood residues and Tesco has started experimenting with laser etched avocado's to label their products instead of using packaging [47][48].

2.2.9 Niche competition

Many niche brands in the Dutch market are gaining traction by targeting health- and sustainability-conscious consumers through eco-friendly products and packaging solutions. These companies typically extend their sustainability efforts beyond the products themselves to include environmentally friendly packaging strategies.

For instance, several niche brands in personal care, such as Seepje and HappySoaps (see Figure to the right), have introduced innovative, low-impact packaging solutions. Seepje's natural soaps are offered in recycled plastic packaging that doesn't use additional labelling; instead, branding is embedded directly into the plastic, similar to Danone's new labelling approach [49]. HappySoaps also emphasises sustainability, selling natural soaps in minimal packaging; in-store purchases come in recyclable cardboard boxes made from recycled material, reinforcing their mission to reduce single-use plastic waste [50].

Figure 9: Market research

Figure 10: Seepje (left) and HappySoaps (right) [49][51]

In the food sector, companies like RotterZwam and PieterPot are taking distinct approaches to sustainable packaging. RotterZwam, a unique mushroom cultivation company, grows mushrooms on recycled coffee grounds and aims for a zero-waste model with fully sustainable packaging [52]. PieterPot, meanwhile, provides a packaging-free grocery experience by delivering items in reusable glass jars that customers return, reducing waste from single-use plastics entirely [53].

Lastly, De Koffiejongens, known for its compostable coffee capsules, has been noteworthy in the market for its innovative approach to coffee packaging, even gaining the attention of major brands like Nespresso, which has now adopted a similar compostable capsule solution [54].

2.2.10 Supermarket analysis

A short comparative supermarket analysis was conducted to assess Unilever's products in relation to those of its competitors. The analysis took place at two supermarkets located at Bentinckplein in Rotterdam: Albert Heijn and Dirk. The primary objective was to observe trends in packaging materials and design across different brands.

Key findings from the analysis include a noticeable decline in the use of composite cans, with Pringles being one of the few brands still employing this packaging format. In contrast, there has been a significant increase in the utilisation of paper and carton materials across various product categories. Competitors such as Maggi and Remia were observed to employ similar rigid packaging for their jus, although Remia's packaging utilised approximately half the surface area for its label compared to Unilever's.

Additionally, many competitors, including Albert Heijn's noodles, Remia's peanut sauce, and Go-Tan, have shifted to transparent packaging. This trend was less evident among Unilever's products, where more coloured packaging was still common. A particularly notable observation was that many instant noodle products from competitors used larger amounts of plastic in their packaging, a possible result of differences in company origin or in regional regulations.

Finally, when comparing Unilever products with private label supermarket brands, it was found that Unilever tends to use more packaging for similar product amounts looking at fill content. Visual documentation of this analysis is provided in Appendix B.

2.2.11 Conclusion

Key takeaways show that FMCG competitors are prioritising recyclable, reusable, and compostable materials, with advancements in paper-based and mono-material packaging. Niche brands and store brands are also responding with minimalist, transparent, or zero-waste packaging solutions. The matrix (Figure 11) shows the direct competitors mapped on competitive positioning. This helps visualise the market landscape and identifies potential opportunities or gaps. This matrix is based on the desk research. The X axis stands for the strategic orientation, capturing a prioritisation for environmental focus or an emphasis on technology and innovation. The Y axis stands for market adaptability with a contrast in market shaping and market following.

Unilever is positioned in the sustainability-driven market shaper quadrant, alongside leaders like Nestlé. This reflects their strong emphasis on sustainability initiatives, such as using recycled content, and a focus on sustainable material sourcing. Their role as a market shaper indicates a proactive stance in setting sustainability standards and influencing industry trends rather than merely reacting to them. However, compared to innovation-driven competitors like Procter & Gamble and PepsiCo, Unilever's reliance on sustainability-led strategies may limit their ability to fully adopt technological advancements in packaging design, smart materials, and manufacturing efficiency.

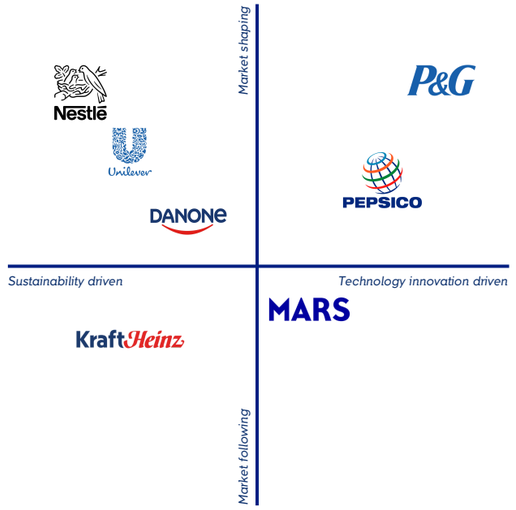


Figure 11: Competitive positioning matrix

For Unilever, this positioning highlights both strengths and areas for improvement, particularly when looking at the uncertain Packaging and Packaging Waste Regulation (PPWR) requirements. As Unilever would like to position itself as a sustainability leader, they therefore have to put in efforts to comply with PPWR and keep their position. While Unilever demonstrates a strong commitment to sustainability through initiatives such as refillable systems and recycled content, their current packaging portfolio falls short in areas of meeting expected PPWR standards, especially regarding recyclability across all product lines (mostly looking at nutrition). A recommendation would be to focus on technological innovation, which could enable smarter and more efficient packaging solutions. Communicating these innovations could also build a stronger brand reputation for Unilever and drive the market. Furthermore, focusing on refillable futures, scaling recyclable, minimalistic and paper options, and maintaining transparency on sustainability progress would position them well to meet evolving consumer expectations and regulatory trends toward sustainable packaging.

2.3 Trend analysis

The FMCG market is continuously evolving, influenced by changing consumer preferences, technological advancements, and sustainability regulations imposed by the European Commission and other initiatives. Understanding these trends is important for businesses aiming to stay competitive in a dynamic landscape. This section explores the key trends shaping the industry, offering insights into how companies can adapt with new approaches to remain competitive. By conducting a trend analysis, we can identify emerging opportunities, risks, and potential shifts in market dynamics, allowing organisations to anticipate and respond strategically to these changes. This analysis is especially relevant in the context of the increasing importance of sustainability, digital transformation, and evolving consumer expectations, all of which are reshaping the FMCG sector. Through this examination, companies like Unilever can better align their strategies to future market demands and regulatory requirements, ensuring long-term growth and relevance in a fast-changing environment.

2.3.1 Sustainability and eco-friendly packaging

Sustainability remains a significant driving force within the FMCG sector, with companies increasingly focusing on eco-friendly packaging solutions. For example, reversible adhesives and water-soluble PVOH are gaining traction as alternatives that reduce environmental impact (Hahladakis & Iacovidou, 2018). In addition, active packaging technologies have shown promise in enhancing food quality and extending shelf

life, thereby reducing food waste (Han et al., 2018). Intelligent packaging systems provide detailed information about the condition of packaged food, improving consumer safety and convenience (Han et al., 2018). Lastly, mildly preserved products are being developed to provide fresh, tasty, and convenient options with improved shelf life and quality (Han et al., 2018).

In addition to these innovations, several materials and processes are being adopted. For example, chemical recycling for plastics is emerging as a viable option to enhance recyclability. Also, the shift towards mono-material packaging simplifies recycling processes [55]. Moreover, compostable and biodegradable packaging, such as Polylactic Acid (PLA), is also gaining popularity (Hussain et al., 2024). Nespresso, as an example, has recently released home-compostable capsules [56].

2.3.2 Innovative recycling solutions

As the industry prioritises sustainability, innovative recycling solutions are also being explored from different perspectives, for example digital watermarks are part of the HolyGrail 2.0 initiative, facilitating better sorting and recycling [57]. New labelling initiatives are gaining interest, such as MCC Verstraete's NextCycle IML that easily separates from its packaging during recycling, MCC Verstraete's Peelable IML that consumers can peel off the product and their more recent IndustrialCompostable IML [58]. Furthermore, there are also wash-off initiatives for labelling and laser coding for food film [59][60].

Digital product passports are emerging as tools to provide essential product information throughout its lifecycle. Blockchain technology is being adopted for supply chain transparency, ensuring that consumers can trace the origins of their products (Ellsworth-Krebs et al., 2021). For example Provenance tracks and verifies the origin and journey of a product through its supply chain, ensuring transparency [61]. Research into plastic-eating enzymes by companies like Carbios is pioneering new methods to tackle plastic waste [62]. Digital product passports can allow retailers the possibility to verify reuse activities (Ellsworth-Krebs et al., 2021)

2.3.3 Market disruptions and consumer preferences

The FMCG landscape is also experiencing significant disruptions. The recent rise of weight loss pills has transformed market dynamics, posing new challenges for traditional food products [63]. Also, consumers choose hygiene, shelf life and convenience above sustainability. In addition the rise of "the millennial effect", where consumers seek more value in products has introduced new challenges. Platforms like TikTok and Instagram are reshaping FMCG marketing by enabling brands to reach targeted, engaged audiences through influencer partnerships and viral content (Haenlein et al., 2020). Another challenge is the rise of small brands and local competitors targeting niche markets with more health-conscious options [64].

2.3.4 Innovative packaging concepts

The FMCG sector is witnessing the emergence of various innovative packaging concepts, including subscription models that encourage refillable packaging, such as those offered by Loop (see Figure 12) by Terracycle or Pieter Pot. Edible packaging made from materials like seaweed, offering a sustainable alternative to traditional packaging solutions. Furthermore, the use of biobased inks and dyes plays a significant role in consumer acceptance, as colour is a key factor in product appeal, influencing 62-90% of purchasing decisions (Versino et al., 2023).

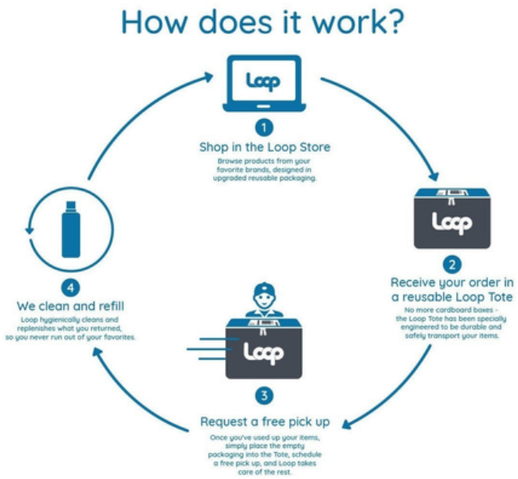


Figure 12: Explanation of Loop by Terracycle [65]

Unilever is responding to the identified market trends and disruptions through various strategic initiatives. If we look at the efficiency and millennial trend, we can for example see that Unilever has recently launched its Magnum bonbon's [66]. These bite-sized ice creams make it easier to grab and go and to portion your ice cream snacking. Furthermore, Dove's Real Beauty campaign is another example of the millennial demand for purpose-driven brands as well as Ben & Jerry's social activism and environmental commitment [67]. In response to the health and wellness trend, we see Unilever's Future Foods initiative [68], aiming to help consumers transition to healthier diets by offering plant-based alternatives like the Vegetarian Butcher range. This aligns with the focus on health-conscious products, which is the key motive to purchase organic foods, providing consumers with nutritious and plant-based alternatives (Kopplin & Rausch, 2021).

With regards to packaging and recycling, as named in the competitor analysis, Unilever has focused much of its attention on refillable solutions. Furthermore Unilever has invested in some partnerships, such as their partnership with Nestlé for developing chemical recycling [69], Loop and the Dutch Sustainable Growth Coalition. Interestingly, Unilever is no longer involved with for example HolyGrail 2.0, whereas its competitors Danone, KraftHeinz, Mars, Nestlé, Pepsico and P&G are.

To adapt to emerging trends, Unilever must accelerate its commitment to sustainable packaging by adopting mono-materials and exploring innovative technologies. It can also invest in advanced recycling solutions, such as digital watermarks and peelable IML, to improve sorting and meet waste management regulations. Leveraging digital product passports and blockchain can provide greater supply chain transparency, aligning with consumer demand for sustainability and traceability. As consumer preferences shift towards hygiene, convenience, and shelf life, Unilever should balance these with eco-friendly packaging solutions that extend product quality. Exploring new business models like refillable packaging and staying ahead of market disruptions from smaller health-conscious brands will also help Unilever stay competitive and relevant in the evolving FMCG landscape.

2.4 Stakeholder analysis

In a large FMCG company like Unilever, operating in a rapidly evolving environment, many stakeholders are involved. Through exploratory conversations, a comprehensive stakeholder map (see figure 13 below) has been developed to visualise key participants and their roles in the PPWR transition. This map categorises stakeholders into direct, indirect, and external groups, giving a holistic overview of the involved groups.

Direct stakeholders are those directly engaged in the project's execution, such as suppliers and R&D teams. Supply chain and

marketing are closely involved in the further project development. Indirect stakeholders include groups like procurement and recycling industries, whose roles, while not project-specific, are essential for its broader success. External stakeholders include for example shareholders, partners and competitors, who have a more influential role in this project.

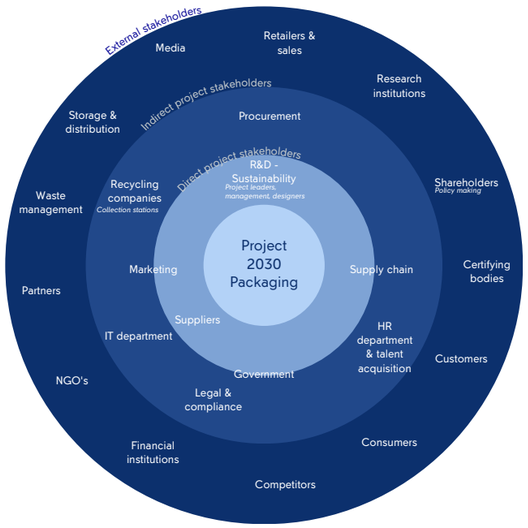


Figure 13: Stakeholder map

Figure 14 on the next page illustrates the end-to-end process for designing packaging that complies with the 2030 PPWR. This figure is also formed through exploratory conversations. This visual representation highlights the complexity of the project and visualises the importance of collaboration among various stakeholders, both internal and external. Each stakeholder plays an important role in achieving success in packaging sustainability, with their collaboration being important to the project's outcomes. The light blue lines portray the transfer of knowledge. The yellow lines show the route from packaging to waste to PCR to packaging.

For instance, the marketing department, shown within the key circle in Figure 14, defines the demands and requirements for new product packaging based on consumer testing. These requirements include specifics such as colours, images, texts, labels, shapes and other design elements that influence product performance. Meanwhile, research and development (R&D) ensures these demands align with technical feasibility, with procurement bridging the gap by coordinating with suppliers to secure viable solutions. Supply chain sets out the project process. Legal affairs, closely connected to government bodies, supports the project team by interpreting new rules and regulations and ensuring compliance with PPWR.

While shareholders and competitors are less directly involved in this project, they remain significant stakeholders. Shareholders influence Unilever's overall strategic approach to sustainability, although their role is limited here due to the EU-specific nature of the regulations. Competitors, on the other hand, are key for benchmarking and monitoring industry trends. By analysing competitors' strategic initiatives, Unilever can identify emerging trends, disruptive innovations, and industry benchmarks that inform its market positioning and innovation strategies.

Recycling and waste management companies play a key role in two aspects of the process. First, they handle the actual recycling of packaging materials, producing post-consumer recycled (PCR) content for companies to use. Second, they share their expertise in recycling processes to enhance the design of PPWR-compliant packaging. Bridging the existing knowledge gap between PPWR regulations and practical design for recyclability is important to achieve meaningful improvements in packaging design.

Figure 14 also highlights the critical collaboration, shown within the orange circle, as will be suggested by literature in the following chapter. It demonstrates the tight integration between waste management, recyclers, collecting companies, suppliers, and R&D. This collaboration is important for developing effective and sustainable solutions that comply with PPWR requirements.

2.5 Conclusion

In conclusion, Unilever should shift towards technological innovation while maintaining its sustainability focus. Embracing trends such as digital watermarks and digital product passports will be interesting. Prioritizing recyclable packaging and using mono-materials will enhance their readiness to comply with upcoming PPWR. Additionally, exploring new business models like service-based and refillable packaging will ensure Unilever remains flexible and future-ready in an uncertain era. Effective communication of their sustainable innovations and collaboration with key stakeholders will be essential to achieving both sustainability and technological objectives.

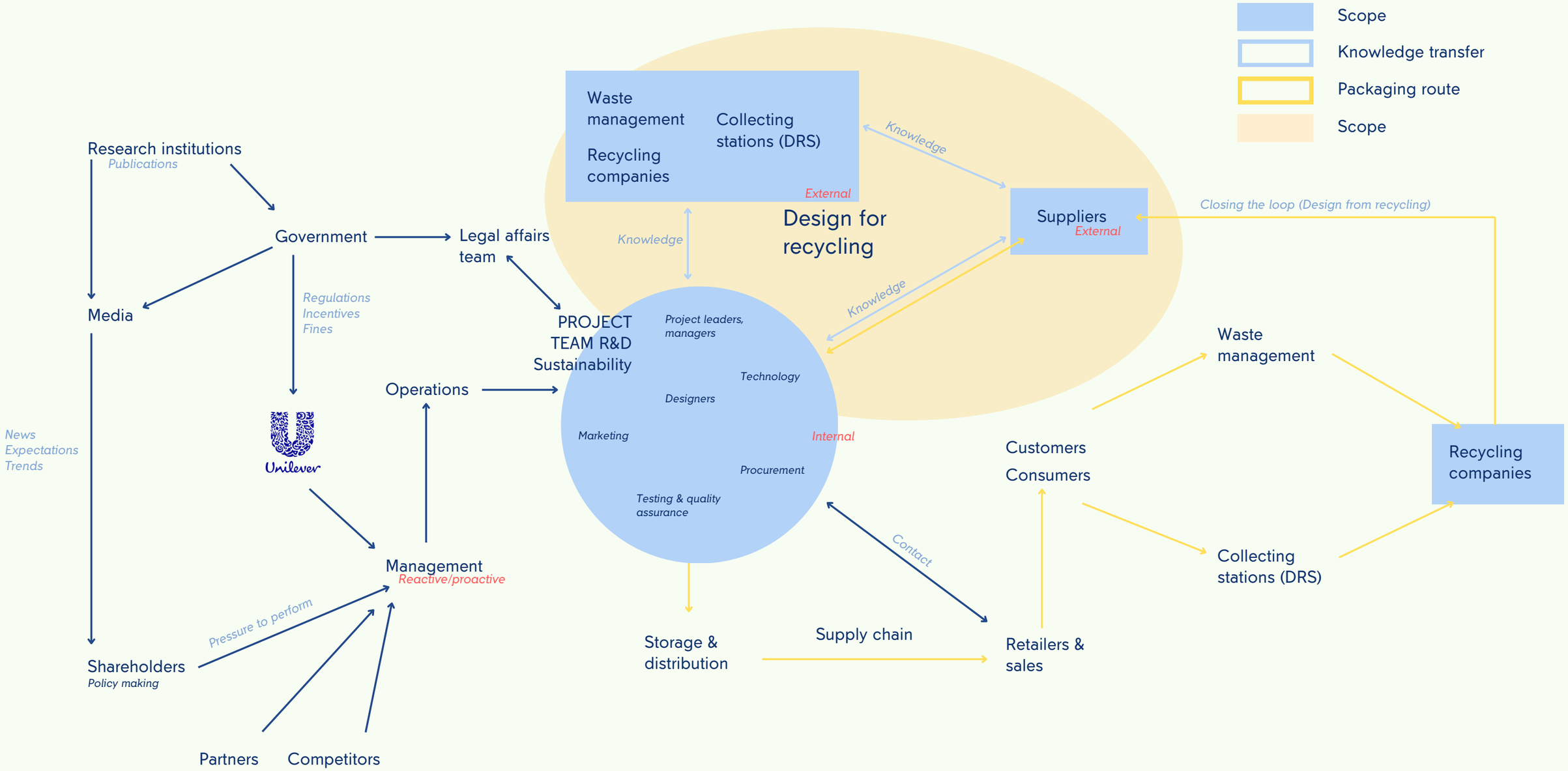


Figure 14: stakeholder map

Literature review and theoretical background

03

3. Literature review and theoretical background

A comprehensive literature review was conducted across key areas including organisational transformation, the circular economy, co-creation within businesses, sustainability in packaging, and waste management and recycling. These areas were specifically chosen to gain deeper insights into the complexities of recycling and sustainability practices, as well as the management of change within businesses. This focus is aligned with the overall objective of the thesis and guide for identifying critical challenges and opportunities in transitioning towards compliance with the PPWR. By exploring these domains, the review aims to find knowledge gaps and strategic enablers that could facilitate effective PPWR implementation across organisational and operational levels. The knowledge and insights that are gained within the literature review are needed for the next step, which is empirical research as well as to design a framework supporting designers and organisations in the direction of sustainable packaging solutions.

In total, approximately 200 papers were examined, of which 70 were considered relevant to this study. The literature search was conducted through desk research using platforms such as Google Scholar and Web of Science. The following keywords guided the search: ‘organisational transformation’, ‘circular economy’, ‘sustainability’, ‘food packaging’, ‘co-creation’, recycling’, and ‘waste regulations’. The research and sub questions provided in chapter 1 guided the identification and selection of relevant literature.

This chapter is organised into several subsections: circular economy, EU Packaging and Packaging Waste Regulation (PPWR), packaging and sustainability, the 4R framework, design for recycling, organisational transformation, co-creation, and sustainability frameworks. Following a critical discussion, a proposed framework is introduced, which will be tested in subsequent chapters.

3.1 Circular economy

The PPWR, which is central to this project, is rooted in the principles of the circular economy. Kirchherr et al. (2023) state the circular economy as *“a regenerative economic system which necessitates a paradigm shift to replace the end-of-life concept with reducing, alternatively reusing, recycling and recovering materials throughout the supply chain with the aim to promote value maintenance and sustainable development, creating environmental quality, economic development and social equity to the benefit of current and future generations. It is enabled by an alliance of stakeholders (industry, consumers, policymakers, academia) and their technological innovations and capabilities”*. In the circular economy the elimination of waste and pollution, the circulation of products and materials and the regeneration of nature are central [17]. Eco-efficiency is integral to the circular economy as it focuses on delivering goods and services that meet human needs while minimising waste and resource use. This approach encourages closed-loop systems, enhancing sustainability by promoting durability, reuse, and recycling to align with the Earth's carrying capacity (Kara et al., 2022). A visual representation of the circular economy can be seen in Figure 15 on the next page.

From a micro-systems perspective, these changes occur at the product level, influenced by firms and consumer preferences. At the meso-level, the circular economy involves regional activities, such as industrial parks, while at the macro-level, it encompasses national or global efforts, affecting overall industry structures. Circular economy initiatives operate across all three levels (Kirchherr et al., 2017). Transitioning towards a circular economy requires collaboration from a wide range of industry sectors, involving stakeholders such as suppliers, manufacturers, recycling processors, distributors, retailers, end consumers, and waste collection service providers. In the specific context of packaging, this includes raw material producers, packaging designers, manufacturers, transport and distribution networks, consumers, waste management organisations, and public authorities (Zhu et al., 2022). The circular economy relies on the cooperation of all stakeholders (Ellsworth-Krebs et al., 2021).

The circular economy aims to establish a closed-loop system, particularly at the product's end-of-life. However, as Corvellec et al. (2021) note, there are limitations to this approach, including challenges related to material properties, manufacturing and reprocessing technologies, the absence of reliable measurement tools, and the exclusion of voices from the Global South. There are two types of 'leakages'; technical and biological. Technical leakages refer to the loss of materials, labour, and energy in products that cannot be reused, refurbished, or recycled within closed-loop systems. Biological leakages, on the other hand, involve the degradation, loss, and depletion of soils, ecosystem services, and natural capital (Mishra et al., 2018).

3.2 European Union's Packaging and Packaging Waste Regulations

Packaging is the largest application field for plastics, accounting for approximately 40% of the global yield of plastics. Front end design for recycling determines 80-90% of the recovery value of plastic packaging (Ding & Zhu, 2023). The European Commission has introduced the Packaging and Packaging Waste Regulations (PPWR) as a development from the Packaging and Packaging Waste Directive (PPWD) to establish clear requirements for companies in the packaging industry, with a focus on enhancing sustainability, reducing packaging waste, and advancing the circular economy through greater use of recycled materials (Niero, 2023). The circular economy not only strengthens the EU's competitiveness by protecting businesses from resource shortages and price volatility, but also creates new business opportunities. Furthermore, it creates local jobs across different skill levels, promotes social integration, and encourages more efficient and innovative production and consumption methods (Niero & Hauschild, 2017).

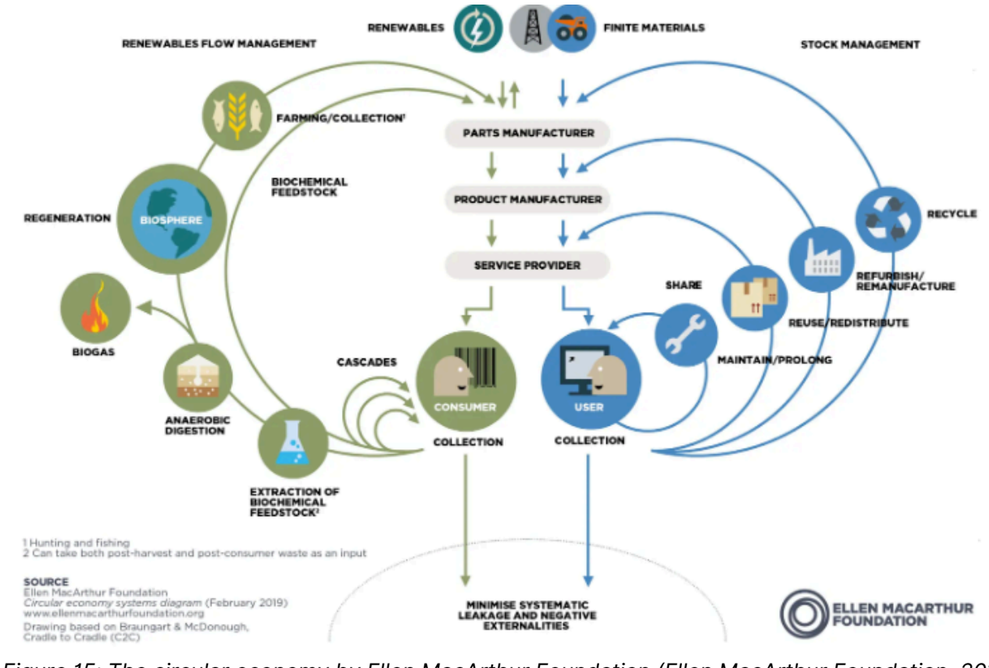


Figure 15: The circular economy by Ellen MacArthur Foundation (Ellen MacArthur Foundation, 2019)

The PPWR seeks to harmonise legislation and regulations across the EU, facilitating the smoother operation of the internal market. A key element of these regulations is the promotion of Design for Recycling (DfR) principles (Circpack, 2024), which will be explored in a subsequent section. Additionally, the regulations promote standardised labelling and instructions to aid consumers in properly disposing of packaging materials. The design stage of packaging influences around 80% of its environmental impact (Zhu et al., 2022). Although 10-20% of the costs and benefits of recycling depend on process optimisation, the majority of these outcomes are determined at the design stage (Kriwet et al., 1995).

A key feature of the PPWR is the extension of producer responsibility. Extended Producer Responsibility (EPR) makes producers accountable for managing the environmental impact of their products throughout their entire lifecycle, including disposal. The regulations address essential aspects such as recyclability, reduction in weight and volume, recycled content, and reuse. This is expected to result in more efficient use of shipping space, greater incorporation of recycled materials, fully recyclable products, and comprehensive technical documentation, such as QR codes for consumers and recycling companies (Europen, 2024). Additionally, it aims to reduce "invisible waste," which arises from poorly sized packaging (Annadur & Jain, 2023).

Furthermore, the regulations include specific provisions for contact-sensitive packaging, especially for items in contact with food or medical supplies (Circpack, 2024). A Figure that summarises some of the regulations is portrayed below.

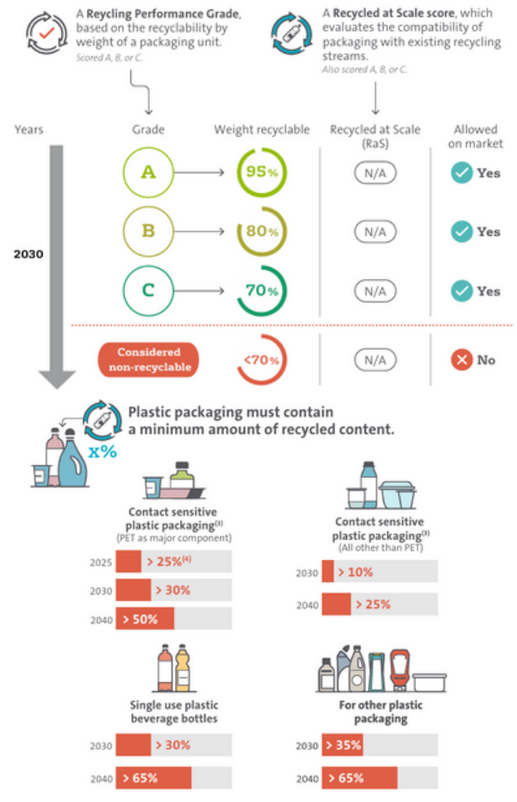


Figure 16: Packaging and Packaging Waste Regulations (Circpack, 2024)

3.3 Packaging and sustainability

The literature identifies three types of packaging “primary, secondary and tertiary”. Primary packaging is in direct contact with the product and is handled by the customer. Secondary packaging groups individual units for transportation, while tertiary packaging is designed for the storage and handling of secondary packaged items (Ncube et al., 2021).

The report focuses on primary packaging because it is the most frequently discarded and contributes significantly to packaging waste. Given its direct contact with the food product and strict regulatory requirements, primary packaging poses unique challenges for sustainability, recyclability, and compliance with circular economy principles, making it a critical area for innovation and transformation within the packaging industry (Cecon et al., 2021). It is also an interesting area due to the fact that it is a consumer value driven market, leading to more limitations (and requirements) for packaging design (Boz et al., 2020).

Packaging serves several essential functions, including containment, apportionment, protection, unitisation, convenience, and communication (Annadur & Jain, 2023). It plays a crucial role in the preservation system, acting as a barrier between the product, especially food, and external elements. Packaging provides protection against physical, chemical, and biological threats, such as carbon dioxide, UV radiation, oxygen, water vapour, and microorganisms. Multi-layered films, for instance, often offer strong protective barriers, though they tend to be less sustainable (Versino et al., 2023). Figure 17 below visualises the protection of packaging along with the threats.

In response to increasing demand for sustainable food packaging, several innovations have emerged, including sustainable and green packaging (SOGP), active packaging, intelligent packaging, and smart packaging (Han et al., 2018). SOGP involves the development of biobased and biodegradable materials, while smart and active packaging focuses on providing real-time information about the product's condition and enhancing food quality to extend shelf life (Firouz et al., 2021). However, the adoption of these innovations presents technical challenges, such as the material properties for SOGP relying on durability, barrier properties and mechanical strength, and reliable technologies that can function consistently throughout the product’s lifecycle for active and intelligent packaging, often in harsh environments. Moreover, this often drives significant costs (Han et al., 2018).

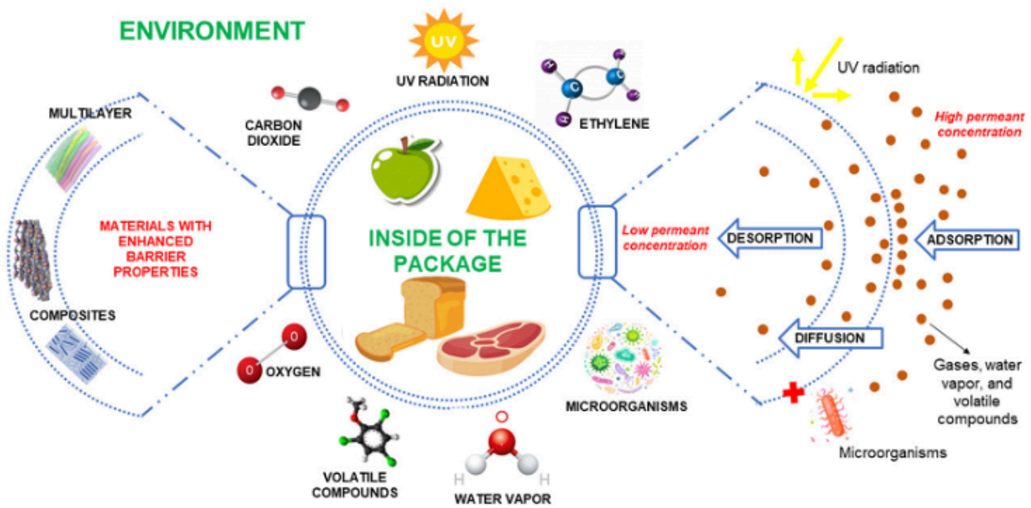


Figure 17: Protection of packaging (Versino et al., 2023)

Grönman et al. (2012) propose a framework providing step by step guidance for designing sustainable food packaging, emphasising that the environmental impact of food losses throughout the product lifecycle far outweighs the environmental cost of the packaging itself (see figure 18). Consequently, it is vital to design packaging that not only appeals to consumers but also ensures the product is fully utilised, remains preserved throughout its intended shelf life, and is safeguarded from spoilage or damage (Grönman et al., 2012).

3.4 The 4R framework

The 4R framework has gained prominence within the circular economy, representing a hierarchical approach to waste management: reduce, reuse, recycle, and recover (Kirchherr et al., 2017). At its core, the framework prioritises the reduction of material use, followed by the reuse of products, recycling of materials, and, as a last resort, the recovery of energy from waste. Each of these stages represents a critical step towards minimising environmental impact and moving closer to a zero-waste economy.

Reuse is particularly notable for its greater effectiveness in reducing waste compared to recycling, as it preserves more of a product's original value and requires fewer resources for reprocessing. However, despite its benefits, reuse often faces challenges due to its perceived complexity among consumers.

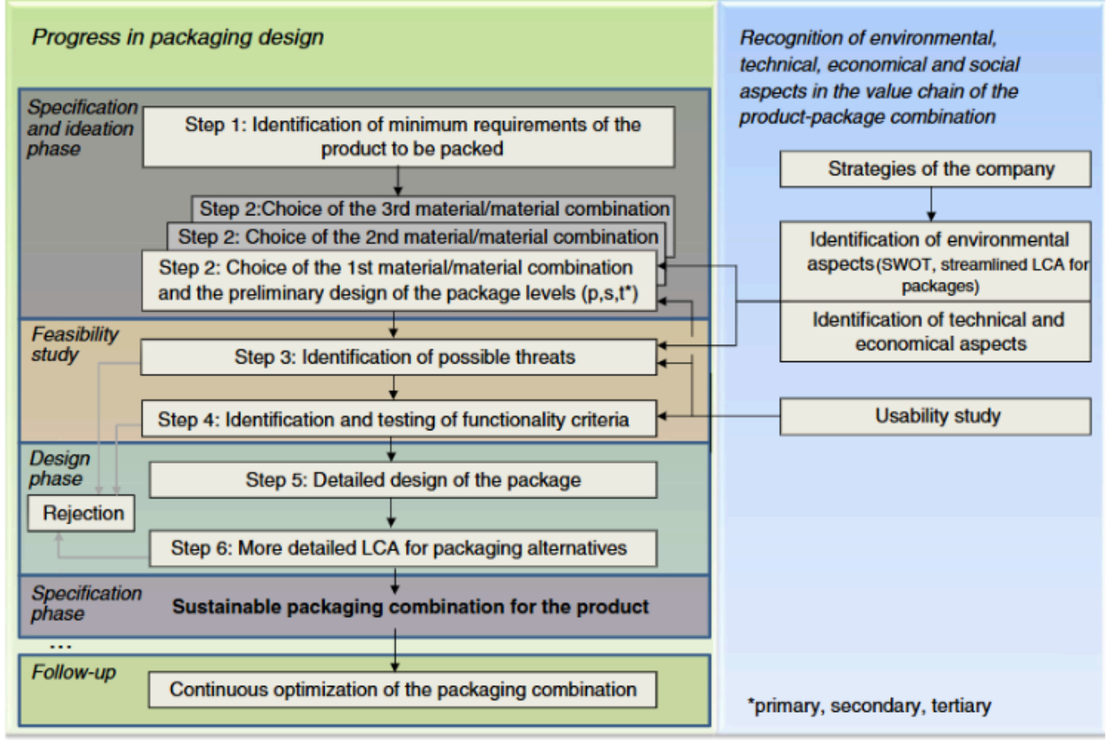


Figure 18: A framework for a guiding approach to design sustainable food packaging (Grönman et al., 2012).

This complexity can derive from the logistics of returning, cleaning, and reusing products, as well as from ingrained habits that favour single-use items (Ncube et al., 2021). Consequently, the success of reuse initiatives is heavily reliant on consumer willingness and ease of participation.

Current developments in reusable packaging systems include various formats, such as refillable bulk dispensers, refillable parent packaging, returnable packaging, and transit packaging. The economics of these systems are influenced by key factors such as transport distances and logistics, total market volume, integration into a standardised system, return rates, and the costs associated with cleaning and labour. Environmental impacts also play a critical role, with considerations around transport distances, return rates, and the implications of sorting, cleaning, maintenance, and potential product damage (Coelho et al., 2020). It is therefore questionable whether at the current state of infrastructure and supply chain, reusable packaging has less of an environmental impact than recycled packaging. In the PPWR, considerations should be taken into account by incentivising reuse rather than charging for waste taxation (Ellsworth-Krebs et al., 2021).

Other barriers and concerns for businesses include affordability, health and safety, brand reputation and competition (Ellsworth-Krebs et al., 2021). To address these barriers, designers play a crucial role in simplifying and streamlining the reuse process. This can be achieved through product designs that make reuse convenient and through the development of infrastructure that supports seamless participation, such as efficient return systems. Moreover, designers should aim to familiarise consumers with reuse systems through educational efforts and product labelling, thereby improving consumer acceptance and uptake (Miao et al., 2023).

In addition to the role of consumers and designers, the recycling stage remains integral within the 4R framework. However, recycling should ideally be positioned as a secondary option to reuse, as it still requires energy and resources for material recovery. Recovery, the final step, involves extracting energy from waste that cannot be recycled, though it is considered the least desirable option in the hierarchy, as it signals the end of a product's lifecycle.

Overall, the 4R framework promotes a shift towards more sustainable product life cycles, encouraging both businesses and consumers to prioritise waste prevention and resource efficiency.

3.5 Design for Recycling

The Packaging and Packaging Waste Regulations (PPWR) set clear guidelines that mandate the use of Design for Recycling (DfR) principles in packaging. Under these regulations, packaging is considered recyclable in Europe if it meets several specific criteria: (i) it must be collected in a manner that preserves its potential for reuse, recycling, or other recovery processes; (ii) it must be sortable into distinct waste streams without jeopardising the recyclability of other materials; (iii) it must be recyclable into high-quality secondary raw materials capable of substituting primary resources; and (iv) it must be efficiently collected, sorted, and recycled at scale across EU member states (Circpack, 2024). Incorporating these criteria into the design phase is critical to ensuring recyclability, as sorting and recycling considerations must be integrated from the outset alongside use and collection factors (Hahladakis & Iacovidou, 2018).

In the broader context of circular design, designers are encouraged to also consider logistical factors, such as transportation distances, packaging dimensions, and forms that minimise emissions throughout the product's lifecycle (Zhu et al., 2022). This holistic approach aims to reduce environmental impact from design through disposal.

When designing packaging for recyclability, several key components must be addressed: base resin, closure systems, small parts, colours, additives, adhesives, barriers, layers and coatings, labels, sleeves, ease of dismantling, material composition, inks, printing, pumps, dimensions, attachments, and the ease of emptying the packaging (Circpack, 2024; Ding & Zhu, 2023). For instance, additives can significantly impact the quality of plastic packaging, and contamination during recycling may lead to more packaging being sent to landfill (Hahladakis & Iacovidou, 2018). The challenge of material identification also continues; Near Infrared (NIR) sorting technology, which is currently used to identify plastic types, has limitations. For example, it may give false results with multi-layered plastics, as it often detects only the topmost layer, and it struggles with identifying dark or (carbon) black plastics, which renders them 'invisible' (Ragaert et al., 2017).

Material selection is a crucial element in DfR. Packaging materials must maintain the functionality required to protect product quality, while also being cost-effective, clean, safe, and non-hazardous to both humans and the ecosystem. However, one significant limitation is that plastics typically deteriorate after being recycled up to seven times, making them eventually unusable (Zhu et al., 2022). This limitation has led to the emergence of another strategy known as Design from Recycling, where the starting point of a new product is the raw material derived from the recycled waste of a previous product’s end of life. Designers in this approach focus on identifying the strengths and weaknesses of these recycled materials and matching those characteristics with the needs of a new or existing product (Ragaert et al., 2017). This concept is often referred to as the Material-Driven Design Method (Ragaert et al., 2019).

Another essential consideration in DfR is Design for Disassembly. Packaging that incorporates multiple polymers or composite materials should be designed to be modular, allowing for easy separation of components to facilitate efficient recycling (Zhu et al., 2022). The goal is to minimise the variety of materials and joining elements used in the packaging, which helps make harmful or valuable components more accessible for proper recycling (Kriwet et al., 1995).

When recycling plastic waste, it is important to recognise four levels of characterisation: (i) the primary polymer type, (ii) the specific product type, (iii) the design of the polymer and how easily it can be separated, and (iv) the material's colour (Ncube et al., 2021). These factors determine compatibility with recycling streams, ease of processing, and the final value of recycled materials. There is also a distinction between post-industrial waste, which is typically of higher quality and easier to recycle, and post-consumer waste, which is often more complex to process due to contamination and mixed material use (Vogt et al., 2021).

Recycling methods can be classified into four main types: mechanical recycling (primary and secondary recycling), chemical recycling (tertiary recycling), energy recovery (quaternary recycling), and landfill disposal. In mechanical recycling, plastics are collected, sorted, washed, and ground into smaller parts that can be remelted into new products. However, one challenge with this method is that polymers degrade under certain conditions, such as exposure to high

temperatures or prolonged use, affecting the quality of the recycled material. When mechanical recycling is not economically or technically viable, chemical recycling offers an alternative. This process, which includes methods such as chemolysis or pyrolysis, breaks polymers down into smaller molecules that can be repurposed as chemicals or oils (Ragaert et al., 2017). However, chemical recycling is currently limited by high costs, technological constraints, and the poor reusability of catalysts (Ding & Zhu, 2023).

To improve recycling processes, governments play a critical role in setting regulations, while businesses must drive innovation, and institutions should prioritise research. At the same time, individuals are essential in taking action by making responsible consumption choices (Ncube et al., 2021).

The table in Appendix C gives an overview of all the Design for Recycling requirements that were mentioned by different papers for the different phases in designing packaging. The Design for Recycling (DfR) requirements span across four key phases of packaging design: material selection, conceptual design, design development, and design validation. Material selection focuses on using recyclable and reusable materials, incorporating minimum recycled content, ensuring food safety and product shelf life, and exploring new biomaterials and biocomposites. Conceptual design prioritises material reduction, colour choices (avoiding black), mindful use of additives, adhesives, and coatings, and enabling reuse and end-of-life options. Design development emphasises ease of dismantling, modular design, avoiding multi-polymers in non-separable parts, reducing material varieties, minimising empty space, and ensuring label recyclability. Design validation highlights the importance of assessment tools (e.g., LCA), circular economy indicators, ease of emptying, and reducing food losses.
Overall, the key principles aim to optimise recyclability, reduce environmental impact, and ensure efficient material recovery while balancing functionality and consumer usability.

3.6 Organisational transformation

Mishra et al. (2018) define four types of value creation: economic, environmental, information and consumer-oriented. Innovations are important for companies not only to comply with the EU 2030 PPWR regulations but also to maintain a competitive edge in an increasingly sustainability-driven market (Wiesmeth, 2020). Companies generally approach sustainability either reactively, responding to regulatory demands, or proactively, by anticipating changes and seizing opportunities. Proactive companies, particularly those in competitive sectors, tend to gain a stronger market position by engaging in eco-innovation and integrating sustainable practices early (Giacomarra et al., 2019). By doing so, they can reap long-term benefits, such as being perceived as socially responsible, fostering internal innovation, and attracting talent that is increasingly drawn to environmentally conscious businesses (Hu & Zeng, 2024).

A critical driver of sustainable innovation is stakeholder engagement. Organisations must collaborate with primary, secondary, internal, and external stakeholders, all of whom contribute to the success of sustainability efforts. External stakeholders, such as universities and research institutions, bring in valuable knowledge that enhances innovation and overall performance. Within the supply chain, suppliers, customers, and competitors play an especially important role in promoting eco-innovation throughout the system (Giacomarra et al., 2019). Expanding co-creation models to include external expertise can accelerate sustainable innovation, leading to solutions that may not have been considered internally. Additionally, organisations must be mindful of their sustainability risks, the likelihood of negative environmental or social conditions within their supply chain. However, many of these risks remain "invisible" until they are closely examined, as per the iceberg analogy, where the greatest dangers lie beneath the surface (Meinlschmidt et al., 2018).

Drivers of organisational change extend beyond compliance and competition. Increasingly, customers demand sustainable and responsible products, employees push their organisations toward more conscientious business practices, and B2B startups disrupt markets with value propositions based on ethics, sustainability, and responsibility. These changes foster the rise of Conscientious Corporate Brands (CCBs), companies driven by an internal moral compass that addresses sustainability challenges while remaining profitable (Iglesias et al., 2022). Nevertheless, the primary driver for businesses to engage in environmental improvement often remains the prospect of economic benefits, as creating a more sustainable and valuable product can attract new customers and enhance profitability (Zhu et al., 2022).

Understanding stakeholders and clearly defining their roles is essential for fostering value co-creation, especially in sustainable design and innovation contexts (Wiesmeth, 2020). Engaging stakeholders effectively creates synergy, facilitates knowledge exchange, and drives innovation, ensuring that sustainability challenges are tackled at all levels of the organisation (Ny et al., 2008). Establishing a shared understanding of these challenges is fundamental for achieving organisational success in sustainability efforts. In addition to understanding and engaging stakeholders, cultivating both internal capabilities and a culture of openness toward knowledge sharing is crucial for advancing innovative performance. In today's context, an organisation's innovative success heavily relies on its ability to build networks with external partners, which fosters valuable knowledge exchange and enhances co-creation opportunities (Piller et al., 2011). Together, these internal and external efforts form the foundation for addressing sustainability challenges throughout the organisation.

Transformational change within organisations tends to follow one of two paths. Sugarman (2007) describes the "Grow" approach, which emphasises collective learning and problem-solving among employees, and the "Drive" approach, in which top executives direct change through restructuring and guiding employee behaviour. He advocates for a bi-focal approach that balances short-term business results with long-term process improvements, highlighting that organisational transformation is deeply linked to personal change. Employees' actions and mindsets are critical to the success of broader structural transformations within the company. To complement this, internal training plays a crucial role in developing a culture of innovation that embraces quick experimentation, often referred to as a 'fail fast' approach. This training not only enhances employees' abilities to learn from both success and failure but also builds their capacity to adapt and contribute to continuous improvement (Mishra et al., 2018).

Another key element of organisational transformation is the development of dynamic capabilities, the ability to sense opportunities in the external environment, mobilise resources, and transform accordingly (Konopik et al., 2021). For example, reallocating resources such as talent and capital to areas where they can deliver the most value is crucial in a competitive market

(Bogers et al., 2019). Firms can even influence the market environment to increase their profits, especially when they face close competition (Teece et al., 1997). However, adopting agile practices can be complex, often encountering resistance due to a lack of understanding, unpredictable challenges, and a lack of knowledge. As a result, it is crucial that higher management is both informed and actively involved in shaping the organisational culture and driving change (Jovanovic et al., 2017).

Managing uncertainty is a core practice in effective innovation management, enabling organisations to navigate complex and shifting competitive landscapes. This involves transferring various types of information, such as insights into customer and market needs (Needs information) and potential technological solutions (Solution information) (Piller et al., 2011). An organisation's competitive advantage is closely tied to its managerial and organisational processes, which are shaped by its asset position and the strategic paths available. In competitive environments, it is advantageous for firms to develop distinctive competencies—those that are difficult for competitors to imitate (Teece et al., 1997). When firms possess resources that are valuable, rare, inimitable, and non-substitutable, they can achieve and sustain competitive advantage. This concept is part of the resource-based view (RBV) of the firm (Eisenhardt & Martin, 2000). The idea of resource interaction, the combination, recombination, and co-development of resources among organisations, plays an important role in driving innovation and competitive advantage (Laursen & Andersen, 2022). As noted by Bogers et al. (2019), significant value can be gained not just from developing new knowledge but from creating systems that combine pieces of knowledge in ways that solve complex problems.

In a rapidly changing environment, organisations benefit from learning by doing. Strategy, in this context, is less about static planning and more about creating a series of unpredictable advantages through timing and loosely structured, adaptable systems (Eisenhardt & Martin, 2000).

To guide the transformation process, Brocke et al. (2020) propose a hierarchical model comprising five levels of transformation: local exploitation, internal integration, business process redesign, business network redesign, and business scope redefinition. Higher-level changes typically incorporate and build upon lower-level ones, making it a comprehensive approach to managing organisational transformation.

3.7 Co-creation

Open innovation, characterised by collaborative efforts across broad networks of external stakeholders such as universities, start-ups, suppliers, and even competitors, has become central to driving innovation within organisations. This approach harnesses the power of both horizontal and vertical partnerships, facilitating knowledge flow and idea generation across organisations (Piller et al., 2011). A common process of open innovation is co-creation: a process that integrates internal and external stakeholders into the innovation process through various tools. Involving users in co-creation offers numerous advantages, including higher acceptance levels of innovations, reduced risk, a decrease in information asymmetries between consumers and producers, greater efficiency in product usage, and enhanced knowledge transfer (Arnold, 2017). As a result, co-creation with users can lead to earlier acceptance of products in the marketplace, providing organisations with a competitive advantage (Arnold, 2017).

Effective co-creation strategies often rely on specific tools and toolkits that often meet five key requirements: enabling trial-and-error learning, maintaining a well-defined solution space, prioritising user-friendliness, incorporating a library of modules and components, and transferring customer solutions efficiently. Key aspects involve varied modes of engaging with customers and stakeholders: listening to feedback, actively asking for insights, and co-developing solutions to meet market needs (Piller et al., 2011). Together, these elements allow for collaboration at different stages, with varying degrees of freedom and involvement, enhancing the impact of open innovation.

In large organisations, the presence of multiple stakeholders can create stakeholder pressure. Primary stakeholders include employees, customers, investors, and suppliers, while secondary stakeholders encompass media, trade associations, and non-governmental organisations (Biggemann et al., 2014). To be effective, sustainability strategies should engage stakeholders throughout the entire value chain, ensuring integrity at each stage.

In the packaging design process, there are important interactions according to Kriwet et al., (1995), for example between the designers and recyclers and the designers and suppliers. Designers should gain knowledge about the ways of collecting, transporting and storing of the product after usage through recyclers and gain knowledge on the markets for materials, the properties/quality of recycled materials and reliability and the specification of the use of recovered materials in new parts from suppliers (Kriwet et al., 1995).

Ongoing dialogue with external sustainability experts is also critical, as it can help organisations identify opportunities for improvement that are strategically aligned with sustainable development goals (Ny et al., 2008).

Barile et al. (2020) propose that organisations operate across three distinct levels: micro, meso, and macro. At the micro level, organisations facilitate co-design, the meso level supports co-development, and the macro level is suited for co-evaluation. Additionally, Barile et al. (2020) introduce a fourth level, the meta level, which focuses on how value co-creation can drive both co-innovation and sustainability. This meta level is particularly useful for fostering co-learning within organisations (Barile et al., 2020).

3.8 Sustainability tools and frameworks

In this section, relevant sustainability tools are outlined that can be used during the design and validation process or can be referred to throughout the project. They are shortly described below.

Backcasting

A commonly used tool in sustainability is the backcasting approach, which begins by envisioning a desired future outcome and then determining the steps needed to achieve it based on foundational sustainability principles. This approach typically includes defining the system, establishing a basic definition of success, formulating strategic guidelines to reach the goal, and outlining specific actions and tools to implement the strategy (Ny et al., 2006). Importantly, sustainability principles should be defined at the outset and can be tailored to the specific company’s needs. While backcasting provides flexibility, allowing for the refinement of sustainability principles during the process, it also sets clear actions to guide the organisation towards sustainability (Ny et al., 2006). Ny et al. (2008) further propose templates for sustainable product development based on the backcasting principle, offering a structured framework for

organisations to follow. Backcasting can for example be used in creating a transition or roadmap.

Life Cycle Assessment (LCA)
Another widely used tool to assess sustainability in product development is the Life Cycle Assessment (LCA). LCA evaluates the environmental impacts of different options across a product's life cycle and serves as a decision-support tool, especially in detecting the benefits of increased recycled content (Niero, 2023). However, LCAs sometimes lack a comprehensive understanding of business strategy and a broader strategic perspective (Ny et al., 2006). To address these limitations, Niero (2023) suggests the Life Cycle Sustainability Assessment (LCSA), which integrates an LCA with Environmental Life Cycle Costing (ELCC) and Social Life Cycle Assessment (SLCA), encompassing environmental, economic, and social dimensions of sustainability. This tool will not necessarily be used within the scope of this project, but is highly relevant to validate the impacts of newly designed packaging.

In addition, material flow analysis can be employed to account for all collection and processing losses during the product's life cycle, offering a more complete picture of resource efficiency and sustainability (Niero, 2023).

Material Circularity Indicator (MCI)
The Material Circularity Indicator (MCI) is a tool that measures how effectively a product aligns with circular economy principles. It assesses key factors such as the proportion of recycled material used in production, the product's utility during its lifespan (in terms of duration and intensity of use), the end-of-life recycling rate, and the efficiency of the recycling process (Niero & Hauschild, 2017). The MCI provides organisations with insights into how well their products adhere to circularity principles, guiding improvements in design and material usage to enhance sustainability. This tool could be useful when designing a new product packaging.

3.9 Discussion

This chapter has explored the literature on sustainable packaging, highlighting frameworks like the circular economy, Design for Recycling (DfR), and the organisational changes needed for Unilever to comply with the EU 2030 Packaging and Packaging Waste Regulation (PPWR). These findings reveal not only the complexities but also the gaps in current strategies and knowledge surrounding the transition towards PPWR compliance. The following discusses the most important aspects.

Key research insights and challenges
The transition towards PPWR-compliant packaging operates at the intersection of technological innovation, organisational transformation, and multi-stakeholder collaboration. While frameworks such as Design for Recycling (DfR) and circular economy principles provide structural guidance, the path towards implementation reveals significant challenges across technical, organisational, and regulatory dimensions, especially when the exact regulations remain uncertain.

Firstly, stakeholder engagement, knowledge exchange and co-creation emerge as critical factors for success, yet they remain among the most complex to manage. Innovation in sustainable packaging does not happen in isolation, it requires collaboration across an extended network of stakeholders, including suppliers, recyclers, customers, governmental agencies, and non-governmental organisations. Each of these actors brings distinct goals, priorities, and capabilities to the table, which can sometimes clash or create misalignment. Although co-creation models that incorporate external actors such as universities and research institutions offer promising opportunities for breakthrough innovations, managing these partnerships requires clear structures, shared objectives, and transparent communication. The absence of these elements can hinder the scalability of collaborative efforts, stalling progress towards PPWR compliance.

Secondly, technical limitations in DfR principles and recycling technologies present a significant barrier to achieving circular packaging systems. While the literature discusses the potential of DfR, in practice, recyclability is often constrained by technical barriers such as the efficiency of Near-Infrared (NIR) sorting technologies, the scalability of new recycling forms like chemical recycling, and the durability of recycled materials. Many plastic packaging formats, especially those with multi-layered or composite structures, are challenging to recycle. Furthermore, the quality of recycled plastic often deteriorates with each recycling cycle, limiting its suitability for applications requiring high material performance, such as food-grade packaging. These limitations highlight a gap between theoretical DfR principles and their practical execution in current recycling infrastructures.

Also important is the role of organisational transformation in driving sustainable innovation within Unilever. Transitioning to PPWR-compliant packaging is not solely a technical challenge but also an organisational one. It requires embedding sustainability at the core of Unilever's business strategy, operational processes, and decision-making frameworks. This transformation can depend on developing dynamic capabilities, the ability to adapt, innovate, and respond proactively to both regulatory pressures and market changes. However, such capabilities cannot be developed overnight. They require strong leadership, continuous employee engagement, and the alignment of incentives with recyclability objectives. Moreover, resistance to change, whether due to operational habits, cost constraints, or perceived risks, remains a barrier that must be addressed through strategic leadership and cultural change initiatives.

Lastly, regulatory complexity and compliance barriers further intensify the challenge of transitioning towards PPWR standards. The PPWR outlines ambitious targets for recyclability, minimum recycled content, and packaging minimisation, but the implementation of these targets often involves significant costs and infrastructural investments. Many supply and packaging facilities are not yet equipped to handle the technological and operational requirements necessary to meet these standards. Furthermore, the regulatory landscape is continuously evolving, with varying interpretations and enforcement mechanisms across different regions. This lack of consistency can create uncertainty for businesses, making long-term planning and investment decisions more challenging.

In summary, the transition towards PPWR-compliant packaging is not a straightforward task but rather a multifaceted challenge requiring simultaneous advancements in stakeholder engagement, technological innovation, organisational transformation, and regulatory compliance. Addressing these interconnected barriers will be important for Unilever and other organisations aiming to align their packaging strategies with the ambitious goals of the PPWR.

Gaps and implications for transitioning towards PPWR
The literature highlights a gap of knowledge on transitioning towards the new and yet uncertain PPWR. An integrated framework that combines technical, regulatory and stakeholder perspectives could guide through PPWR compliance systematically. Tools such

as LCA and MCI provide environmental assessments, they do not offer actionable roadmaps for organisational transformation or address the importance of supply chain collaboration. Furthermore there is a technological maturity gap, meaning that current recycling technologies are not fully scalable or efficient enough to meet PPWR requirements across all (food) packaging types. A stakeholder misalignment can be due to a lack of structured governance that is needed between the diverse actors. Lastly there are operational trade-offs of having to balance cost-effectiveness with sustainability and recyclability goals. This remains a significant challenge for large scale implementation.

These gaps suggest that compliance with PPWR is not solely a technical or regulatory challenge but a systemic transformation issue that spans technological innovation, organisational culture, and collaborative governance.

Future research and strategic directions
To address these challenges, future research and strategic focus should prioritise the understanding of PPWR and the implementation within the organisation. Understanding what dynamic capabilities should be embedded within Unilever's operations and look into technological innovation pathways while improving design strategies for easier recyclability and dismantling. Establishing a model for multi-stakeholder collaboration to align goals, roles and responsibilities could also be of impact. Ultimately, the transition towards PPWR requires a holistic integration of technical, organisational and strategic transformation. Future research can further investigate these interconnected layers to enable a meaningful progress towards sustainable packaging goals.

3.10 Theoretical framework

From the literature review, a theoretical framework can be proposed that visualises the different factors involved in the creation of PPWR proof packaging. Note that this framework focuses on the packaging scope outlined in chapter 1. The primary focus of the framework is based on Design for Recycling (DfR) principles, as outlined in the table in Appendix C. These principles emphasise critical aspects such as material selection (contamination), compatibility with recycling systems (sortability), and minimisation of contamination, all of which are important for achieving packaging recyclability. Additionally, the framework incorporates considerations like harmonised labelling, reduced packaging volume, and the inclusion of recycled content, which are directly linked to PPWR requirements.

As this framework is very general, in the following chapter three frameworks will be created for the three specific case-studies of Unilever product packaging, keeping the theoretical framework in mind. The tailored framework will be tested and refined through further analysis in following chapters, providing actionable insights and validating the theoretical concepts. This iterative approach bridges the gap between theory and practice, offering a pathway to develop PPWR-compliant packaging solutions for Unilever.

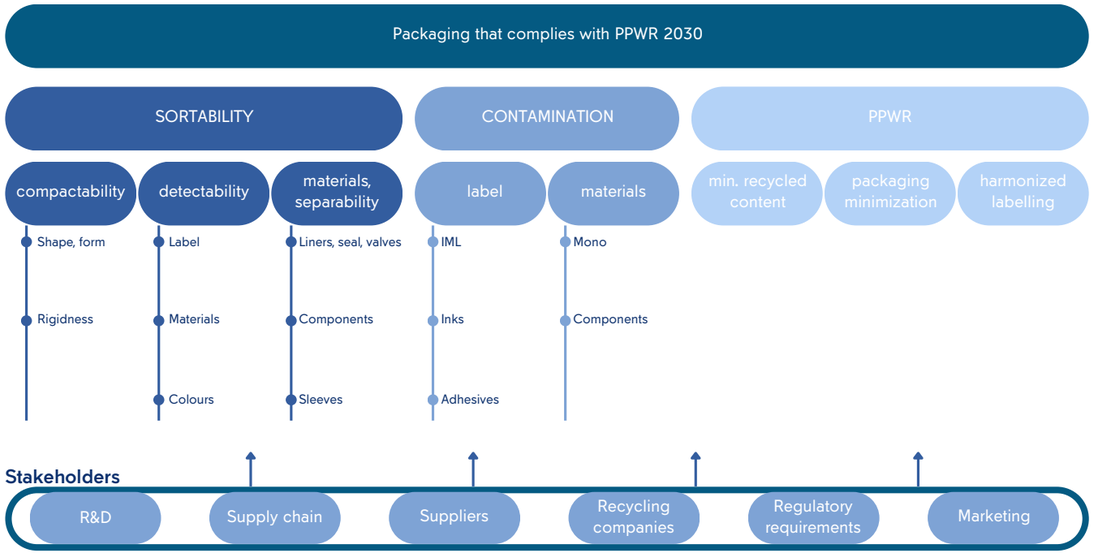


Figure 19: First theoretical framework of factors

Case study analysis

04

4. Case study analysis

To ensure alignment of the framework that was developed in the previous chapter with Unilever's product portfolio, three packaging categories were analysed. The analysis results in a more case-specific framework. The case-specific frameworks were validated through qualitative interviews in the next chapter to gain insights into stakeholder perspectives, influences and factors on packaging design. The insights from interviews with for example recycling experts that had an effect on the frameworks, were incorporated into this chapter to enhance the framework's relevance and applicability and avoid reading repetition.

4.1 Analysis process

To tailor the framework specifically to Unilever's packaging, three representative packages have been selected, each from a different category within the study's scope:

- Rigid packaging with in-mould label: Pot Noodle, Brown sauce and Aromat sprinkler
- Plastic pots with a carton sleeve: Asia Noodles
- Composite cans: Aromare

Figure 20: Packaging that will be analysed

These packages will be assessed according to the PPWR guidelines using different online tools. For the Pot Noodle, the Aromat sprinkler and the Asia Noodles, the RecyClass tool is used. This is an online platform that rates recyclability of plastics from A to F based on the Design for Recycling guidelines. RecyClass evaluations are regularly updated to reflect the latest recycling practices and regulatory standards [70]. The tool can also be challenged by companies like Unilever or suppliers to ensure better validity. To assess the composite cans, guidelines from 4evergreen [71], an alliance for fibre-based packaging, and CITEO [72], a tool for fibre-based packaging, have been acquired.

This analysis will provide insights into each package's current recyclability and identify quick adjustments that could improve their ratings, thus being important factors. These findings will guide the refinement of sustainable packaging strategies.

From this analysis, three individual frameworks can be developed for each package type and subsequently integrated into a comprehensive framework with strategic guidelines. In the next sections, each category will be explained shortly, along with the assessment and the resulting framework.

4.1.1 Rigid packaging with in-mould labels

In the figure below, the rigid-packaging with in-mould labels can be seen. These packages vary for example by colour, shape, label size, closure and weight.

Figure 21: Packaging that will be analysed

The first three packages of this category have been analysed with the RecyClass tool according to the plastics stream. These packages have been implemented in the framework, to see the alignment and the additional factors that should be taken into account. The specific frameworks for each packaging can be found in Appendix G. The separate frameworks were thereafter merged into one framework, which can be seen in the framework section below.

The most important factors influencing recyclability for this category were the use of in-mould labels, the use of aluminium seals, the rigidness and shape of the packaging and the use of dark colours. A thorough explanation is outlined in the framework section.

4.1.2 Plastic + carton sleeve

In the figure below the plastic-carton packaging can be seen. These packages vary from the previous section, due to their carton sleeve and thinner plastic tubs.

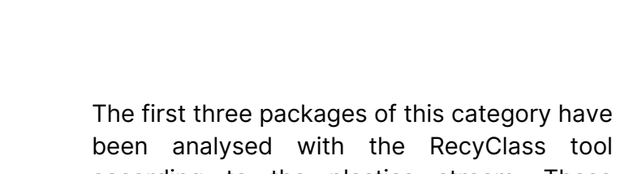


Figure 22: Packaging that will be analysed

The first packaging of this category was analysed with the RecyClass tool according to the plastics stream, as this is the base material of the product. This resulted in a framework aligning to the previous section. Therefore the separate frameworks were merged into one framework for plastics.

The most important factors influencing recyclability for this category were the use of aluminium seals, the glue (adhesive) to the carton sleeve, and the carton sleeve. One important consideration here is whether the carton sleeve can be seen loose from the plastic. There are instructions on the packaging on how to dispose of it, by removing the carton from the plastic. If this is done correctly by the consumer, then the paper will be sent to the paper recycling stream, resulting in better recyclability. The paper recycling framework will be handled in the composite cans section.

4.1.3 Framework for plastics

Figure 24 on the next page shows the framework for plastic packaging complying to expected PPWR based on the rigid packaging with in-mould labels and plastic-carton food packaging. This section will explain the framework.

To comply to the packaging and packaging waste regulations, there are three factors that influence PPWR compliance. Those factors are divided in sub-factors that influence the main factor, which are yet again divided in subfactors.

Sortability is a crucial factor for complying with the Packaging and Packaging Waste Regulation (PPWR), as it determines whether designed packaging can be correctly sorted into the appropriate recycling stream. This, in turn, affects whether the packaging will be recycled. Sortability is divided into three main factors: compactability, detectability, and materials and separability.

- Compactability: This refers to whether the packaging can be processed on a conveyor belt based on its shape or form and whether it can be compacted under mechanical pressure. Proper compactability ensures that the packaging can be directed to the correct recycling stream. Issues such as rolling or bouncing due to a round form on the belt can hinder this process. As this is still a quite uncertain factor, packaging should be tested to assure smooth compactability.
- Detectability: This factor determines whether the recycling machine can identify the material type and direct it to the appropriate stream for processing. Detectability can be influenced by the label on the packaging, the materials used, and the colors in the inks. Ideally, packaging should be made of a single material (mono-material). If multiple materials are necessary, they should not interfere with the detection of the main material. Components that are separated during mechanical processing or by consumers sorting them into the correct bin are preferable (materials and separability). A significant issue is the use of carbon blacks in inks, which can hinder Near-Infrared (NIR) detection. As a basic requirement, the main packaging body material and colour (white, transparent or coloured) should be detectable. White and transparent PCR is of a higher value than coloured PCR.
- Materials and Separability: This subfactor includes considerations for closures, components/composition, and sleeves. The primary requirement is that the main packaging body should be detectable and that different material types can be easily separated (at least under mechanical pressure). This ensures that the packaging can be efficiently processed and recycled. Collection and friction tests can be done with recyclers, to certify separability.

Contamination is another important factor for the recyclability of packaging, as the quality of the granulate after recycling is important for the marketability of post-consumer recycled content. The granulate should be as pure as possible and preferably white or transparent, as these colors are best for redesign. The contamination of plastic depends on the label design, inks, adhesives, laminates and the use of multiple materials in the packaging design. For labels, the subfactors are IML (In-Mold Labeling), inks, and adhesive:

- IML (In-Mold Labeling): Ideally, the label should be made of the same material as the main body of the packaging and be removable during the recycling process. Currently, IML labels are not removable, and the inks in these labels contaminate the recycled granulate, leading to colored granulate instead of the higher quality white or transparent granulate. The main requirement here is to separate the inks from the main packaging body.
- Inks: Inks should be non-bleeding to prevent contamination of the washing water in the recycling stream, which can color the granulates. They should also be EuPIA-compliant and not contain carbon black. The issue with carbon black, as explained previously, is that it is not detectable by NIR (Near-Infrared) machines, making it difficult to sort the product into the right recycling stream. While a small amount may not cause immediate harm, it can accumulate with each recycling cycle, eventually becoming a significant issue.
- Adhesives: Adhesives can contaminate the recycling stream by leaving residues and creating separation challenges. They should preferably be avoided, or otherwise be removable or water-soluble to minimize contamination.

Lastly, the use of different materials should not contaminate the granulate of the recycled content. For example, carton sleeves in plastic-carton packaging should not result in fiber loss. Ideally, the sleeve should be separable in the waste truck or before so that paper goes into the paper stream and plastic into the plastic stream. Therefore, designing for easy separability is recommended.

As a final factor, there are **general PPWR** (Packaging and Packaging Waste Regulation) guidelines that the design should adhere to. The scope of this research focuses more specifically on recyclability of packaging. Therefore, the main goal of the framework is

recyclability, however the additional PPWR regulations must not be forgotten. These are among others:

- Minimum PCR use: For food packaging, there is a requirement to use a minimum of 10% post-consumer recycled (PCR) content. This helps to ensure that recycled materials are being utilized effectively and supports the circular economy.
- Maximization of product-to-packaging ratio: The design should aim to maximize the ratio of product to packaging. This means using the least amount of packaging material necessary to protect and contain the product, thereby reducing waste.
- Harmonized labelling: Packaging should use harmonized labelling according to PPWR standards. This includes clear and consistent labels that help consumers correctly sort and recycle packaging materials. Proper labelling is important for improving recycling rates and ensuring that materials are processed correctly.

4.1.4 Composite cans

In the figure below the composite can packaging can be seen. These packages consist of a paper base, with an aluminium layer. The bottom of the current packaging is fully metal and the caps are made of plastic. Some packs can also contain a plastic sprinkler.

Figure 23: Packaging that will be analysed

As paper is recycled differently and has distinct requirements, composite cans cannot be analyzed through RecyClass. Instead, they are assessed using knowledge from 4evergreen and CITEO. 4evergreen is an organization dedicated to improving the circularity of fiber-based packaging through extensive research and the development of guidelines. CITEO, a French organization, provides tools like the TREE (Tool for Recyclability Evaluation of Eco-design) to assess the recyclability of packaging [71][72].

Most factors like sortability and contamination in the plastic recycling frameworks are compatible with those for paper recycling. In the next section a composite can framework can be found.

For paper recycling, the score of a sum of factors is important, where a low score in a factor can already be a direct knock-out. The sum of all factors should be above zero. The most important factors influencing recyclability for this category are:

- **Yield**: the amount of usable material recovered after recycling must be a minimum 80%.
- **Lamination**: paper should not be double sided laminated as the water needs to have an open surface to be able to take out the fibers
- **Visual impurities**: contaminants like inks, metals and adhesives that affect the appearance and quality of the recycled material should be as low as possible.
- **Level of sheet adhesion**: a low adhesion indicates bond strength, durability and functionality where a high adhesion can lead to production issues.

An overview of the score component breakdown for determining whether packaging is recyclable is provided by 4evergreen and can be found in Appendix H.

4.1.5 Framework for composite cans

In Figure 25, the framework for composite cans is visualized. It is important to ensure that the score component breakdown, as described in the previous section, remains

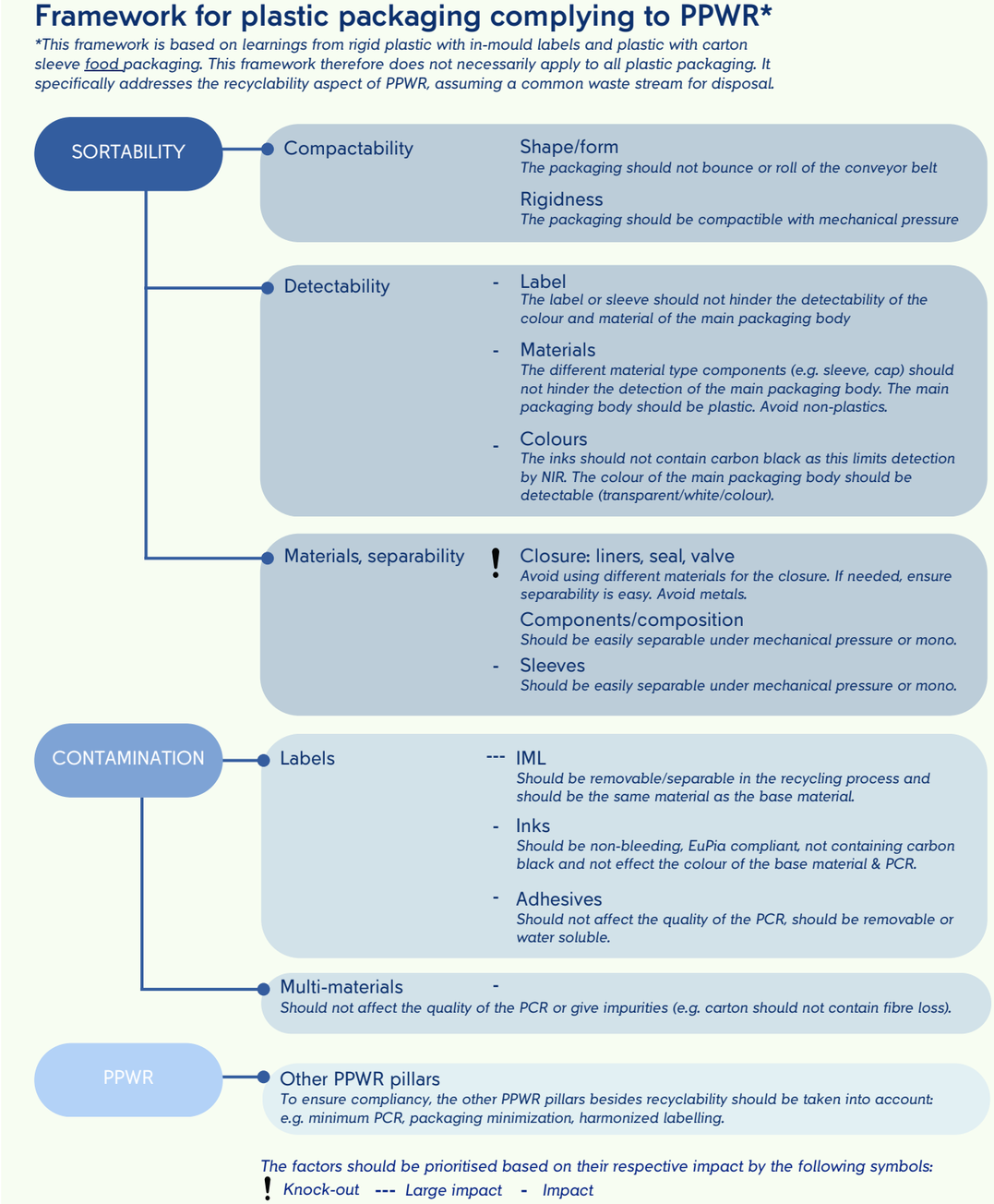
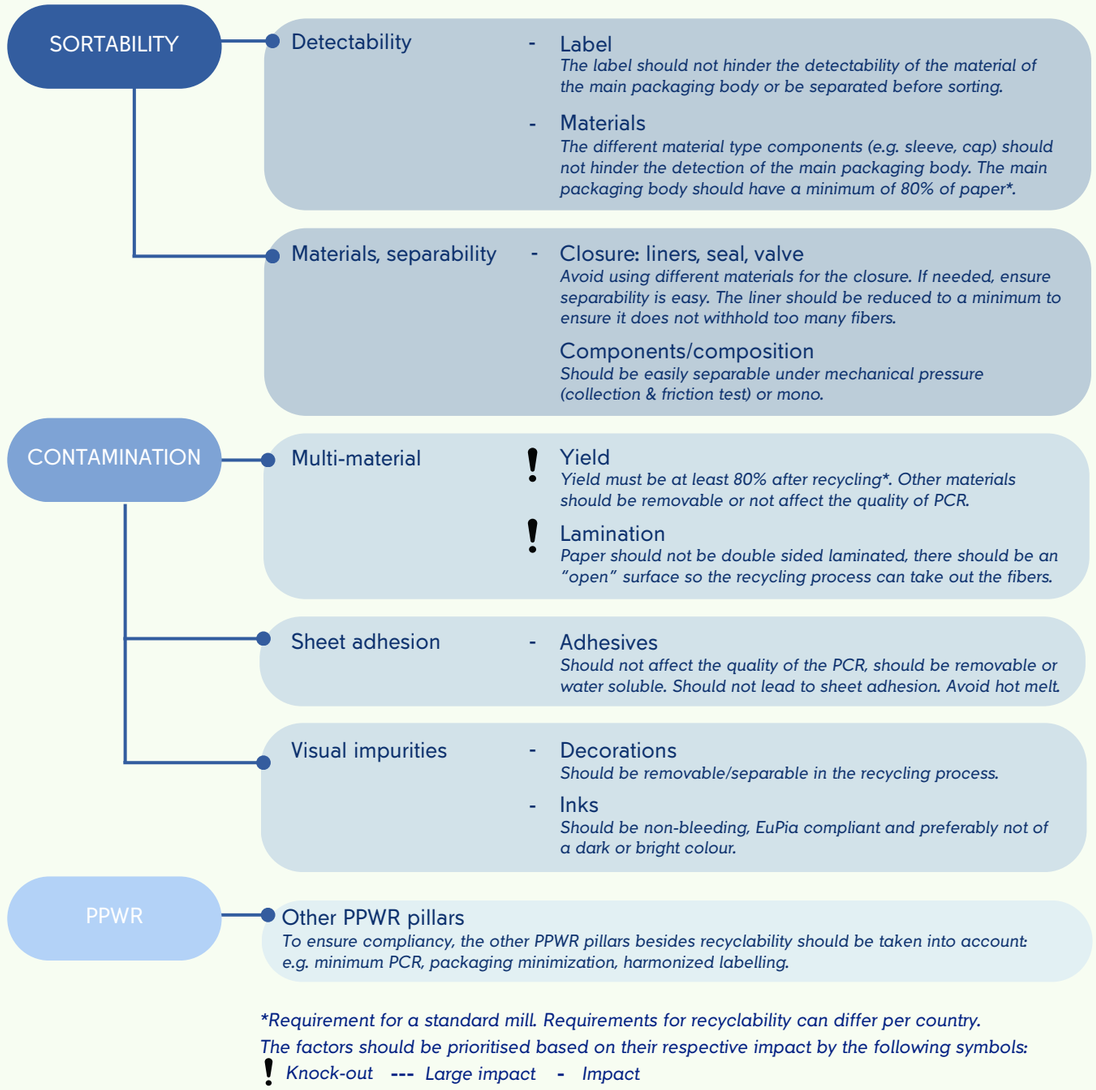


Figure 24: framework for plastic packaging

Framework for composite can packaging complying to PPWR*

***This framework is derived from insights gained from composite can food packaging and may not be applicable to all types of carton/composite packaging. It specifically addresses the recyclability aspect of PPWR, assuming a common waste stream for disposal.*



**Requirement for a standard mill. Requirements for recyclability can differ per country.*
The factors should be prioritised based on their respective impact by the following symbols:
! *Knock-out* --- *Large impact* - *Impact*

Figure 25: Framework for paper packaging

above zero. This can be achieved through rigorous validation testing to confirm that all factors meet the necessary standards for recyclability.

4.2 Conclusion

The analysis of various product packaging reveals that each case is unique in its recyclability improvements. This uniqueness arises from differences in shape, labels, materials, colors, components, closures, adhesives, and more. However, we can conclude that for each case, sortability, contamination (affecting residue quality), and general PPWR requirements are key factors to consider when enhancing packaging recyclability. It is crucial for each stream to understand why certain parts are not recyclable during redesign. For instance, while In-Mold Labels (IML) are generally recyclable, the inks used in IMLs currently contaminate wash water, resulting in impure residue. Therefore, either finding a way to sort IMLs separately from the base product or improving the inks used in IMLs can enhance packaging recyclability. This approach helps us thoroughly understand how to design for recycling.

Ensuring simplicity in design, focusing on mono-material solutions and ensuring components are easily separable during recycling processes, remains the most impactful path forward. Prioritising these principles will not only improve technical recyclability but also streamline processes across the recycling value chain, improving a step towards circular packaging systems. Validations like collection & friction tests can help certify that your multi-component packaging is separable.

Moving forward, the stakeholder interviews in the next chapter will dive deeper into these areas by capturing insights from those directly involved in design, supply chains, marketing, sustainability, and recycling. Their perspectives will help understand the most influential factors, to uncover remaining gaps, and identify opportunities for collaboration across the packaging lifecycle. This will guide the prioritisation of actions needed to bridge the gap between theoretical recyclability and real-world implementation.

This transition marks a shift from technical analysis to a more strategic understanding of influence, collaboration, and actionable change in sustainable packaging design.

Research methodology

05

5. research methodology

This study uses a qualitative research approach. The frameworks resulting from the literature review and the iteration from the case analysis are tested through qualitative interviews to gain insights into stakeholder perspectives, influences, and factors affecting packaging design. Together, these methods aim to support the development and validation of a framework for PPWR-compliant packaging, which will inform design recommendations for Unilever. In addition to addressing visible challenges and opportunities, the qualitative interviews also seek to uncover deeper, less obvious insights that have the potential to inspire more innovative solutions or directions for future developments in recyclable packaging design.

5.1 Methodology

A grounded qualitative interview approach was adopted, involving selected stakeholders engaged in the transition to PPWR-compliant packaging. Semi-structured interviews were employed due to their ability to balance structured guidance with the flexibility needed to explore deeper insights and richer responses. Ruslin et al. (2022) emphasise that this approach offers structure while remaining adaptable, facilitating tailored questions that address the unique perspectives of various stakeholders and packaging types (Ahlin, 2019).

To ensure a comprehensive understanding of the topic, the interviews were grounded in a critical literature review and informed by preliminary exploratory conversations. This approach aligns with Kallio et al. (2016), who highlight the importance of thorough preparatory work for enhancing the relevance and precision of stakeholder interactions. The case-specific analysis framework further supports a nuanced exploration of the research subject.

All interviews were recorded and analysed using a combination of selective and inductive coding methods based on the method described by Strauss and Corbin (1998). Selective coding was based on factors identified through literature research and case analysis, while inductive coding aimed to uncover emerging patterns and creative directions. The interview protocol included three standardised questions posed to all stakeholders, along with an additional 3-5 role-specific questions tailored to their expertise and concerns. The methodology structure was inspired by Simms and Trott (2014). The interview protocol can be found in Appendix F along with the consent form structure that was signed by all participants and the TU Delft HREC approval of the research set-up (Appendix D, E).

5.2 Pilot testing

The interview protocol underwent pilot testing with one expert and a fellow student to ensure clarity, flow, and comprehension. Based on feedback, adjustments were made to enhance the protocol. For instance, the introduction was revised to provide more context and specificity, redundant questions were removed, and certain questions were rephrased to gather more open-ended responses.

5.3 Sampling and stakeholders

Key stakeholders were identified based on the stakeholder analysis in Chapter 2.4 and through exploratory conversations. Six stakeholder types were selected for interviews, involving a total of 13 individuals. These stakeholders were contacted via email within the Unilever or TU Delft networks, provided with a brief explanation of the research, and invited to participate. All 13

agreed to the interview request. These are 8 internal stakeholders and 5 external stakeholders.

The stakeholder groups and their areas of expertise are as follows:

1. Sustainability experts (N=3), to gain insights into strategic sustainability initiatives, priorities and how they influence packaging design decisions.
2. Packaging designers or engineers (N=2), to gain insights on design challenges and technical aspects of creating PPWR-compliant packaging.
3. Supply chain professionals (N=2), to gain insights on logistical challenges, cost implications and operational feasibility of recyclable packaging solutions.
4. Suppliers (N=2), to gain insights on material innovation, manufacturing capabilities and technical constraints.
5. Recycling experts/waste managers (N=3), to provide clarity on recycling infrastructure and challenges with recycling packaging.
6. Marketing specialists (N=1), to provide insights on marketing strategy in relation to PPWR and marketing requirements for packaging.

This variety of stakeholders was chosen to capture a broad perspective on packaging development and its challenges across the supply chain. The diversity of expertise enables a holistic understanding of factors influencing PPWR-compliant packaging design.

5.4 Data collection & analysis

Data were collected using a semi-structured interview guide designed to probe stakeholder perspectives on PPWR compliant packaging development, the role of packaging design within the organisation, and the role of different stakeholders both internal and external. Interviews were recorded and transcribed immediately after completion and analysed using a content analysis procedure inspired by Miles and Huberman (1994).

The analytical process consisted of three phases:

1. Initial Coding: Transcripts were broken down into first-order codes, ranging from phrases to several sentences.
2. Category Development: First-order codes were grouped into emergent categories based on thematic similarities.
3. Theme Identification: Categories were synthesised into overarching themes, summarising core observations.

Preliminary results

06

6. Preliminary results

The purpose of this chapter is to present the findings from 13 stakeholder interviews, which were conducted to explore the key factors influencing PPWR-compliant packaging design. The interviews provided valuable insights into stakeholder roles, perspectives and challenges associated with the packaging development process. The findings will be used to validate the proposed framework and inform actionable design recommendations for Unilever.

The results are organised per stakeholder group and thematically, based on the coding process applied to the transcribed interviews. Each theme highlights critical influences, challenges, and opportunities related to packaging design as identified by the interviewees. This chapter also examines across the stakeholder groups, offering a holistic understanding of the complexities in achieving PPWR compliant packaging solutions.

6.1 Analysis of stakeholder groups

This section describes the insights from the analysis of the individual stakeholder groups.

6.1.1 Sustainability expert

Based on the analysis of the three interviewees, sustainability experts within Unilever can be seen as the knowledge holders. They address recyclability challenges and align sustainability efforts with the realities of recycling infrastructure. One stakeholder noted, *"Recyclability in theory means little if there is no infrastructure to support it"* (S2).

Collaboration across the value chain is essential, requiring partnerships in trade associations to guide improving recyclability of packaging material.

6.1.2 Packaging designer

Packaging designers play an important role in the development and validation of packaging solutions that balance technical feasibility with sustainability requirements. They work closely with suppliers, focusing on machinability, product requirements, and factory processes to ensure practical solutions.

Their expertise drives the search for new technologies to create sustainable solutions, in collaboration with suppliers and procurement. The increasing focus on sustainability, driven by innovation and legislative developments like PPWR, underscores the criticality of their role.

6.1.3 Supply chain & suppliers

The supply chain could be seen as the coordinator, working with multiple stakeholders. Stakeholders note it is important to try to align recyclability design changes with for example machine or line upgrades for efficiency.

Suppliers play a key role in bringing innovations that align with Unilever's strategies and requirements, particularly in recycling and sustainability. As one stakeholder (S8) stated, *"We need to balance the quality of our product with simplicity, efficiency and sustainability requirements."* Suppliers aim to design products that meet recycling needs while also ensuring they remain functional in the supply chain. For example, when designing a recyclable IML, the goal was to make it strong enough to survive the use phase but weak enough to detach during recycling. *"We looked at the recycling steps and saw grinding as an opportunity"* said one stakeholder (S8).

Suppliers often follow the customer's lead, as *another stakeholder (S9) mentioned, "Mainly we follow what the customer wants," particularly in areas like PCR use. Sometimes it can be difficult to maintain relationships: "It is difficult for us to keep contact with a large organisation... but we try to give information through webinars,"* shared a stakeholder (S8).

Overall, suppliers aim to stay aligned with customer specifications, ensuring their products meet regulatory standards while offering recyclable and lightweight solutions. Their ability to influence innovation can be limited by customer expectations and the actions of assigned suppliers.

6.1.4 Recycling expert/waste managers

The goal of this group, besides recycling, is to raise awareness within the industry about the impact of packaging design on recyclability outcomes. As one stakeholder (S10) noted, *"Our main purpose is to make plastics recyclable, and we want to give the tools to the industry to know what that is based on fact-based information"*. Their role is to advance knowledge in areas where recyclability is still unclear, offering insights into how current packaging performs in recycling processes and sharing this intelligence openly. *"We generate technical knowledge and share that openly with everyone"*, said another stakeholder (S10).

They also provide consultancy to companies, advising on how to launch packaging that meets recyclability standards and ensuring that recyclate is used effectively. As one stakeholder (S11) emphasised, *"If you do not have a market to sell your recyclate to, you will still have to burn it."* Their influence is significant, as they work directly with recyclers, packaging manufacturers, and brand owners, helping to identify challenges in packaging design and recommending improvements. *"We can give good advice on this,"* stated a stakeholder (S12), reflecting their expertise in sorting and recyclability tests. Ultimately, their aim is to provide the industry with the tools and knowledge needed to improve recycling processes and ensure that more materials are recyclable.

6.1.5 Marketing specialist

The focus of this team is to align strategy with consumer needs and gaps, using data to understand consumer behaviour and needs. They work closely with R&D to ensure technical feasibility balances with e.g. consumer expectations.

6.2 Thematic analysis of findings

Based on the various stakeholder perspectives and insights gained, several key themes emerge, shedding light on the challenges and opportunities within recyclable packaging design. The most important and commonly named were the following:

1. Factors for actual recyclability
2. Economic viability
3. Knowledge and need for certainty
4. Balancing challenges and trade-offs

These themes offer a holistic overview of the current packaging situation, highlighting both contradictions and challenges in moving towards more sustainable and recyclable packaging solutions, as well as areas for strategic design recommendations.

6.2.1 Factors for actual recyclability

A recurring theme that was identified is the challenge of actual recyclability. Under actual recyclability, the stakeholders highlighted recyclability at scale, design for recycling, sortability and quality. Ensuring economic viability for recyclers was another factor highlighted under this topic, however as this

has a broader application, it will be outlined in the next section.

One of the recurring themes under actual recyclability, was the challenge of making packaging recyclable at scale. With recycling at scale was meant designing with materials that are currently already broadly recycled in practice. As those recycling infrastructures have evolved, they can also be more efficient and cost-effective leading to possibly higher quality recyclates. In the end of course, the recyclates need to be economically attractive to buyers, which will be discussed further in the next section. The emergence of biobased plastics has interesting benefits for sustainability, however it makes it difficult for recyclers, as they will have to adapt their machines to it as highlighted by stakeholder (S11) *"We should always keep the current sorting installations in mind. Therefore, think about design and recycling at scale. This is sometimes difficult with new innovations like the biobased."* and by (S12) who recommends focusing on what current infrastructure and installations can do *"especially also looking at the recycling at scale requirements from the PPWR. I think it is good to get a better understanding of what materials are really collected and sorted everywhere and then focus on those ones rather than speculating."*. Other stakeholders also mention the importance to focus on what is currently possible when designing for recycling and not trust too much on future innovations.

With design for recycling, stakeholders mention the importance of not only designing to theory but also to practice. This means among others to validate whether packaging is actually recyclable, and the packaging behaves as designed in the recycling stream. Multiple stakeholders also mention the importance here of not relying on the customers in the design to sort the packaging, as every customer behaves differently *"Consumers are not aware or do not really have the motivation to separate waste. We need them to sort it correctly, otherwise it will not be recycled. So mechanical impact sorting itself might be better."* (S12). *"You cannot expect from the consumer to separate components. You will have to design it so it can get mechanically separated from the machines"* (S11). Therefore, it is important to take in account the different steps in the recycling stream. Multiple stakeholders highlight the opportunity here to design with for example the mechanical pressure in mind as done by S8: *"We looked at the recycling steps and saw mechanical impact as an opportunity"* (S8). *"We need to balance it being strong enough, but yet weak enough to come off during recycling"*. To design for recycling it is important to understand the recycling stream and to be connected to recyclers, as they can give you the knowledge to design correctly.

As mentioned before, sortability is one of the important factors for actual recyclability. If a packaging is not correctly sorted to the right stream, it can contaminate the stream that it is in, leading to lower PCR quality, and/or it will be incinerated. Therefore, with sortability, stakeholders highlight the importance of designing as much as possible with mono materials and to design with the sorting and detecting machine in mind. This means to not use carbon black inks as this cannot be detected and to look at how a label is designed. The label should not hide the base material if the base material is different compared to the label material and if the colour of the base material is white or transparent as these go in a separate sorting stream. However, if a label can be removed before the sorting step, then this is not an issue. *"If you can prove that during the collection and sorting of the packaging the cardboard sleeve is removed from the containers because of mechanical stress to which it is subjected then we can approve."* (S10).

Lastly, quality (contamination) is important for actual recyclability: *"We need to ensure that the packaging is well designed so they can obtain better quality and can be used for high quality applications"* (S10). This also ties in with the next section; economic viability. The goal of recycling is to provide new granulates to design packaging with. The higher the quality of this granulate, the higher the opportunities are for redesign and the more a buyer would pay for the material. For designing, in the case of plastics, white and transparent mono-packaging is worth the most, as this can be used for many purposes. Coloured plastic is worth less, as the recyclate will become a greyish colour. Therefore, it is important to ensure that the white and transparent packaging stays white and transparent in the recycling stream and is not contaminated with other materials and colours. One of the factors that is important to take into consideration here is the inks used for the label of the packaging. This can contaminate the wash water in the recycling stream and the colour of the material. Therefore inks should either be able to be removed from the packaging or to be for example water soluble in the case of plastics. Adhesives are another important factor that were mentioned often to avoid. When designing a product that needs different components, it is recommended to design something that can be easily separated as mentioned by S11: *"You should design it for recycling, so it keeps the highest quality of the base material. Always design it so that things can get removed. Otherwise, the application options are lower. "*.

6.2.2 Economic viability

Economic viability has different definitions for different stakeholders. For the recyclers, it is important that the PCR is of high quality to ensure good sellability. As mentioned previously, the white and transparent packaging should remain their colour quality whereas for coloured packaging: *"in the end the recycled granules will be dark greyish anyway. And the application for this is just like lower quality products or benches for example anyway"* (S12). To ensure a proper circular economy, some investments need to be made to help recyclers with upgrading their machines and quality, so the PCR quality is upgraded as well: *"We need people to invest to also see the return on investment and make a circular economy out of it"* (S8).

For all FMCG companies, it is important to maintain economic growth, especially when they have shareholders to consider. This means balancing the additional costs of sustainability with savings on other ends. Here, it is also important to consider the payback time of an investment. Additional costs come for example from more expensive materials, new equipment, or advanced technologies. Savings can come from increased efficiency, simplifications, reduced material usage and lower EPR fees. It is important to consider these saving opportunities when preparing a business case for a more recyclable packaging to be convincing. Multiple stakeholders mention to search for win-win situations. For example, by tackling more 'issues' at once than just an improvement on recyclability: *"We should integrate benefits for both supply chain and sustainability to increase the value of the project for example through more efficiency."* (S7).

Taking consumers into account is a priority. Currently, within the FMCG section, sustainability is not a big consumer purchase driver as food products often remain value driven. Therefore, it is important to design something that leads to the same or a better consumer experience. Furthermore, for most FMCG products, the purchase decision is made in store: *"So we often need to try to bring consumers to that shelf or to get the product out of the shelf"* (S13). The use of artworks on labels and the characteristic

shapes of products are therefore key to attract consumers according to marketing insights.

6.2.3 Knowledge and need for certainty

One insight that came through multiple stakeholders is the need for knowledge and certainty. With knowledge, uncertainty about the PPWR regulations is meant, but also the knowledge about design for recyclability and specifications from suppliers. Partnering with the industry is needed to gather knowledge from recyclers, designers, suppliers and other stakeholders to also ensure actual circular design. Furthermore, internal communication and knowledge-sharing remains of crucial importance, to ensure alignment of different roles. Furthermore, stakeholders within the R&D team mention that sharing knowledge and learnings within their team and cross functionally works well. Having a sustainability 'expert' in the team is also seen as a benefit. As mentioned previously, it is important to not assume that consumers know how to sort packaging. Multiple stakeholders mention that consumers should become more aware by communication about certain changes. For example, in the case of PCR usage but also for disposing a product in the right container. This will also make them more aware of sustainability.

As the official packaging and packaging waste regulations will be uncertain until 2028, it is a large challenge for many companies. As multiple stakeholders mention that it takes time to validate new designs on technical feasibility, consumer usability and actual recyclability, the R&D team already has to start designing now to ensure they are ready for 2030. However, this takes some investments, which are not sure about the future consequences and are therefore difficult to continue with. *"The urgency should become clear which is difficult, because we do not know the direct impact and there is no official legislation"* (S3). Furthermore, FMCG companies are in a very competitive environment, making it a strategic decision to invest or not to invest.

6.2.4 Balancing other challenges and trade-offs

As mentioned before, there is a value-driven need to balance on-cost with savings. Designing with a win-win situation in mind will lead to a better business case. In the following, some other challenges, contradictions and trade-offs will be presented.

Stakeholders mentioned multiple requirements that must be taken into account when redesigning packaging. One of the most important requirements was the assurance of food safety. Not only for keeping the product safe in the packaging from bacteria and moisture, but also with consumer usability. When taking the Pot Noodle for example: *"We use hot boiling water in pot noodle for example and that can be very dangerous, a sleeve here is very important"* (S4). When minimising material therefore, it remains important to think about barrier properties and other risk minimisation factors.

In general, legislation is an important requirement to keep in mind. PPWR is an obvious legislation, as not adhering means that your product cannot be sold. Other legislation is for example the regulation to list each ingredient in the local language as text on packaging. This means for marketing that there is a minimum amount of label needed, which is a challenge with the maximum percentage of label on a product in mind according to PPWR and Recyclass.

A challenge for packaging designers is balancing the actual recyclability requirements with functionality, consumer usability, technical feasibility and costs while maintaining consumer experience. This means a lot of validation and therefore also a lot of time needed to develop and validate PPWR-proof packaging. The uncertainty of legislation again makes it difficult to invest in validations and trials.

Another challenge is to keep alignment across functions within a large company. As mentioned previously, tackling multiple win-win issues at once gives a stronger business case.

Implementing PPWR-compliant design changes involves navigating complexities such as cost, time, consumer perceptions, and technical feasibility. Significant financial investments and delays arise from adapting machinery and validating new designs. Consumer expectations for usability and aesthetics can further complicate compliance, with another stakeholder stating, *"You cannot sacrifice the consumer experience entirely to achieve sustainability"* (S3). Additionally, technical challenges, such as ensuring technical feasibility while aligning with recycling infrastructure, outline the balance required to meet regulatory and practical demands.

Lastly, having the right timing is another challenge. This entails the right moment to launch the better recyclable product, the right moment to invest in for example new suppliers and the right timings to invest in a certain technology. As new innovations like watermarks, chemical recycling, intelligent sorting and AI feel around the corner, we cannot yet rely on them being ready by 2030. Therefore, it is difficult to know the payback time of an investment, thus being risky for a company. Cross value chain initiatives are needed to improve the circular economy and therefore should be done by multiple companies. However, the risk can be a trade-off.

6.3 Conclusion

The analysis of the stakeholder interviews highlights the complexities and trade-offs that are associated with designing recyclable packaging within the framework of existing infrastructure, emerging innovations and evolving legislation. The key themes: factors for actual recyclability, economic viability, knowledge and the need for certainty and balancing challenges and trade-offs, provide an understanding of stakeholder perspectives and actionable insights. The themes highlight the importance of a strategic and collaborative approach to drive recyclable solutions while balancing functionality, feasibility, consumer experience and economic considerations.

6.3.1 Connecting the analysis and insights to the framework

The PPWR-compliant packaging framework, that was developed in the previous chapter, provides a structured approach to addressing key factors influencing recyclability: sortability, contamination and quality management, mono-material use, and adherence to regulatory standards. These pillars align well with stakeholder insights on the importance of designing for existing infrastructure, for quality PCR and for good detection and sorting.

However, the analysis reveals challenges that could strengthen the framework's application, while also adding complexity. For instance, the framework's focus on mono-materials and harmonisation can conflict with the need to balance functionality and consumer appeal, which is currently not integrated within the framework. Additionally, incorporating the role of stakeholders more explicitly in this framework could further strengthen it and provide a more comprehensive approach to design decisions.

Given the complexity of incorporating all

relevant factors and stakeholders into a framework for circularity and PPWR compliance, it may be interesting to simplify the understanding of the ecosystem for stakeholders in the design phase. This could help balance the details of the framework with a more accessible approach for practical implementation. Furthermore, understanding the complexity of PPWR design implications can be a guidance towards designers and stakeholders for decision making. Complexity drivers, as named by stakeholders, can vary from cost, time, consumer perceptions and technical feasibility.

6.4 Design recommendations

Based on the analysis, several other recommendations emerged:

Aligning with current infrastructure and prioritising scalability

Designers should focus on developing packaging solutions that are compatible with existing recycling infrastructures to ensure practical recyclability. This includes favouring mono-materials and avoiding design choices that compromise sortability or detectability, such as the use of carbon black inks. Collaborating with recyclers during the design phase can foster alignment with current recycling capabilities and ensure packaging performs effectively in real-world scenarios. Given the variability in sorting and recycling systems and inconsistent consumer sorting behaviours, it is crucial to design with the worst-case scenario in mind. Packaging that is recyclable in advanced systems but fails in less developed ones risks not being accepted by PPWR.

Bridging knowledge gaps across the value chain

Another area for recommendation is to focus on improving knowledge gaps on regulations like PPWR, material specifications and recycling expertise. For example, cross-functional training and communication channels could be organised to bridge the knowledge gaps in collaboration with industry partners, suppliers and recyclers. Engaging in cross value-chain initiatives can lead to interesting learnings and can also accelerate innovations that can advance the circular economy.

Developing a comprehensive understanding of recycling streams

A comprehensive understanding of how the different recycling streams work (e.g. plastic vs paper and uniform vs separate bins), should be a key priority for packaging designers. By mapping the entire recycling process, designers can tailor their solutions to meet specific requirements effectively. A notable example is S8, whose company developed an in-mould label (IML) that not only meets recyclability standards but also remains intact throughout the product's use phase. Such examples highlight the value of combining technical expertise with practical application.

Enhancing project setups for integrated recycling goals

Stakeholders observed that improving communication during project initiation could help better align business objectives with sustainability goals, leading to more successful outcomes. A recommendation is to integrate recyclability considerations into broader business processes. For instance, when upgrading machinery or introducing new materials, designers could test recycled content alongside other business objectives. By aligning sustainability goals with operational priorities, organisations can create win-win scenarios that strengthen business cases.

Simplification and standardisation of packaging

Lastly and more generally, as mentioned before, designers should prioritise mono materials and minimise packaging components. Recyclers mentioned a need for standardisation of packaging to improve the recycling process. This might be interesting to look into, also taking into account the future potential of reusable packaging and modularity.

Design phase
07

7. Design phase

This chapter marks the beginning of the design phase of this project. It outlines the primary method, namely the double diamond, along with other methods used throughout the process. The methods that were used, provided a framework to navigate from identifying and understanding the problem to implementing validated solutions. This chapter aims to clarify the design process and its underlying principles. It is written in a summarized form, therefore an additional detailed thought process with the different outcomes is outlined in Appendix I.

7.1 Double diamond

To guide the design process, the double diamond method was chosen, which can be seen in Figure 26 below (Kochanowska et al., 2021). This method is effective as it emphasizes both the problem space and the solution space, ensuring a balanced approach to design. Given the complexity of this project and the outcome of the qualitative analysis, it is good to look more extensively into the problem space and define a more specific problem to design for. The double diamond framework consists of four distinct phases: Discover, Define, Develop, and Deliver. Each phase plays an important role in systematically addressing the design challenge. By following this methodology, the design process is both comprehensive and systematic, ensuring that the final solution is well-informed and effective. The figure below shows an illustration of the double diamond process, which will be used throughout this chapter. In the following sections each phase is detailed. This chapter builds upon the findings in earlier sections, integrating them into a cohesive design process. The next pages visualise the design process.

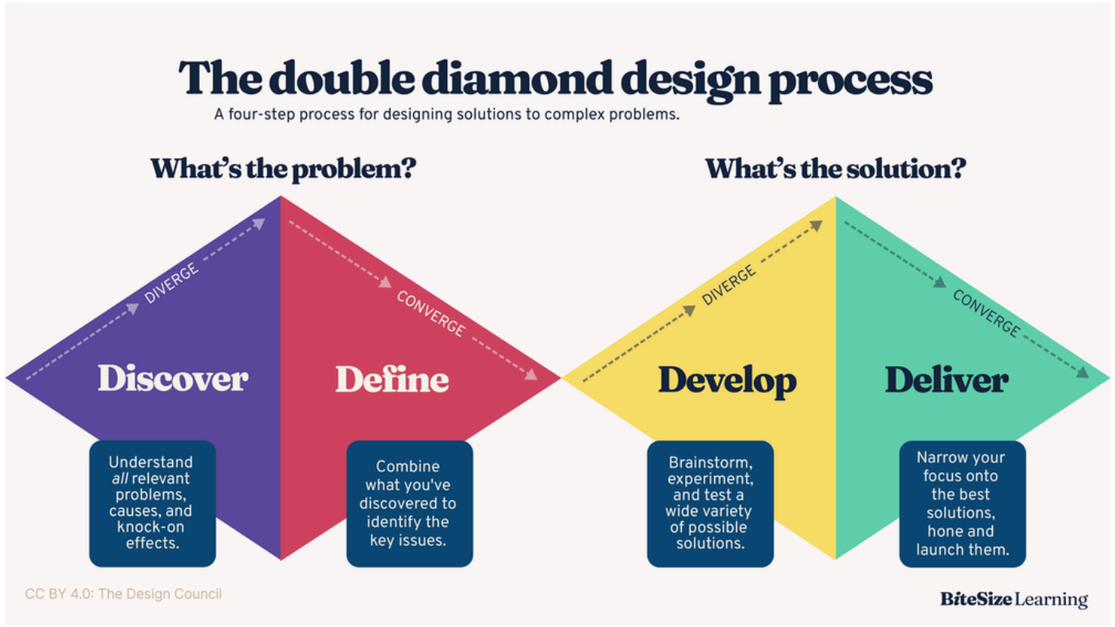
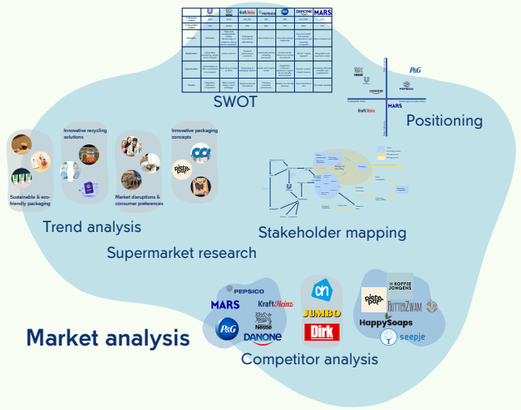
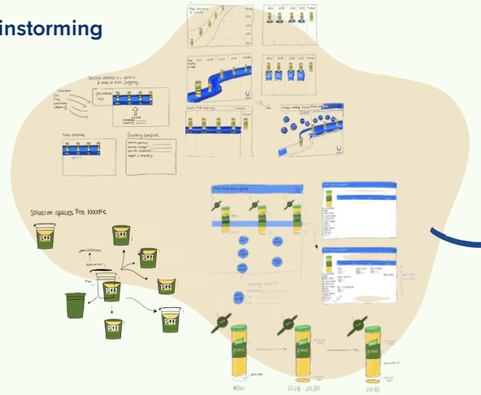
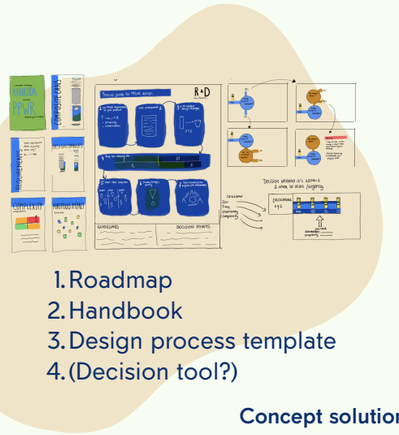


Figure 26: Double diamond process (Parsons, 2024)



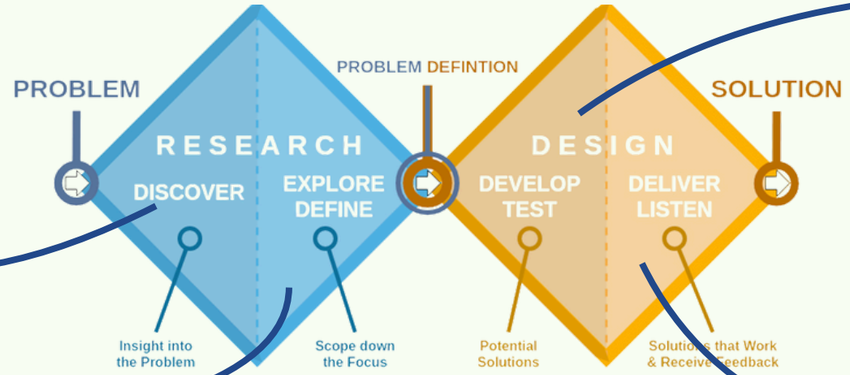
Literature research





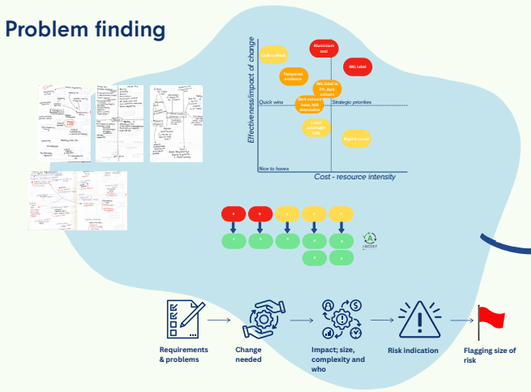
Concept solutions

01. DISCOVER



03. DEVELOP

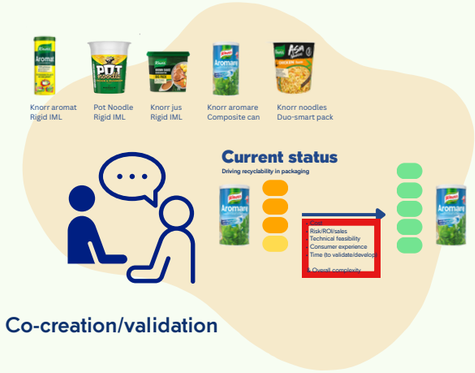
02. DEFINE



How can we effectively **visualize** all **gathered insights**, ensuring that key trends, challenges, opportunities, and strategic priorities are clearly communicated and easily accessible for **informed decision-making?**

How can we make the gathered insights **actionable and user-friendly** for R&D designers, enabling them to navigate complexities, make informed decisions, and implement effective solutions?

Defining



Co-creation/validation

04. DELIVER

Finalizing & validation

Visual representation of the design process

7.1.1 Discover

The first phase of the double diamond model involves an extensive exploration of the problem space, characterized by divergent thinking aimed at gathering a wide range of insights and information. Various research methods, including user interviews, observations, and literature reviews, were employed to understand the context and identify underlying issues. This data collection has been conducted in the previous chapters.
The market analysis underscored the importance of staying relevant to trends and highlighted the potential to focus more on technology-driven innovation. The literature review provided a foundational understanding of the problem space, emphasizing current uncertainties and developments in sustainability, and the need for change. It also highlighted the necessity for dynamic capabilities and flexibility for companies in transitional phases, as well as the challenges of recycling at scale. The case-specific analysis offered practical examples and pinpointed specific pain points related to the PPWR requirements. Additionally, the qualitative interviews provided insights into the broader challenges of transitioning to a circular industry for example on uncertainty, knowledge gaps and economic viability. These combined insights form a basis for the subsequent phases of the double diamond process.

7.1.2 Define

Building on the insights gathered during the Discover phase, the Define phase focuses on synthesizing this information to identify the core problem to set a clear direction for the design process. The insights from the Discover phase are important in shaping a well-defined problem statement.

A problem map was created to identify the different problems and the interconnections between the different issues (see Figure 27 to the right). This revealed the complexity of addressing isolated problems and highlighted the need for a holistic approach to achieve impactful solutions. A set of desired outcomes and goals was defined, including recyclability compliance objectives, which proposed a visual roadmap as a solution to synthesize and prioritise these goals. However a direct link towards the practical case-analysis was missing here and was also necessary to ensure actionable outcomes.

To bridge this gap, a PPWR-specific problem map was developed, drawing from the established frameworks and analysed packaging categories. A step-wise problem analysis was conducted (see Figure 28), mapping out PPWR requirements, their associated packaging challenges, and necessary design changes. These changes were evaluated based on impact, scale, stakeholder involvement, and risks. A cost/resource intensity vs. recyclability impact matrix (similar to a cost-effectiveness analysis) was then used to prioritise solutions. This approach flagged high-risk areas, quick fixes, and "nice-to-haves," ensuring that strategic priorities were clearly defined. The resulting problems and solutions were categorised into short-, mid-, and long-term actions, guiding the roadmap development. A more detailed breakdown is provided in the confidential appendix.

Identifying a single core problem proved challenging, as the issue stems from multiple interconnected challenges. However, the overarching problem can be defined as:

The difficulty in decision-making due to the complexities of design changes, incomplete information/specifications, and the absence of a structured process to design, assess and prove the recyclability of packaging.

As a result, the following problem scopes were identified, focusing on the visualization of insights and practical application for R&D designers respectively

- How can we effectively visualize all gathered insights, ensuring that key trends, challenges, opportunities, and strategic priorities are clearly communicated and easily accessible for informed decision-making?
- How can we make the gathered insights actionable and user-friendly for R&D designers, enabling them to navigate complexities, make informed decisions, and implement effective solutions?

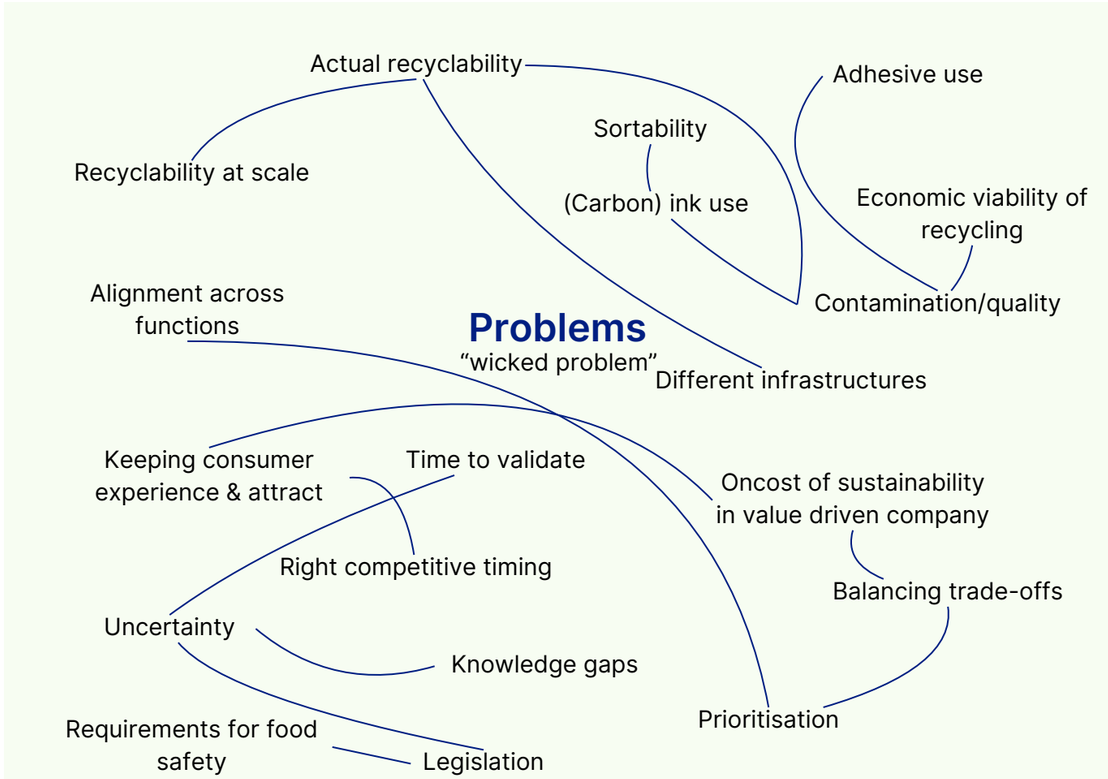


Figure 27: Problem map with many links showing the complexity of the situation

Figure 28: Step-wise analysis (see confidentiality appendix for implemented steps)

7.1.3 Develop

Once the problem was clearly defined, the Develop phase began. This phase reintroduced divergent thinking, generating a wide range of potential solutions. Over two weeks, two brainstorming sessions were conducted with a peer student using techniques such as mind mapping, brainwriting, and role storming. These sessions led to multiple concept ideas, which were further refined and tested in the final phase. Since the problem scope was divided into two areas, the following sections outline the development process for “visualisation of insights” and “practical applications for R&D” separately.

7.1.3.1 Visualisation of insights

In the define phase, the need of short-, mid- and long-term mapping was noted. As the PPWR (Packaging and Packaging Waste Regulation) has a timeline for implementation and my insights from this project cover a broad range, a strategic roadmap along with a tactical roadmap was developed to outline all the learnings and strategic choices related to PPWR. This roadmap will serve as a comprehensive guide, detailing the steps and decisions made throughout the project, and will help in aligning the project outcomes with the regulatory requirements and strategic goals.

The roadmap was created using the method developed by Lianne Simonse (Simonse, 2024), which is known for its structured approach to strategic planning and innovation management. This method involved several key steps, which can bee seen in Figure 29 to the right.

By following Lianne Simonse's method, the strategic and tactical roadmaps not only capture all the learnings and strategic choices made during the project but also provide a clear and actionable plan for moving forward.

This approach ensures that the project is well-structured, strategically sound, and aligned with the regulatory timeline and objectives. Iterations on the roadmapping can be found in Appendix I.

01 Mapping insights

Key trends, challenges and opportunities

02 Strategic prioritization

Balancing short- and long-term goals while considering cost-effectiveness

03 Roadmap development

Outlining the key milestones and timelines required to achieve the project objectives

04 Stakeholder engagement

Input helped refine the strategic choices and ensure that the roadmap is aligned with the needs and expectations

05 Implementation and monitoring

Regular monitoring and evaluation will be recommended to track progress, make adjustments as needed, and ensure that the project stays on course

Figure 29: Roadmapping method

7.1.3.2 Practical applications for R&D

To translate insights into actionable design solutions, various methods of visual representation were explored. Three primary formats emerged as the most effective:

1. Designer’s handbook: documents requirements, design changes, problem mappings, strategic priorities, and scalability per case. It provides designers with a structured understanding of recycling guidelines.
2. Interactive decision tree: guides designers through decision-making by mapping complexities and priorities. This tool would lay the foundation for a potential AI-driven decision-making system.
3. Designer process template: outlines the step-by-step process used in this project, enabling future designers to replicate the methodology. It includes structured guidelines and examples to ensure consistency and effectiveness.

These formats were developed through iterative brainstorming and could also be integrated as complementary tools. Initial visual drafts can be found in Figure 30.

To guide the practical application the following design goal was created:

“To create a design that guides packaging designers in the PPWR transition by facilitating design process and decision-making, while highlighting complexities and the influence of different stakeholders.”

The design should include the following four pillars:

1. Facilitate decision-making: provide clarity in navigating PPWR compliant design changes.
2. Provide a structured pathway for designers: ensure designers follow a consistent and effective process.
3. Engage stakeholders holistically: integrate multi-stakeholder perspectives in decision-making.
4. Lay a scalable foundation for other packaging types

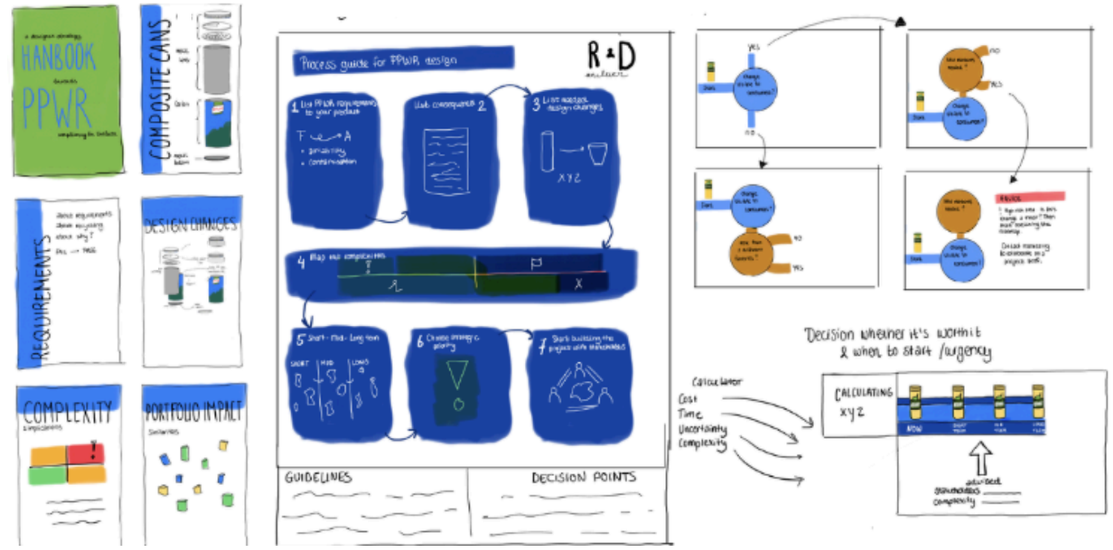


Figure 30: handbook, process guide and decision tree drafts

7.1.4 Deliver

The final phase, Deliver, focused on testing and refining the solutions developed in the previous phase through an open (co-creation/validation) session and a second “final” validation session. This phase involved convergent thinking, where concepts are created and tested to evaluate their effectiveness.

7.1.4.1 Open session

The objective of the co-creation/validation session was to create a more concrete practical application of the design and to get more insights into the complexities associated with certain design changes. Co-creation was intentionally not performed in the Develop phase, as idea generation was too broad and needed to be narrowed down to practical, hands-on solutions.

Participants

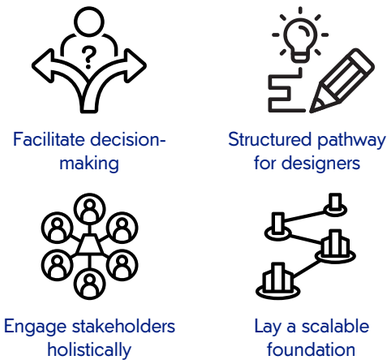
The session involved four participants: two packaging designers, one marketing expert, and one supply chain professional. These participants were selected to provide a comprehensive perspective from key stakeholders in the design process. The sessions lasted 30 minutes for marketing and supply chain, and 40-50 minutes for the packaging designers, as additional focus was placed on the practical design format for them.

Format

Initially, the session format involved presenting specific design changes and asking participants to rate them on a scale of 1-7 in terms of complexity. However, during the first session, it became clear that the ratings could not be grounded well enough, and participants struggled to assess changes they had not previously implemented. Additionally, rating all design changes across multiple factors was very time-consuming. As a result, the format was adjusted to an open discussion about the complexity drivers for each design change, laying the groundwork for a deeper understanding of the key drivers, which could be explored further in a future project.

Session structure

A brief introduction of myself and my research was provided, along with an explanation of the purpose of the session. The goal of the session was twofold. First to gather input on complexity, based on the variables cost, technical feasibility, consumer experience and time. Second, to get input on the best format for the practical design solution along with other requirements and wishes. Therefore the session was split into two parts. The goal of the design concept was also outlined, building on 4 factors:



Part 1: complexity drivers

In the first part, five product packs were presented individually (see example Figure 31), highlighting their current non-compliant components and potential design changes. Key design changes were introduced, with variables such as technical feasibility, cost, time, and consumer perception being examined. The main question posed to the participants was: *“To move from a non recyclable score to a recyclable score, what design change decisions are necessary? What complexities arise from these decisions?”*. Participants were asked a series of open-ended questions to initiate discussion:

- What impact does this design change have on X? (e.g. X = cost involved, X = consumer perception change)
- What is the driver behind this impact on X?
- What other factors should be taken into account when implementing this design change?

For marketing, the questions focused more on consumer perception. For the supply chain, the focus was on time and cost, and for the packaging designers, it centred around technical feasibility. However, participants were occasionally asked to consider all factors to ensure a comprehensive view.

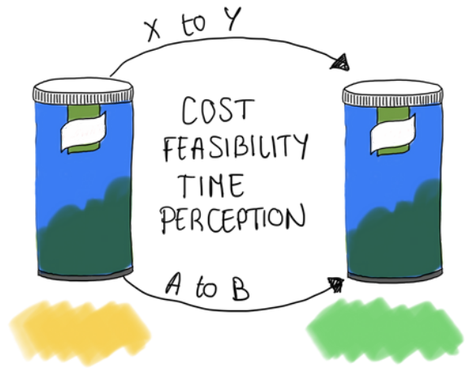


Figure 31: design changes & complexity

Part 2: practical design format

In the second part concept solutions were presented to clarify the approach and stimulate ideas. Participants were asked to evaluate the practicality of different formats and provide feedback on what elements should be included to ensure usability. Key questions included:

- What format would be most practical to use for this design?
- What information should be included in the format?
- Do you have any additional wishes or requirements to improve usability?

Results part 1: complexity drivers

Each discussion was analysed into themes that were emerging, high, low and medium risk areas and other complexity drivers. After all sessions, there were 7 complexity drivers standing out, which should be taken into account when doing design changes. Understanding the drivers and integrating them into the design process early can help accelerate decision-making and improve collaboration across stakeholders. This section outlines some complexity drivers and provides decision points to guide designers through the challenges.

Existing solutions

The availability of pre-existing solutions significantly affects complexity. If a solution already exists, such as a PP seal replacing an aluminium seal, implementation is far easier. If the required solution is new or untested, the process becomes highly complex and resource-intensive.

Decision point: investigate whether suppliers or competitors offer proven solutions that can be adapted to your design. Collaborate with suppliers to leverage their existing innovations.

Supplier capabilities

The ease of implementation is often related to supplier readiness. If the supplier already has the capability to produce the desired change, complexity is reduced. Engaging suppliers without the required technology or expertise increases lead times and costs.

Decision point: assess supplier readiness and engage with those who can deliver proven, scalable solutions.

Equipment updating

The adaptability of existing manufacturing lines plays a critical role in complexity. If a line already requires upgrades, incorporating design changes becomes less disruptive. However, introducing materials that are incompatible with current machines gives

challenges.

Decision point: evaluate whether the machine or line needs updating in the near future to reduce cost to test your innovations.

In-house vs. outsourced production
The location of production impacts complexity. Changes are often easier and less costly to implement in in-house facilities. Outsourced production, especially involving multiple suppliers, adds layers of coordination, cost and variability.

Decision point: prioritise testing and scaling innovations in in-house facilities before rolling them out to outsourced suppliers.

Scale of implementation
Packaging redesigns for larger volumes present unique challenges compared to smaller runs. Smaller volumes can often adopt the designs of larger players or learn from early adopters. For larger volumes, implementing changes across multiple suppliers and plants introduces logistical complexity.

Decision point: see if it is feasible to pilot the design change at a single facility and at a lower scale. Assess the difficulty of implementing this in the other plants with other lines.

Impact on look and feel
Significant visual or tactile changes to packaging can complicate the redesign process. Large changes may require some transitional packaging formats or a great marketing story to preserve brand trust with consumers.

Decision point: consider introducing intermediate design formats and develop a compelling story to explain the changes to consumers.

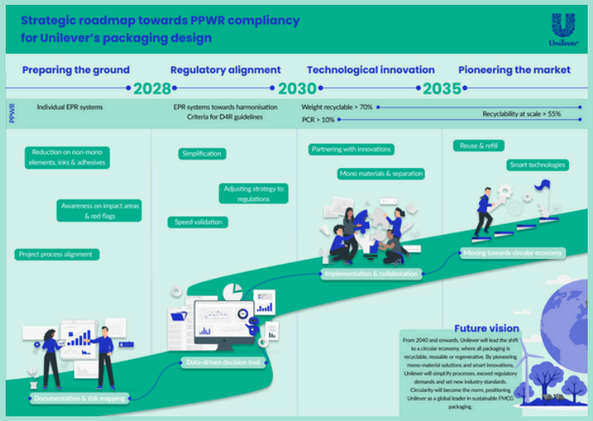
Shelf life
Design changes that affect the shelf life of a product are particularly complex, as they impact product quality and supply chain processes. Materials that compromise barrier properties may require longer testing and development.

Decision point: often a change in shelf life is not feasible. Therefore test in an early phase whether the packaging design change will have an impact on this.

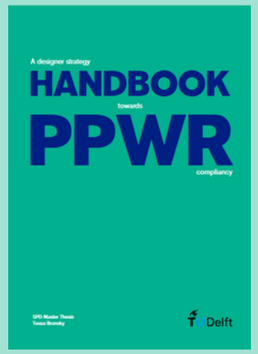
Results part 2: Format requirements and wishes
Based on the discussions, the following list of requirements and wishes could be built for the format:

- The practical design should serve as a quick reference or reminder
- It should be easy to use, read, and understand at a glance
- A complementary more detailed version could be created for those who wish to explore further.
- The practical design should be concise and direct, similar to a checklist
- If feasible, the practical design should be physically visible, allowing for easy reference in the workspace.
- It should be scalable, so it can be applied to a variety of packaging types.

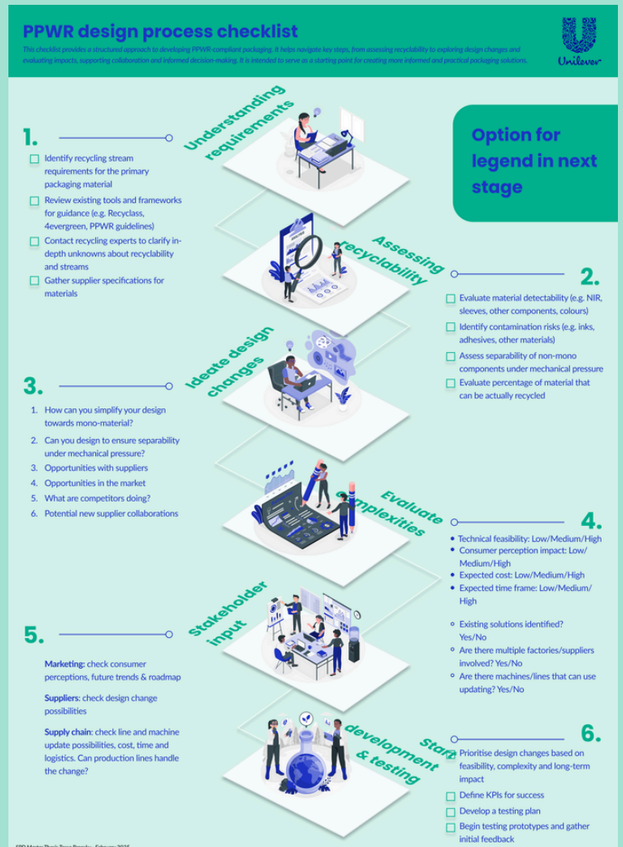
Based on the insights from this session, a designer process template was selected and further refined as the primary practical design tool. To provide deeper understanding, a complementary handbook was developed, alongside a strategic and tactical roadmap to outline the broader vision. The intermediate designs, illustrated in Figure 32, were the base for validation, which is outlined in the next chapter.



Strategic roadmap



Handbook



Design process tool

Tactical roadmap

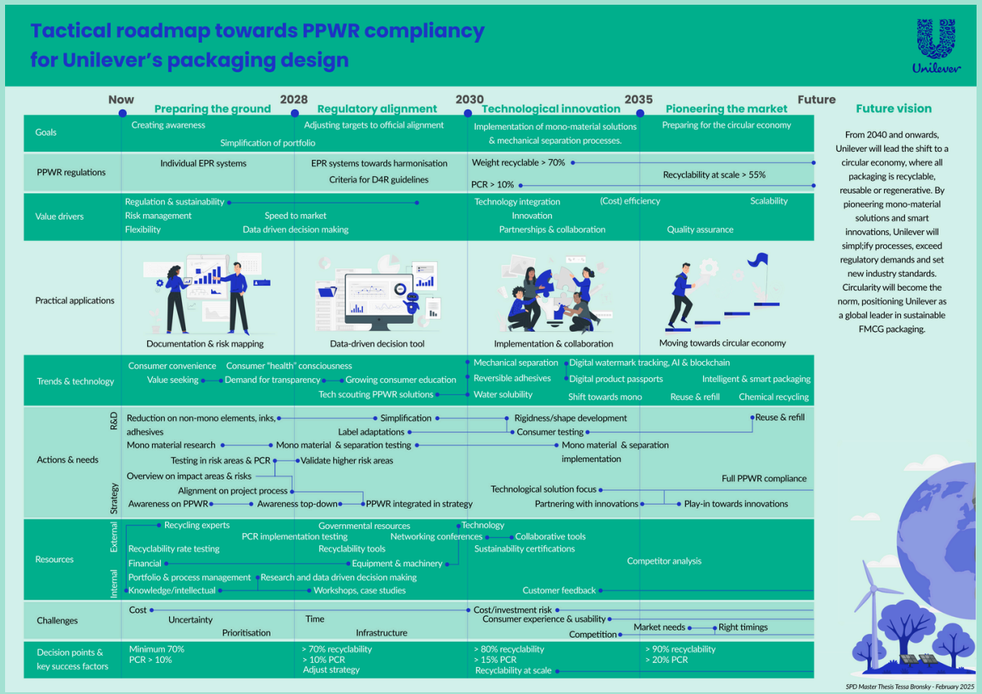


Figure 32: In-between designs

Validation of designs

08

8. Validation of designs

To ensure that the designs are both usable and understandable for the R&D team, a final validation session was performed on the design concepts. The objective of this validation session was to validate the clarity, practicality and areas for improvement of the design process template by gathering feedback from the R&D team. While the primary focus was on the design process template, the complementary handbook and roadmaps were also mentioned, and a few questions were asked about them.

8.1 Session structure

Participants

Nine R&D team members from various roles took part in the session. The design process template, along with the handbook and roadmaps, is specifically designed for the R&D team and will be used by them. Therefore, only R&D members are included in this session. The participants exist of six R&D members from the allocated internship team, one R&D member from a different branch (Unilever Food Solutions) to assess the scalability for other teams, one Digital R&D member, evaluating the potential for integrating data-driven decision tools and aligning the template with existing digital workflows, and one Regulatory Affairs R&D member to ensure regulatory alignment.

Format

The validation process combined scheduled Teams meetings as well as in-person walk-around sessions, allowing for flexible participation. Each session lasted approximately 30 minutes per participant and included a mix of open and closed questions.

The research was shortly introduced, along with an explanation of the purpose of the validation session. The importance of their feedback in refining the process template for practical use was emphasised.

The template was explained, focusing on its purpose and functionality. The complementary designer handbook and roadmaps were briefly mentioned but not in too much detail. Physical and digital copies were available. Key aspects to focus on included the layout, the logic behind the steps, ease of use, and clarity. After the explanation, participants had the opportunity to ask questions, which also allowed for initial testing of the template's clarity. A set of open and closed questions followed:

Open questions:

1. What is your first impression of this template?
2. Is the purpose and structure clear to you
3. What do you find most useful?
4. Are there areas that feel confusing or could be simplified
5. Would you feel comfortable using this for your projects? Why or why not? What would make it easier to use?

Closed questions:

1. On a scale of 1-7, how clear is the template?
2. On a scale of 1-7 how practical is it for project use?
3. Would you recommend any changes? (Yes/no) If yes, what changes?
4. Does it cover all aspects you would expect in a design process template? (Yes/no) If no, what other aspects would you preferably see?

After the initial questions, there was a short explanation of the complementary handbook and roadmap, followed by additional questions.

1. Does the handbook seem like a useful resource for diving deeper into specific design considerations?
2. What would you want to dive deeper into or learn about in the handbook? What should not be missed?
3. Based on this quick look, do you think the roadmap would be a helpful guide for understanding the long-term context of the process template?
4. Does the roadmap spark interest/conversation for you? If not: what would make it more interesting or relevant?

8.2 Post session analysis

The validation session provided valuable insights into the clarity, usability, and practicality of the design process template, roadmaps, and handbook. Key themes emerged from both open-ended and closed feedback, highlighting strengths and areas for improvement. The results have been summarised below, along with adjustments made based on the feedback received. A more extensive version of feedback can be found in Appendix K.

Design process template

The design process template received positive feedback overall (average 6/7 for both clarity and practicality), with participants noting its logical flow and the effectiveness of its 1-6 step structure with checkboxes. It was particularly appreciated for guiding users through the process clearly and being useful for onboarding new team members and communicating PPWR-related design factors to stakeholders. However, there were several areas identified for improvement.

Firstly, participants suggested making the template digitally interactive, with features such as sharing to enhance usability. They also recommended linking to supporting documents, such as test plans and regulatory guidelines, to provide deeper guidance. Additionally, incorporating Unilever's branding was suggested to align the template with existing frameworks, improving familiarity and encouraging adoption.

Some of the visuals in the template were seen as too detailed, and it was recommended to simplify them or ensure they relate more directly to the accompanying text. A short introduction to PPWR and a timeline of regulatory requirements were suggested to provide essential context, especially for users unfamiliar with the regulations.

Finally, positioning the template as a standardised approach for all packaging innovation projects, along with making it a living document that evolves with regulatory changes, would ensure its long-term value.

The updated version of the template now includes clickable elements, an improved layout for clarity, and a regulatory overview. These adjustments aim to increase interactivity, enhance usability, and provide clearer references to PPWR regulations and considerations.

Handbook

The handbook was generally well-received as a valuable reference for newcomers or those revisiting specific topics. However, it was noted by some participants that it could be more accessible if it had a better balance between detail and simplicity. Suggestions included adding a breakdown of the main PPWR regulations and timelines to provide context for users unfamiliar with the subject. Some participants also recommended integrating an AI-powered research assistant to help users quickly access PPWR-related information.

The handbook underwent minor adjustments, mostly based on strategic strength (e.g. impact on portfolio, future-proof suggestions).

Roadmaps

One key piece of feedback was the need to focus more closely on the now–2030 phase, as this period is the most important for their planning. Participants noted that many actions that need to be implemented by 2030 must already be underway, or in progress, so certain steps should be brought forward in the timeline.

In relation to the data-driven decision tool, participants expressed strong support for its development. They recognised its potential to help them proactively ensure recyclability compliance, enabling them to stay ahead of regulations rather than react to them. However, they also highlighted that the tool would need to be developed in stages. The first phase could involve a manual decision tree, followed by partial integration into existing systems, and ultimately, once regulations are finalised, full automation through a dedicated software tool. A participant with expertise in digital R&D and AI systems confirmed that building such a tool would be feasible.

As a result, the roadmap has been adjusted to focus more on immediate actions (now–2030) and has incorporated a phased approach to developing the data-driven decision tool.

The finalised concepts will be presented in the next chapter.

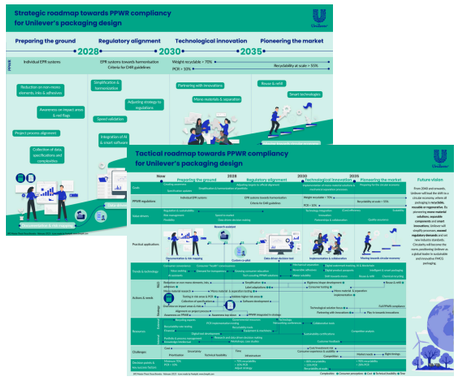
Final design solutions

09

9. Final design solutions

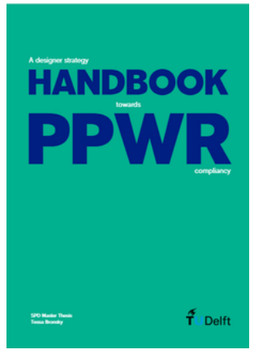
This chapter presents the finalised design solutions along with an explanation and some recommendations. The final set of solutions consists of four components. The first is a strategic and tactical roadmap, outlining the future vision and actionable steps. A design process template was created to guide designers in making packaging PPWR compliant. The process template is short and to the point with a complementary designer handbook that goes more in-depth. This documentation, along with risk mapping and process creation, represents the initial phase of the roadmap. The fourth and final component is a proposal for a data-driven decision tool, which forms the second step in the roadmap. Each design solution will be described individually in the following sections.

01 ROADMAPS



02 PROCESS TEMPLATE

03 HANDBOOK



04 DATA DRIVEN FUTURE

9.1 Strategic roadmap

On the next two pages, the strategic roadmap is visualised. A full version of the roadmap is attached to the repository. The purpose of this roadmap is to outline the long-term vision for achieving recyclable packaging solutions that align with the Packaging and Packaging Waste Regulations and future industry needs. It focuses on high-level objectives and is intended for quick overview purposes, therefore only showing the main goals, the PPWR regulations and the practical applications. The roadmap is divided into four phases.

Documentation and risk mapping: The first phase, documentation and risk mapping, will take place before the regulations are finalised in 2028. During this time, efforts should focus on gathering specifications, building internal knowledge, and mapping potential risks within the current portfolio. PPWR should become a widely recognised and integrated topic within the organisation, with processes established to ensure compliance in packaging design. Strategic priorities should address “red-flag” areas by initiating the development of improved recyclable packaging solutions. The main aim of this phase is to use the knowledge and specifications required to meet the regulations and to begin testing in key areas.

Data-driven decision tool: The second phase will work around the development of a data-driven decision tool. With the regulations expected to take effect in 2028, the coming two years will provide an opportunity to ensure compliance. Drawing from the insights gathered during the previous phase, the decision tool will support the analysis of optimal design changes based on current capabilities, complexity drivers, wishes and the PWPR regulations. This phase will focus on adjusting to the finalised regulatory framework and accelerating the testing and development of recyclable packaging to meet the requirements.

Implementation and collaboration: As 2030 will have passed, the focus on “making it to the shelf” will be settled. This gives room for technological innovation to ensure the regulations are “exceeded” instead of just being met. New start-ups will have grown to scale-ups with validated solutions and will become valuable partners offering innovations that drive the adoption of recyclable mono material and separable packaging. Intelligent technologies will play an important role in advancing sustainable packaging solutions.

Moving towards the circular economy: The final phase will focus on moving towards a circular economy, as consumer acceptance of reusable and refillable packaging gains traction. Unilever should prioritise leveraging smart technologies to position itself as a market pioneer, driving innovation and consumer adoption of circular solutions. By embracing these advancements, Unilever can establish itself as a leader in promoting a circular economy while achieving long-term sustainability goals.

Both the strategic and tactical roadmaps were developed with the PPWR deadlines as key milestones. During the design phase, the input of these milestones were set by analysing the trade-off between resource/cost intensity and the recyclability impact of various interventions. A more detailed process can be found in Appendix I.

9.2 Tactical roadmap

The tactical roadmap (see following pages) complements the strategic roadmap by detailing the actionable steps required to achieve the outlined objectives. While the strategic roadmap provides the high-level vision, the tactical roadmap translates this into a series of practical actions. The value drivers show the measurable benefits and the trends and technologies give an overview of emerging industry trends and technological advancements that support the roadmap goals. Actions and needs are outlined along with resources and potential challenges. Additionally, the tactical roadmap has blue connecting lines to indicate relationships and dependencies between factors. These connections highlight sequential steps as well as interdependencies.

Together, the strategic and tactical roadmaps provide a comprehensive pathway foundation to meeting the PPWR regulations, while also taking into account the broader vision for sustainable packaging solutions. The following section introduces the accompanying design solution, representing an initial step towards the practical applications outlined in the roadmaps.

Strategic roadmap towards PPWR compliancy for Unilever's packaging design

Preparing the ground
Regulatory alignment
Technological innovation
Pioneering the market

2028 — **2030** — **2035**

PPWR

- Individual EPR systems
- EPR systems towards harmonisation
- Criteria for D4R guidelines
- Weight recyclable > 70%
- Recyclability at scale > 55%
- PCR > 10%

Reduction on non-mono elements, inks & adhesives

Awareness on impact areas & red flags

Project process alignment

Collection of data, specifications and complexities

Simplification & harmonization

Adjusting strategy to regulations

Speed validation

Integration of AI & smart software

Partnering with innovations

Mono materials & separation

Reuse & refill

Smart technologies

Moving towards circular economy

Implementation & collaboration

Data-driven decision tool

Documentation & risk mapping

Future vision

From 2040 and onwards, Unilever will lead the shift to a circular economy, where all packaging is recyclable, reusable or regenerative. By pioneering mono-material solutions and smart innovations, Unilever will simplify processes, exceed regulatory demands and set new industry standards. Circularity will become the norm, positioning Unilever as a global leader in recyclable FMCG packaging.

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Tactical roadmap towards PPWR compliancy for Unilever's packaging design

Unilever

	Now	2028	2030	2035
	Preparing the ground	**Regulatory alignment**	**Technological innovation**	**Pioneering the market**
Goals	Creating awareness Specification updates	Adjusting targets to official alignment Simplification & harmonization of portfolio	Implementation of mono-material solutions & mechanical separation processes.	Preparing for the circular economy
PPWR regulations	Individual EPR systems	EPR systems towards harmonisation Criteria for D4R guidelines	Weight recyclable > 70% PCR > 10%	Recyclability at scale > 55%
Value drivers	Regulation & sustainability Risk management Flexibility	Speed to market Data driven decision making	Technology integration Innovation Partnerships & collaboration	(Cost) efficiency Quality assurance Scalability
Practical applications	01 Documentation & risk mapping	02 Research assistant 03 Custom co-pilot 04 Data-driven decision tool	Implementation & collaboration	Moving towards circular economy
Trends & technology	Consumer convenience Value seeking AI assistants Consumer "health" consciousness Demand for transparency Growing consumer education Tech scouting PPWR solutions	Mechanical separation Reversible adhesives Water solubility Digital watermark tracking, AI & blockchain Digital product passports Shift towards mono	Intelligent & smart packaging Reuse & refill Chemical recycling
Actions & needs – R&D	Reduction on non-mono elements, inks, adhesives Mono material research Simplification Label adaptations Mono material & separation testing Rigidness/shape development Consumer testing Mono material & separation implementation Reuse & refill
Actions & needs – Strategy	Testing in risk areas & PCR Collection of specifications Overview on impact areas & risks Validate higher risk areas Software development Alignment on project process Awareness on PPWR Awareness top-down PPWR integrated in strategy Technological solution focus Partnering with innovations Full PPWR compliance Play-in towards innovations
Resources – External	Recycling experts Recyclability rate testing Financial Governmental resources PCR implementation testing Recyclability tools Equipment & machinery Technology Networking conferences Collaborative tools Digital tool development Sustainability certifications Competitor analysis
Resources – Internal	Portfolio & process management Knowledge/intellectual Research and data driven decision making Workshops, case studies Customer feedback
Challenges	Cost Uncertainty Prioritisation Technical feasibility Time Infrastructure Cost/investment risk Consumer experience & usability Competition Market needs Right timings
Decision points & key success factors	Minimum 70% PCR > 10%	> 70% recyclability > 10% PCR Adjust strategy	> 80% recyclability > 15% PCR Recyclability at scale	> 90% recyclability > 20% PCR

Future vision

From 2040 and onwards, Unilever will lead the shift to a circular economy, where all packaging is **recyclable, reusable or regenerative**. By pioneering **mono-material solutions**, **separable components** and **smart innovations**, Unilever will simplify processes, **exceed regulatory demands** and set new industry standards. Circularity will become the norm, positioning Unilever as a global leader in sustainable and innovative FMCG packaging.

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Complexities: Consumer perceptions Cost Technical feasibility Time

9.3 Designer process checklist

The Recyclable-Ready design process template has been developed to guide designers in creating packaging that meets PPWR recyclability compliance. It serves as a checklist, helping designers navigate the essential steps, from understanding regulatory requirements to exploring potential design changes and evaluating their impacts. This tool is designed to be a practical starting point, enabling the creation of more informed, recyclable packaging solutions.

The process template is available in two formats: as an A3 poster for display in the office and as a digitised, interactive document. The interactive version includes clickable elements that provide access to additional information, such as detailed PPWR guidelines, links to tools and frameworks and an example case. These clickable links ensure that users can easily explore relevant content without overwhelming them with too much text. The clickable links are visualised on the next two pages.

The template can be integrated into R&D's system and existing workflows, providing a consistent and accessible reference for packaging designers. In the longer term, it is intended to be incorporated into Unilever's current process tools, further streamlining the journey towards PPWR-compliant packaging.

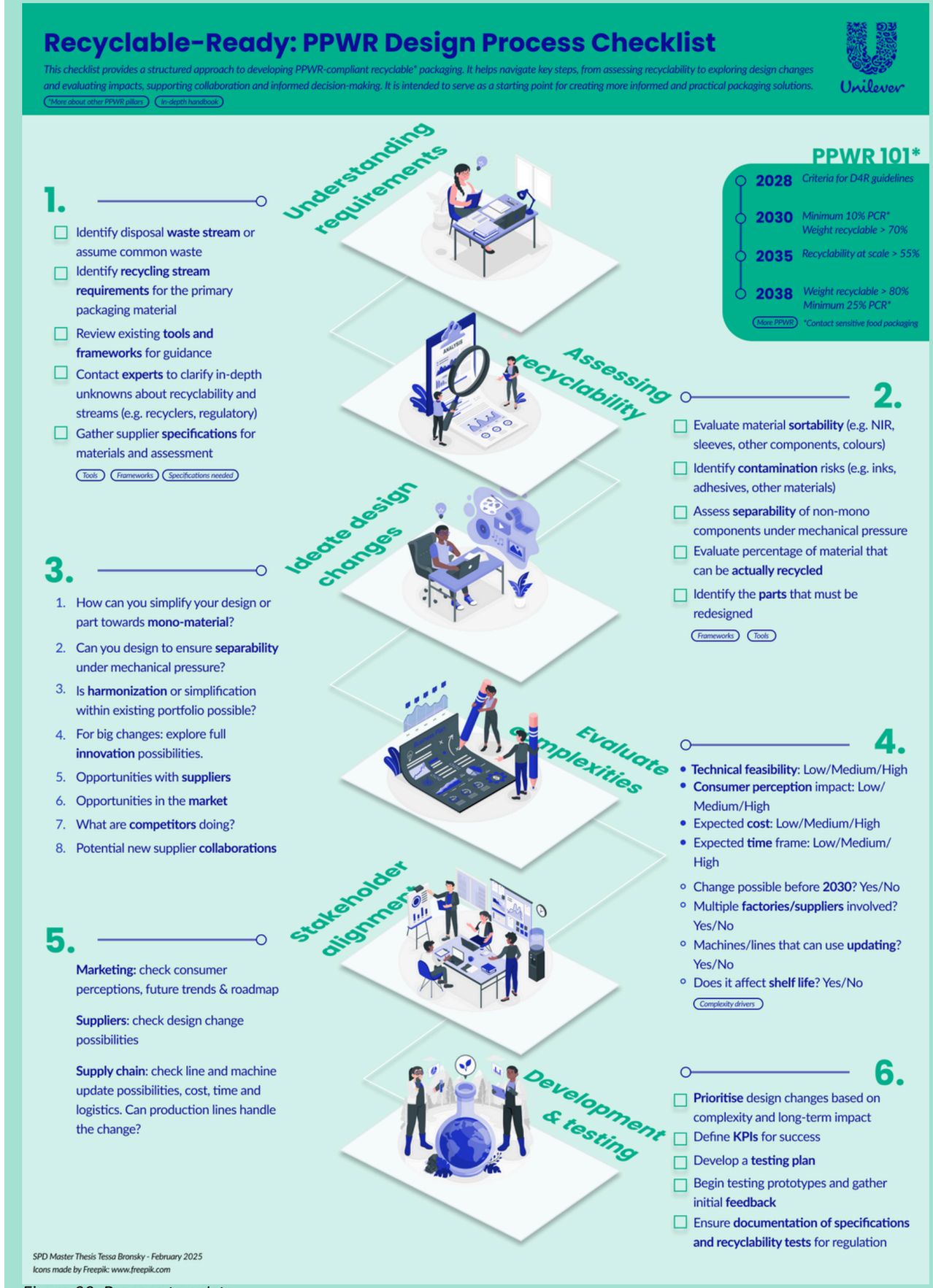
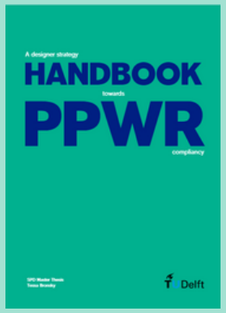
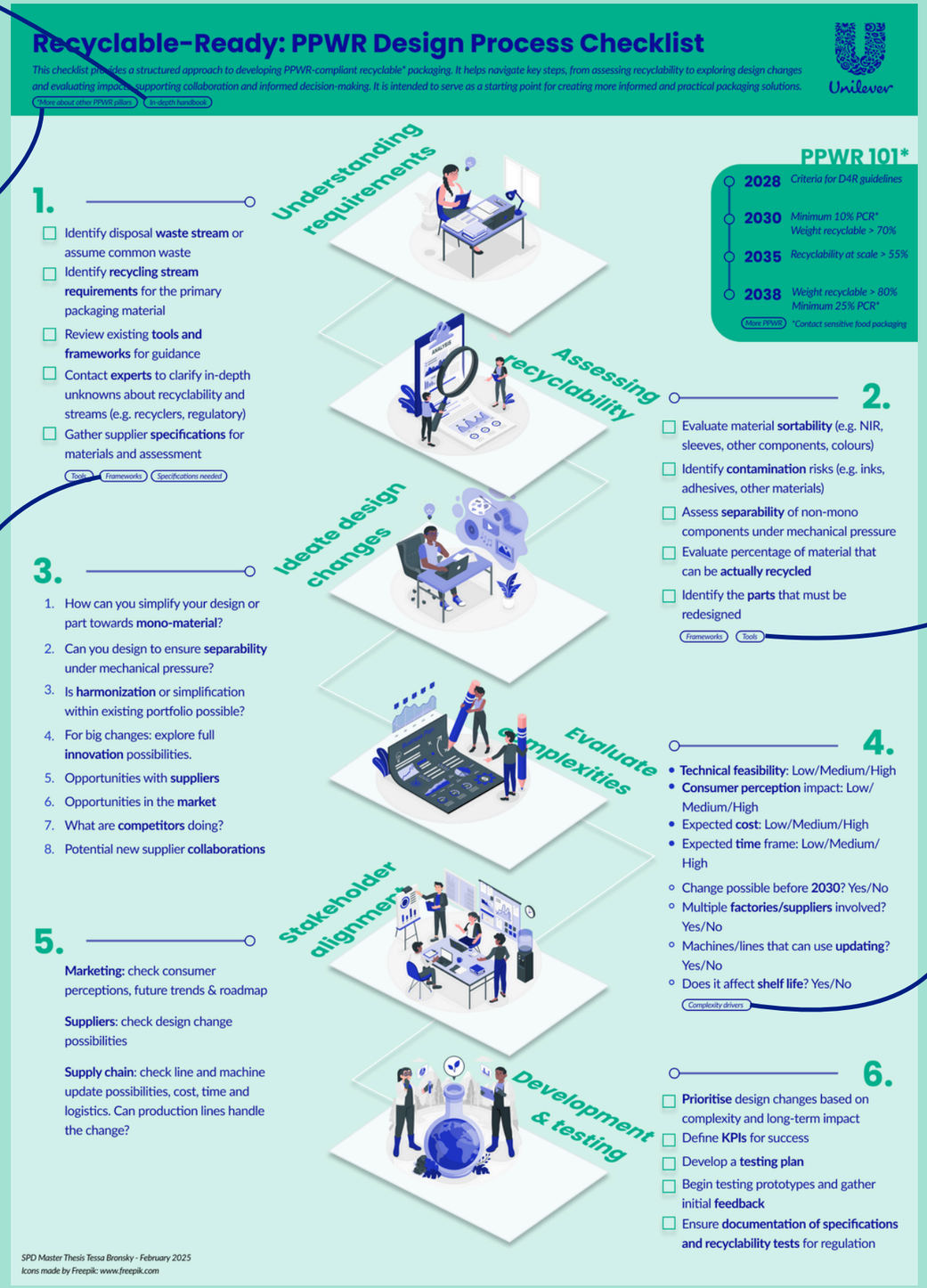


Figure 33: Process template

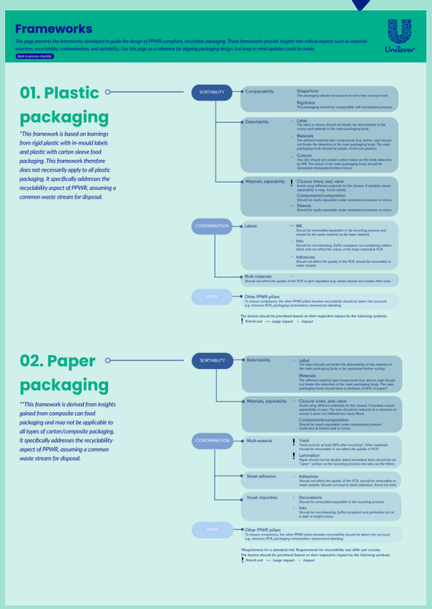


Link to PPWR handbook

Link to more information on PPWR and its other pillars to take into account



Link to useful tools and links to learn more about recycling or to assess packaging



Link to the frameworks for plastic and paper packaging

Link to the other underlying complexity drivers to take into account

Figure 34: Clickable links in template

9.4 Designer handbook

The designer handbook is the in-depth version of the process template. It shows and explains insights for specific packaging cases and works according to the strategic framework. It gives underlying reasoning for recyclability and recommendations for redesign. Furthermore it gives some personal tips and advice from my experience. This is the first step towards documentation as mentioned in the roadmap and can be used as a reference for designers. Some example pages can be seen on the next page.

Chapter 0 outlines the frameworks for rigid plastics and paper. Chapter 1, 2 and 3 go in-depth on the specific case-categories, explaining the design guidelines, current in-alignment factors and design changes that are needed. It also shows the impact & complexity matrix and ends with some design requirements and recommendations for design (packaging specifics results can be found in the confidential handbook). Chapter 4 further explores complexity drivers, factors that influence the design process and their potential impact. This chapter concludes with the foundation for a transition score, helping designers assess the feasibility of proposed changes. Chapter 5 closes the handbook with personal recommendations, highlighting key steps for moving forward and linking the handbook to the Recyclable-Ready process template, the strategic roadmaps, and the data-driven decision tool proposal. The complete handbook can be found in the confidential Appendix.

Given the handbook's more detailed nature, it is best suited for use as a reference guide for designers. It can be uploaded to a research assistant platform, where designers can access it for more specific questions and in-depth information when needed.

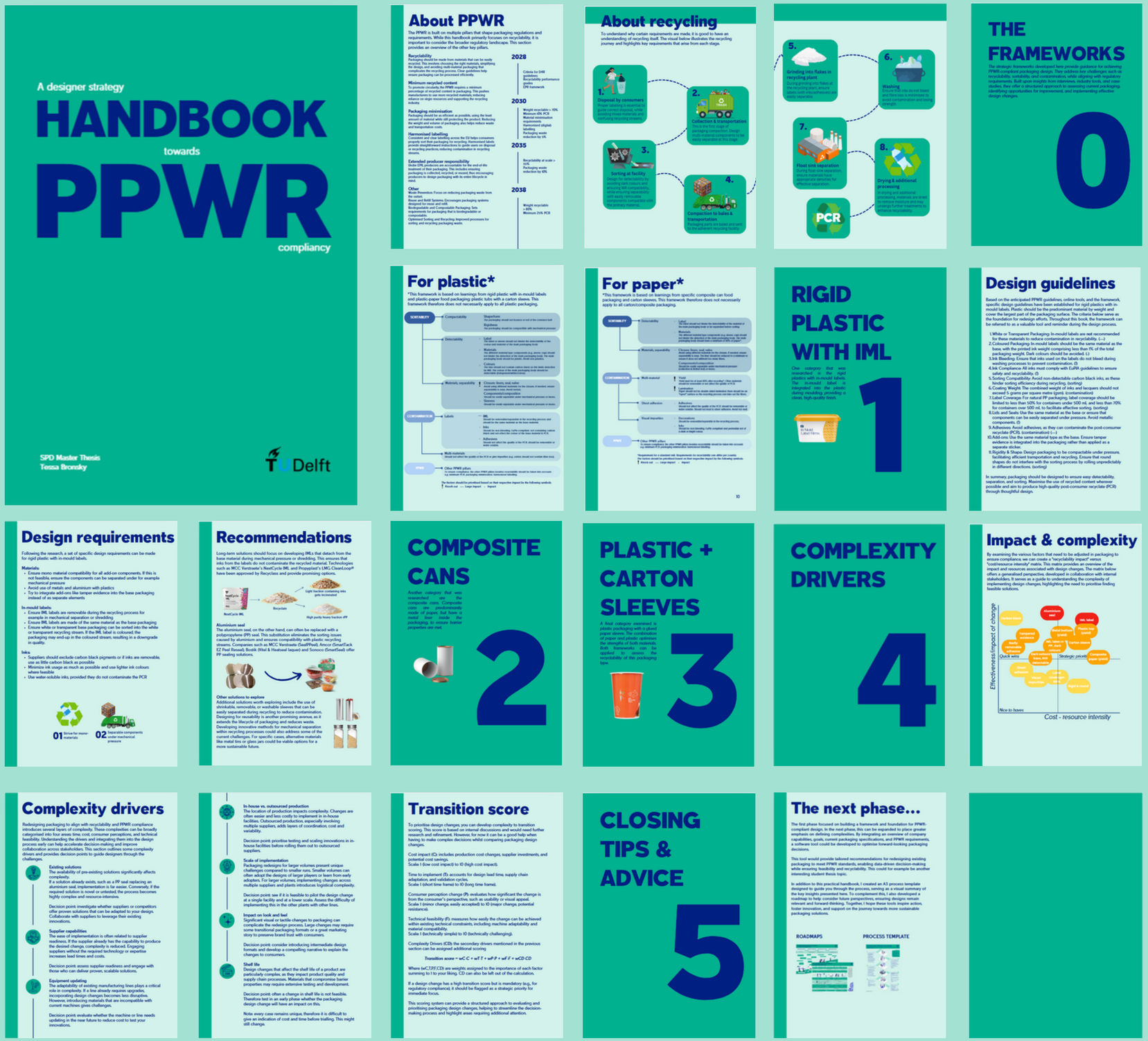


Figure 35: Handbook

9.5 Proposal for a data driven decision tool

As mentioned in previous sections, including the roadmap and Chapter 2's recommendation to embrace a technology innovation focus, a data-driven decision tool presents a key opportunity to automate and enhance the packaging recyclability analysis process. Currently, the recyclability of packaging is evaluated manually, which is time-consuming and can lead to inconsistencies. Transitioning to a software-driven approach would streamline this process, integrating various factors such as complexity drivers, company goals, technical feasibility, and recycling regulations into a unified tool.

The proposed software tool would be designed to assess packaging in relation to the Packaging and Packaging Waste Regulation (PPWR) requirements and possibly other relevant sustainability goals. The tool would have the following functionalities:

- Compliance checking: the system would automatically assess whether packaging meets specific requirements, highlighting any areas where it falls short or is non-compliant according to the A-F scoring system.
- Recommendations for improvements: it would suggest actionable recommendations for redesign, based on the input packaging and the scoring criteria. These suggestions would help guide designers in making compliant changes.
- Portfolio harmonization: the tool could also provide insights on how to harmonize the current packaging portfolio, ensuring that changes are not only compliant but also optimise the company's overall packaging strategy.
- Proactive compliance: moving away from a reactive approach, this tool would allow the company to stay "ahead" of regulations, anticipating regulatory requirements and ensuring compliance before they become mandatory.

As this is a long-term project that will need to evolve and be developed over time, the following phased approach is proposed for its implementation:

Phase 1: Implementation of handbook and design process on SharePoint

In the first phase, the current handbook and design process template will be uploaded to SharePoint. This will centralise the resources and provide employees with easy access to the materials they need to understand recyclability requirements and guide their packaging design decisions. This serves as the foundation for the data-driven tool, providing the background information that will later be integrated into the software.

Phase 2: Set-up of a research assistant for packaging documentation

The next phase involves setting up a digital research assistant. This assistant would help with documenting packaging recyclability, linking back to examples of best and worst practices. Employees would be able to interact with the research assistant by asking specific questions related to packaging recyclability. The assistant would then redirect users to previously examined packaging cases that are similar, providing a context-specific solution based on historical data. This phase aims to establish a knowledge base that will inform the next phases.

Phase 3: Integration of Microsoft custom co-pilot

In Phase 3, a Microsoft custom co-pilot would be implemented. This AI-powered chatbot would be trained to understand the detailed requirements of recyclability regulations and the design process template. Employees could interact with the co-pilot by asking specific questions about the recyclability of their packaging designs. The co-pilot would guide users through the design process, helping them identify areas of concern and providing advice on how to align with regulations. This phase adds a layer of interactivity and support, helping designers in navigating the complexities of packaging compliance.

Phase 4: Full integration of the data-driven decision software tool

The final phase involves the integration of the data-driven decision tool itself. This software would automate the analysis of packaging specifications, allowing designers to upload their packaging designs directly into the tool. The software would then analyse these designs in relation to the PPWR requirements, alerting designers to any misalignments and suggesting appropriate changes based on complexity drivers and regulatory guidelines. The tool would also assist in optimising the portfolio by recommending harmonisation opportunities. Additionally, this tool would serve as a verification mechanism, "proving" that the packaging complies with the EU's recycling regulations, providing the documentation necessary for external audits and compliance reporting.

This phased approach ensures that the development of the tool is manageable and allows for iterative improvement, with each phase building on the previous one. Over time, as the tool evolves, it will become an important part of the packaging design process, significantly improving efficiency, compliance, and recyclability.

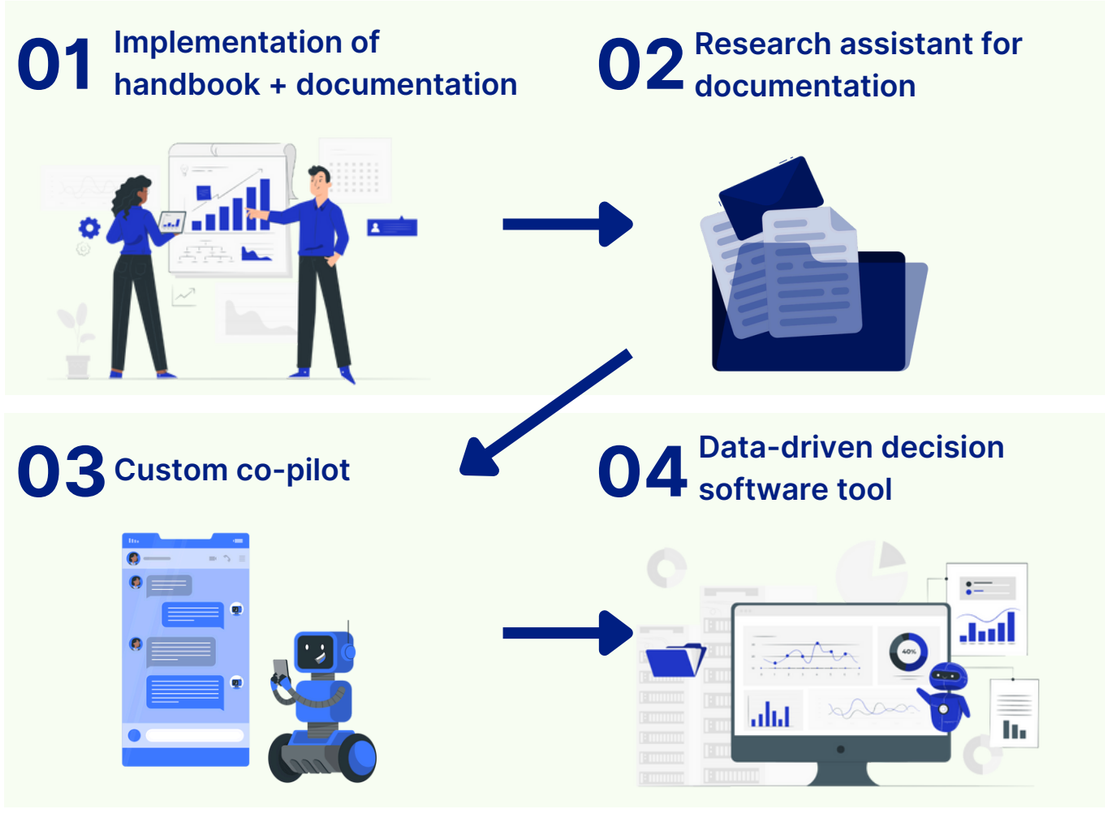


Figure 36: Phases of data driven decision tool

Conclusion

10

10. Conclusion

This thesis contributes to the growing body of knowledge on designing for recyclability, specifically in the context of the EU 2030 Packaging and Packaging Waste Regulation (PPWR). By exploring the complexities of packaging recyclability and uncertain regulations, this research aims to provide a structured approach for organisations like Unilever to navigate compliance while fostering a more sustainable and circular future. The research questions that were stated in the first chapter are answered in this conclusion. The sub questions will first be answered individually after which the main research question will be answered:

"How can an organisation like Unilever effectively adapt their packaging recyclability strategy to meet the EU 2030 Packaging and Packaging Waste Regulation (PPWR)?"

10.1 Subquestions

What internal collaboration factors and organisational processes contribute to successful implementation of sustainable packaging solutions?

The successful implementation of sustainable packaging solutions requires strong internal collaboration across multiple departments, including R&D, supply chain, and marketing. One of the key findings is the importance of aligning recyclability objectives with production capabilities, ensuring that packaging design changes can be integrated into existing manufacturing processes. Additionally, knowledge gaps within organisations pose challenges to recyclability efforts, particularly regarding the uncertain technical and regulatory aspects of PPWR compliance. The role of sustainability experts becomes important in bridging these gaps, ensuring that regulatory requirements are translated into new knowledge, learnings and design decisions. A well-structured and streamlined process for PPWR compliance is necessary to avoid fragmented decision-making and to align all stakeholders towards a shared goal of designing for recyclability. Furthermore, as discussed in the literature, organisations navigating regulatory uncertainty can benefit from dynamic capabilities, allowing them to remain agile in adapting to evolving requirements (Konopik et al., 2021). Managing uncertainty is a core practice in effective innovation management and involves transferring various information types and potential technological solutions (Piller et al., 2011). By fostering flexibility in design directions and allocating resources effectively (Eisenhardt & Martin, 2000; Laursen & Andersen, 2022), companies can better respond to emerging challenges while ensuring long-term compliance, recyclability and a competitive advantage.

What are the regulatory requirements under the EU 2030 PPWR and how do they impact factors for sustainable packaging design?

The EU 2030 PPWR will introduce strict regulations to improve packaging recyclability, shaping both material selection and design strategies. The key pillars of the PPWR currently include packaging minimisation, harmonised labelling, minimum recycled content, recyclability guidelines, extended producer responsibility, and broader requirements related to recycling at scale, waste prevention targets, and reuse and refill objectives. This research highlights two main design priorities emerging from these regulations: the transition towards mono-material packaging and the need to ensure the separability of different packaging components. Mono-material packaging is preferred due to its better compatibility with recycling processes, reducing contamination and improving material recovery. At the same time, enabling the separation of components such as labels, adhesives, and multi-layered structures is essential to ensure that each material can be properly processed within

existing recycling systems while maintaining food safety and technical feasibility. These regulatory requirements necessitate early-stage design integration, alignment with internal technical specifications, and continuous collaboration with recyclers to ensure practical and effective implementation.

How can partnerships with external stakeholders such as suppliers and recyclers be leveraged to facilitate innovation and ensure compliance within the EU 2030 PPWR?
Collaboration with external stakeholders, particularly suppliers and recyclers, is essential for overcoming design and implementation challenges in recyclable packaging. The research finds that engaging with suppliers early in the design process ensures that material specifications align with recyclability requirements while maintaining functional and aesthetic packaging properties. Additionally, recyclers play a crucial role in validating the end-of-life performance of packaging, ensuring that theoretical design choices translate into real-world recycling success. These partnerships help fill knowledge gaps and give insights to potential technological solutions, particularly regarding material compatibility, sorting technologies, and separability options (needs and solution information) (Piller et al., 2011). Effective communication and collaboration with external stakeholders can facilitate innovation and ensure that packaging solutions are both compliant and practically recyclable.

What role can designers play in the PPWR transition and how can they help facilitate this process?
Designers hold a central role in the transition towards PPWR-compliant packaging, as they can among others translate regulatory requirements and technical design choices into practical, scalable solutions that can be used (and understood) by multiple stakeholder groups. This can also be seen as translating needs information to solution information. This research highlights that designing for recyclability extends beyond detailed material choices, requiring a big picture perspective that considers the entire packaging life cycle, from production feasibility to consumer interaction and end-of-life disposal as well as stakeholder interaction in the development phase. Designers must navigate multiple constraints, including regulatory compliance, cost implications, and consumer perceptions, while ensuring that recyclability goals are met. To support this transition, structured design processes and clear workflows are necessary to streamline decision-making and avoid inconsistencies across different packaging formats. The framework developed in this study provides a structured approach to guiding packaging design towards recyclability, enabling organisations to implement systematic and effective design strategies.

10.2 Main research question

How can an organisation like Unilever effectively adapt their packaging recyclability strategy to meet the EU 2030 Packaging and Packaging Waste Regulation (PPWR)?
To effectively adapt to the EU 2030 PPWR, organisations like Unilever must adopt a structured and forward-thinking approach to packaging recyclability. This requires the implementation of a clear process framework that integrates regulatory requirements into internal decision-making, ensuring alignment across departments and stakeholders. Furthermore, maintaining a long-term perspective is essential, not only to meet current regulations but also to anticipate future developments and proactively address compliance challenges.

Technological innovation is a key enabler in this transition. By using AI-driven tools and data-driven decision-making systems, organisations can optimise packaging development according to resource capabilities, regulatory requirements, and design complexities. Automation and digital tracking systems further enhance this process by improving material specifications and ensuring compliance with changing standards.

Ultimately, a successful packaging recyclability strategy depends on the integration of structured processes, proactive innovation, close contact with knowledge experts and cross-functional alignment. By embedding these principles into their operations, organisations like Unilever can not only achieve PPWR compliance but also drive the industry towards more sustainable and circular packaging solutions.

10.3 Contribution

This section provides an explanation of how my thesis contributes to Unilever, academia and to the sustainability goals mentioned in chapter 1: from an environmental, economic and societal perspective.

Unilever
For Unilever, this research lays an initial foundation for designing packaging in compliance with the PPWR. The developed framework identifies key factors for compliance, the handbook provides in-depth case studies, and the process template offers a structured, step-by-step approach to integrating recyclability thinking considerations into packaging design. Additionally, the infographic serves as a communication tool, simplifying PPWR guidelines and facilitating knowledge transfer and alignment to both internal teams and external stakeholders. Lastly, the proposal for a data-driven decision tool represents a potential next step in increasing efficiency, ultimately reducing costs and time associated with regulatory adaptation and packaging redesign, increasing flexibility and dynamic capabilities.

Academia
From an academic design perspective, this research addresses a critical knowledge gap by providing structured frameworks and methodologies to help support PPWR-compliant packaging design. The process template, in particular, offers a systematic approach that can be further explored and refined in future research. Additionally, this thesis lays the foundation for further academic research into areas such as designing for separability of components under mechanical pressure, ensuring materials remain recoverable within existing recycling infrastructures.

Environmental
From an environmental standpoint, this research contributes to improving packaging recyclability by fostering a design approach that prioritises end-of-life considerations. The process template encourages designers to adopt a lifecycle perspective, ensuring that packaging is not only functional but also compatible with recycling systems. By embedding recyclability into the early stages of design, this approach supports the transition towards a circular packaging economy.

Economic
From an economic perspective, this research supports the advancement of the circular economy by promoting better recyclability practices. As outlined in Chapter 1, improved recyclability can enhance resource efficiency, reduce reliance on virgin materials, and potentially strengthen Europe's independence in raw material sourcing. Moreover, the transition to a circular economy could generate new job opportunities across the packaging, waste management, and recycling sectors. Furthermore, this research provides a strategic framework that could support

companies in achieving regulatory compliance without compromising business performance. By proactively integrating recyclability into design, brands can avoid future adaptation costs and potential penalties (like being removed from the shelf) under stricter environmental regulations. Moreover, optimised packaging design can lead to cost savings in waste management and logistics, benefiting both businesses and municipalities. The insights from this research may also drive innovation in material development, smart packaging and circular business models, opening new revenue streams within the FMCG industry.

Society

From a societal perspective, this thesis contributes to shifting design mindsets towards circularity. By integrating structured design processes that prioritise recyclability, it empowers designers to make informed decisions that align with broader sustainability goals. Beyond influencing design practices, this research fosters collaboration across the packaging value chain, from designers to recyclers, ensuring that packaging is effectively integrated into real-world recycling systems. In the long run, this systemic shift can drive more sustainable consumer behaviours, enhance industry-wide accountability, and raise awareness of packaging's role in advancing a circular economy. Moreover, by improving the clarity and effectiveness of recyclability considerations in packaging design, this research can help enhance public participation in circular economy initiatives, encouraging consumers to make more informed disposal choices and engage more actively in waste reduction efforts.

10.4 Limitations

There are several limitations to this project that should be noted and taken into account. These limitations vary form complexities in the design process, research constraints, and external factors such as regulations and stakeholder perspectives.

Research and interpretation

This research was conducted independently, which introduces several limitations related to the research design and data interpretation. Although efforts were made to enhance reliability and validity through peer feedback, reflexivity, and an iterative approach, the absence of a research team limits the ability to triangulate perspectives and validate findings comprehensively.

While the interview sample provides a reasonable diversity of perspectives, its relatively small size may restrict the generalisability of the findings. Moreover, the focus on Unilever and its network, rather than a broader spectrum of organisations or industries, means the results may not be fully applicable to other companies or sectors. Furthermore, capturing consumer needs and perceptions, which are essential for successful packaging design, should also be taken into account. Expanding the stakeholder group to include a wider range of perspectives, including those of consumers and competitors, would provide a more comprehensive understanding of the challenges and opportunities in sustainable packaging design. The research findings, therefore, should be viewed as preliminary, providing a foundation for future studies that involve larger and more diverse samples.

Scope and depth

Given the broad scope of this project, which aims to develop frameworks and decision-making tools for recyclable packaging design, the outcomes have been generalised. While the research provides valuable insights into packaging recyclability and PPWR compliance, it is based on specific case studies, meaning that some other factors may not be fully captured (e.g. flexible plastics). Each packaging type presents unique challenges, and aspects such as the technical complexities of materials or the specificities of different recycling streams may not be explored in full detail.

The frameworks and tools developed are designed to be adaptable and flexible; however, they may not offer solutions for every packaging scenario. Future research could build upon these findings by incorporating a wider range of case studies, exploring additional material and technology-specific considerations, and assessing evolving market and regulatory conditions. As the recommendations are based on current industry practices, there remains a gap between theoretical guidance and practical implementation. Further real-world testing and validation will be needed to refine these solutions and ensure their applicability across diverse packaging contexts.

Complexities

A key challenge in this project is navigating the complexities associated with the cost, time, technical feasibility, and consumer perceptions of sustainable packaging. Developing and implementing packaging solutions that comply with the Packaging and Packaging Waste Regulation (PPWR) often requires substantial investment in redesign, testing, and production adjustments. These costs can be difficult to estimate accurately, especially before the alternative designs are tested under real-world conditions. Additionally, the timeline for implementing such changes, from initial design to full consumer adoption, adds another layer of uncertainty.

Consumer perceptions of sustainable packaging further complicate the process, as they do not always align with environmental objectives. There is no guarantee that consumers will accept new packaging formats or be willing to pay more for sustainable alternatives. While this project provides a foundation for considering these factors and their underlying drivers, further research into these complexities would be valuable in refining and optimising sustainable packaging solutions as well as being able to make more informed design decisions.

Changing Regulations

As mentioned, the Packaging and Packaging Waste Regulation (PPWR) is set to become official in 2028, and until then, the exact regulatory requirements can still change. This uncertainty presents a limitation in terms of long-term planning, as the specific compliance criteria may change over time. In this project, efforts have been made to ensure that the design recommendations are broadly aligned with recyclability principles, as advised by recycling experts, but the regulations may still change, requiring adjustments to the frameworks and tools.

In addition to the PPWR, other regulations affecting packaging sustainability (such as extended producer responsibility schemes and national recycling targets) are also evolving, further complicating the landscape. As these regulations develop, the frameworks will need to be updated to ensure ongoing compliance and effectiveness.

10.5 Recommendations

This section outlines some recommendations on further research and development.

Expanding research on frameworks and processes

Future research should focus on refining and expanding the frameworks and processes developed in this thesis. By analysing a broader range of packaging case studies across different materials and formats, along with a more diverse range of stakeholders, companies can gain deeper insights into best practices for designing recyclable packaging. This would allow for more comprehensive guidance tailored to diverse product

categories and market conditions.

Investigate complexities and drivers
The complexities associated with cost, time, technical feasibility, and consumer acceptance require further exploration to support more informed decision-making. A deeper understanding of these challenges will enable companies to balance sustainability goals with practical constraints, improving the adoption of recyclable packaging solutions. Additional research could also assess how different business models and supply chain structures influence these complexities.

Developing a data driven decision tool for recyclability
A data-driven tool could streamline the packaging design process by providing real-time insights into recyclability specifications, regulatory compliance, and material compatibility. Such a tool could serve multiple functions, including:

- Assisting designers with design choices based on recyclability criteria.
- Alerting stakeholders to potential design complexities and regulatory challenges early in development.
- Offering certification or recyclability scoring based on industry standards.
- Providing alternative solutions and recommendations for optimising, simplifying and harmonising packaging sustainability.

Enhancing industry collaboration
One of the key insights from recycling experts is the need for greater industry collaboration to achieve more unified packaging solutions. Currently, variations in materials, formats, and labelling contribute to inefficiencies in sorting and recycling processes. By working together, companies can establish shared packaging standards, improving the compatibility of packaging with existing recycling infrastructure.

Personal reflection

11

11. Personal reflection

This final chapter provides a reflection on the results of this thesis. The reflection is structured around the key pillars for Industrial Design Engineering at the TU Delft, namely desirability, feasibility and viability. Lastly, I will end with a more personal reflection on my process and the project.

11.1 Feasibility

Looking at feasibility in this project, the process template is a ready-to-use tool that can be implemented straight away to support PPWR compliance. It offers a practical, streamlined approach for packaging assessment, providing clear, actionable guidelines to be used by packaging teams, as well as other stakeholders for alignment. While periodic updates will be necessary as regulations evolve, the template can be easily adjusted, to ensure its long-term relevance and functionality.

In contrast, the data-driven decision tool requires further research and development. A digital expert confirmed its potential but emphasised the importance of a structured setup to avoid inaccurate inputs, which could undermine the reliability of outputs. This challenge was raised by a participant during the validation session (garbage input could be garbage output) and highlights the need for strong data integration and user-friendly interfaces to ensure the tool's success.

11.2 Desirability

Reflecting on desirability, in-depth knowledge on current packaging assessment was desired as well as a way to make it scalable and to extrapolate results to other packaging types. The need for a structured, scalable approach to packaging assessment is clear across the FMCG industry. As regulations become stricter, non-compliance can result in products being removed from shelves, making a streamlined process highly relevant. The template accommodates varying steps, making it desirable for R&D, supply chain, marketing as well as other stakeholders.

Moreover, the structured approach benefits recycling industries and policymakers by providing clarity and consistency in compliance efforts. This could support an easier transition to recyclable packaging, fostering a harmonised shift towards circular economies.

11.3 Viability

In the longer term and from 2028, the proposed solutions would need revision based on the actual regulations and developments to stay relevant. While the current design solutions may not be entirely future-proof, the roadmaps for long-term sustainability allow companies to prepare for upcoming regulatory and technological changes.

A data-driven decision tool holds more long-term potential. As digitalisation and automation become increasingly important, refining the tool to ensure scalability and adaptability will be important for its success. If further developed, it could become a valuable asset for companies navigating complex regulations and optimising packaging design for the future.

11.4 A last personal note

Looking back on my project, I am pleased with the final results. One of my goals before starting was to deepen my knowledge of sustainability, particularly in terms of recyclability. I am grateful for the opportunity to do so and to have engaged with so many talented professionals across recycling, packaging technology, marketing, and supply chain along with the help of a great TU Delft supervision team. I truly felt like part of the R&D team at Unilever, as they actively involved me in meetings, learnings, and workshops. Since I enjoy learning, integrating stakeholder perspectives, and translating insights into strategic recommendations, I appreciated having the space to explore these areas alongside my deep dive into different packaging categories.

Another personal goal was to consider multiple stakeholder perspectives, which turned out to be one of the aspects I enjoyed most. It not only kept me motivated but also sparked new ideas. This also confirmed my interest in working at the intersection of strategy and design (and sustainability), something I will keep in mind as I begin my job search.

Reflecting on the challenges I encountered, one of the difficulties I faced was choosing a single direction. This can be seen in my decision to develop multiple design solutions rather than focusing on one. While this approach comes from my perfectionist traits, I recognise that in the future, it may be more effective to refine and perfect a single solution rather than attempting to cover everything, which is not always feasible. Additionally, at the beginning of my project, I found it challenging to proactively reach out or set up meetings with stakeholders. However, I was pleasantly surprised by how open and willing people were to support my research. Over time, I gained confidence in asking questions and voicing my opinions. This comes from my trait of being a bit shy and tentative in new groups (in Dutch a “kat uit de boom kijker”). This experience helped me overcome my initial hesitation in new group settings, something I will continue to work on, as I am confident in the quality of work I can deliver.

In terms of strengths, I have gained expertise in packaging recyclability, a topic I can now discuss for hours. Beyond the technical aspects of design changes, I also enjoy ensuring that transitions are viable at an organisational level, not just within a single team. I take a strategic approach to decision-making, stakeholder interactions, and envisioning future-proof designs. As I look ahead, I am keen to pursue opportunities in strategic design, working with multiple stakeholders to drive sustainable and future-ready solutions.

Thank you for taking the time to read my thesis report. I hope it inspires new ways of thinking and sparks valuable discussions. If you have any questions or would like to explore potential collaborations, please feel free to reach out. For now, I’m looking forward to a well-earned break and am excited to see where the next six months will take me!

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Appendix

A. Approved project brief

DESIGN FOR our future

TU Delft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME
Complete all fields and indicate which master(s) you are in

Family name	Bronsky
Initials	T.
Given name	Tessa
Student number	4875389

IDE master(s)	IPD		Dfl		SPD	✓
2nd non-IDE master				
Individual programme *(date of approval)*				
Medisign				
HPM				

SUPERVISORY TEAM
Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Shahrokh Nikou	dept./section	Marketing and Consumer Research
mentor	Pien Jager	dept./section	Design for Sustainability
2nd mentor	Marije Luijendijk		
client:	Unilever		
city:	Wageningen	country:	Netherlands
optional comments			

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Shahrokh Nikou — Digitally signed by Shahrokh Nikou, Date: 2024.09.13 13:22:25 +02'00'

Name Shahrokh Nikou Date 9 Sep 2024 Signature

CHECK ON STUDY PROGRESS
To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total ____ EC

Of which, taking conditional requirements into account, can be part of the exam programme ____ EC

★	**YES**	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Robin den Braber — Digitaal ondertekend door Robin den Braber, Datum: 2024.09.20 08:51:23 +02'00'

Name Robin den Braber Date 20 sept 2024 Signature

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen — Digitally signed by Monique von Morgen, Date: 2024.11.04 19:29:30 +01'00'

Name Monique von Morgen Date 4 Nov 2024 Signature

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Name student Tessa Bronsky **Student number** 4,875,389

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Developing a strategic framework for Unilever's packaging to comply with EU 2030 PPWR: enhancing sustainability through stakeholder collaboration and innovation.

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

The shift towards sustainability in packaging is becoming increasingly important as the European Union had tightened its regulations. In November 2022 the European Commission proposed the Packaging and Packaging Waste Regulation (PPWR), which replaces the Packaging and Packaging Waste Directive. The aim of this new regulation is to further harmonize rules across member states of the EU, particularly in areas such as packaging design, labeling and eco-modulation. The PPWR states that recyclability and reusability should be integrated from the design phase. The PPWR aligns with the objectives of the European Green Deal, targeting a significant reduction in packaging waste and greenhouse gas emissions.

The transition to sustainable packaging presents several challenges. Current practices in packaging often rely on materials that are difficult to recycle or reuse, and companies must now innovate within a framework that balances sustainability with cost-efficiency. Additionally, the need to restructure existing infrastructures while maintaining functionality and market appeal adds complexity. Some companies have already faced setbacks in meeting sustainability goals due to over-ambition, incorrect assumptions and a lack of cohesive management.

Unilever, a global leader in consumer goods, provides an ideal case for examining these challenges. Despite previously setting sustainability targets for 2024, the company faced difficulties in achieving these. This makes Unilever a relevant and complex case study for developing a new approach to meet the upcoming 2030 regulations. Stakeholders such as packaging designers, suppliers and recycling companies all play critical roles in this ecosystem. Designers must innovate sustainable packaging solutions, supply chain managers must ensure these solutions are feasible and scalable and recycling companies must ensure these solutions are recyclable. Understanding and aligning these roles in design is essential to successfully transforming packaging practices and achieving regulatory compliance.

→ *space available for images / figures on next page*

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Unilever faces significant challenges in aligning its packaging systems with the EU's 2030 Packaging and Packaging Waste Regulation (PPWR). This regulation requires that packaging is recyclable and reusable, yet Unilever's current practices often fall short of these standards.

Particularly in rigid packaging with in-mould labels, composite cans and polyolefin packs there are significant challenges to be faced in meeting the new requirements. One of the main issues is ensuring that packaging is fully recyclable while maintaining product functionality and market appeal. Additionally, internal communication and coordination between various stakeholders - such as suppliers, recyclers and pakcaging designers about recyclability are important. The lack of their alignment can lead to inefficiencies and delays in decision-making and implementation.

The company must also address gaps in understanding current packaging specifications and their recyclability within the PPWR framework. Engaging with suppliers and recyclers to validate these specifications and exploring necessary improvements is another complexity in Unilever's transition to sustainable packaging.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Create a strategy framework to assess and improve the recyclablility of Unilever's rigid packaging with in-mould labels, composite cans and polyolefin packs in alignment with the EU 2030 PPWR, fostering cross-departmental collaboration and engagement with suppliers and recyclers to enhance sustainability across the company's packaging portfolio.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

To carry out the graduation project, I will take a qualitative approach supported by desk reasearch and and strategic analysis. I will conduct qualitative interviews with stakeholders across key departments, including packaging designers, supply chain managers and external actors such as suppliers and recyclers to gather insights into current practices, challenges and opportunities for improving recyclability. The project will follow three key phases:
1. Desk research and literature review: an extensive review of the European Union's 2030 PPWR and best practices in sustainable packaging desing. This phase will also involve exploring tools, guidelines and industry benchmarks for packaging recyclability and reusability, as well as trends and competitor analysis. (see doc for literature focus)
2. Clarification of current specifications: engage with designers, suppliers and recyclers to validate the recyclability of Unilever's rigid packaging with in-mould labels, composite cans and polyolefin pakcs. This phase will assess current packaging performance against the PPWR standards.
3. Co-creation of solutions: collaborating with suppliers and recyclers to identify and explore necessary improvements to Unilever's packaging and strategy. This co-creation process will focus on developing innovative, sustainable solutions that enhance recyclability. --> Findings will be formed in a comprehensive strategy framework outlining actionable steps.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	9 Sep 2024
Mid-term evaluation	5 Nov 2024
Green light meeting	24 Jan 2024
Graduation ceremony	21 Feb 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:
I plan to work full-time with 10 days off in total, of which 5 after the mid-term and 5 during Christmas break. I have 10% extra (10 days) reserved for additional Unilever work.

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

I am deeply committed to sustainability and aspire to work on projects that create a meaningful impact. Throughout my academic journey, I have pursued electives on sustainability and participated in GreenTU to deepen my understanding of the field. This project aligns with my passion for purposeful work and offers an opportunity to apply my knowledge in real-world context. Additionally, I aim to prepare myself for a professional career by taking risks and improving my networking and stakeholder collaboration skills through qualitative interviews and co-creation. I believe that the strategies developed in this project can serve as a model for other companies, contributing to a broader positive impact on the environment and society. Furtermore, by focusing on organizational support and cross-departmental collaboration, I hope to develop competencies in project management and stakeholder engagement, which are crucial for driving systemic change in large organizations.

Personal goals:
Deep-dive sustainability
Co-creation with stakeholders
Stakeholder management
Time management

B. Supermarket analysis

A supermarket analysis was performed in two different supermarkets to spot trends and to benchmark Unilever's packaging with competitors. These were the key insights.

Decrease in amount of products in composite can packaging. Composite cans are most used in countries like Italy. Van Gilse's powdered sugar used to be in composite cans, but changed to plastic.

Rigid packs; brown and dark colours
% surface lower for Remia

See-through trend
Albert Heijn sleeve, easier to remove & no bottom?
Enkhuizen; paper inside as label

Plastic use
Same type as to-go coffee
Paper option?
No to-go option (plastic package)
Sobo; water drain

C. Design for Recyclability table

Phase	DfR requirements	Source
Material selection	Material reusability	(Zhu et al., 2022)
	Material recyclability	
	Product application	
	New biomaterials	
	Biocomposites	
	Biodegradable materials	
	Mechanical properties and processability of reprocessed recycled materials	
	Agro materials for packaging	
	Reclaimed	
	Mixture of recycled/virgin materials	
	Animal and vegetable residue	
	Ocean plastics	
	Minimum recycled content	(Circpack, 2024)
	Packaging prevention targets	
	Food safety	(Hahladakis & Iacovidou, 2018), (Han et al., 2018)
	Product shelf life	(Han et al., 2018)
	Base resin	(Ding & Zhu, 2023)
Conceptual design	Times of reuse	(Zhu et al., 2022)
	Exchangeability to another fragrance	
	End of life options	
	Location (where is it used)	
	Local return rate	
	Reduce material varieties	
	Colour (avoid black or dark colour)	
	Mindful hazards of recycled materials for special applications	

	Closure systems and small parts	(Circpack, 2024)
	Additives	
	Adhesives	
	Barriers/coatings	
	Labels/sleeves	
	Barrier layer/coating/additives	(Ding & Zhu, 2023)
	Labels/inks/adhesives	
	Closures and pumps	
	Colour and dimensions	
	Attachments	
Design development	Size (storage)	(Zhu et al., 2022)
	Ease of use	
	Thickness, strength, durability, branding and advertising, circular economy	
	Cleaning and maintenance	
	Modular design	
	Light weighting	
	Avoid redesigning and combining multiple circular economy concepts	
	Avoid using lacquer	
	Differentiation between one-off and refillable packaging	
	3 layered design	
	Label recyclability for each material	
	Avoid designing non-separable plastic parts	
	Avoid using multi-polymers for non-separable parts	
	Ease of dismantling	(Circpack, 2024)
	Inks/printing	
	Packaging minimization (empty space)	
	Collection of packaging	
	Mandatory labelling information	

	Knowledge on label, complexity for consumers	(Niero, 2023)
	Collection & sorting	(Ncube et al., 2021)
	Utility during use phase	(Niero & Hauschild, 2017)
	Disassembly	(Kriwet et al., 1995)
	Minimise the variety of materials	
	Minimise the number and variety of joining elements	
	Make harmful/valuable components/materials easy accessible	
	Avoid precedence relations between parts	
Design validation	Assessment tools (LCA)	(Zhu et al., 2022)
	Circular economy indicators	
	C2C certification & MCI	
	Ease of emptying	(Circpack, 2024)
	Food losses	(Grönman et al., 2012)

D. Consent form

Consent Form for Participation in an Interview

Thank you for considering participating in this research project. You are being invited to participate in a **master thesis research study** titled "Unilever's Path to EU 2030 Packaging Compliance: Strategic Framework and Current Portfolio Review". This study is being done by Tessa Bronsky from the TU Delft in collaboration with Unilever Nutrition R&D.

The purpose of this research study is to gain insights into the role and influences that specific stakeholders have within the process towards a PPWR-compliant packaging design and will take you approximately 30 minutes to complete. The insights and results will be used to validate a strategic framework and will be published in a master thesis graduation report. We will be asking you to share your experiences and influence within the packaging design. And to talk about the impact the new Packaging and Packaging Waste Regulations will have. Most questions will relate specifically to your role within the design process. This document outlines your rights as a participant and provides information on how your data will be handled to ensure your privacy and confidentiality.

Key Points to Note:
Voluntary Participation:

Your participation is entirely voluntary. You have the right to decline to answer any question or withdraw from the interview at any time, without providing a reason or facing any consequences.

Purpose of the Research:

The information collected will be used solely for the objectives of this research project and will not be shared or used for other purposes without your explicit consent.

Confidentiality:

All information you provide will be treated with strict confidentiality. Your identity will be anonymised in any reports or publications resulting from this research unless explicit permission is granted.

Data Storage and Use:
Your responses will be securely stored and accessible only to authorised researchers involved in this project. After the project is completed, your data will be retained or disposed of in compliance with applicable data protection laws.

Risks and Benefits:
Participation involves no physical or emotional risks. While there are no direct personal benefits to you, your input will contribute significantly to the study's success and may inform future advancements in the field.

Contact Information:
If you have questions or concerns about your participation or the research, please contact me at tessa.bronsky@unilever.com.

Consent Agreement:

By signing below, you confirm that you have read and understood the information provided above and agree to participate in this research. You understand your rights and confirm that your participation is voluntary.

Participant's Name (Printed): _____

Signature: _____

Date: _____

Researcher's Name (Printed): Tessa Bronsky

Signature: _____

Date: _____

E. HREC documents

Delft University of Technology
HUMAN RESEARCH ETHICS
CHECKLIST FOR HUMAN RESEARCH
(Version January 2022)

IMPORTANT NOTES ON PREPARING THIS CHECKLIST

1. An HREC application should be submitted for every research study that involves human participants (as Research Subjects) carried out by TU Delft researchers
2. Your HREC application should be submitted and approved **before** potential participants are approached to take part in your study
3. All submissions from Master's Students for their research thesis need approval from the relevant Responsible Researcher
4. The Responsible Researcher must indicate their approval of the completeness and quality of the submission by signing and dating this form OR by providing approval to the corresponding researcher via email (included as a PDF with the full HREC submission)
5. There are various aspects of human research compliance which fall outside of the remit of the HREC, but which must be in place to obtain HREC approval. These often require input from internal or external experts such as Faculty Data Stewards, Faculty HSE advisors, the TU Delft Privacy Team or external Medical research partners.
6. You can find detailed guidance on completing your HREC application here
7. Please note that incomplete submissions (whether in terms of documentation or the information provided therein) will be returned for completion **prior to any assessment**
8. If you have any feedback on any aspect of the HREC approval tools and/or process you can leave your comments here

I. Applicant Information

PROJECT TITLE:	***Designing a strategic framework to guide Unilever towards EU's Packaging and Packaging Waste Regulations for 2030***
Research period: *Over what period of time will this specific part of the research take place*	**25 November – 10 Janary (Interviews and possible validation)**
Faculty:	**Industrial Design Engineering**
Department:	**Strategic Product Design**
Type of the research project: *(Bachelor's, Master's, DreamTeam, PhD, PostDoc, Senior Researcher, Organisational etc.)*	**Master thesis**
Funder of research: *(EU, NWO, TUD, other – in which case please elaborate)*	**TUD**
Name of Corresponding Researcher: *(if different from the Responsible Researcher)*	**Tessa Bronsky**
E-mail Corresponding Researcher: *(if different from the Responsible Researcher)*	
Position of Corresponding Researcher: *(Masters, DreamTeam, PhD, PostDoc, Assistant/ Associate/ Full Professor)*	**Master student**
Name of Responsible Researcher: *Note: all student work must have a named Responsible Researcher to approve, sign and submit this application*	**Shahrokh Nikou**
E-mail of Responsible Researcher: *Please ensure that an institutional email address (no Gmail, Yahoo, etc.) is used for all project documentation/ communications including Informed Consent materials*	
Position of Responsible Researcher : *(PhD, PostDoc, Associate/ Assistant/ Full Professor)*	**Full Professor**

II. Research Overview

NOTE: You can find more guidance on completing this checklist here

a) Please summarise your research very briefly (100-200 words)
What are you looking into, who is involved, how many participants there will be, how they will be recruited and what are they expected to do?

Add your text here – (please avoid jargon and abbreviations)

I am creating a framework that shows the most important factors to take into account to ensure design with alignment towards the 2030 EU packaging and packaging waste regulations. To validate this framework, I am interviewing 12 people with different roles to the design of a packaging. These are 80% people within Unilever (designers, marketeers, supply chain etc.) and 20% stakeholders from Unilever (suppliers, and recyclers). These people are recruited by email. I have already been in contact with them through general meetings. They are expected to answer a set of 5-7 questions in relation to their role towards packaging design and their influence on the design.

b) **If your application is an additional project** related to an existing approved HREC submission, please provide a brief explanation including the existing relevant HREC submission number/s.

Add your text here – (please avoid jargon and abbreviations)

-

c) **If your application is a simple extension of, or amendment to,** an existing approved HREC submission, you can simply submit an HREC Amendment Form as a submission through LabServant.

III. Risk Assessment and Mitigation Plan

NOTE: You can find more guidance on completing this checklist here

Please complete the following table in full for all points to which your answer is "yes". Bear in mind that the vast majority of projects involving human participants as Research Subjects also involve the collection of Personally Identifiable Information (PII) and/or Personally Identifiable Research Data (PIRD) which may pose potential risks to participants as detailed in Section G: Data Processing and Privacy below.

To ensure alignment between your risk assessment, data management and what you agree with your Research Subjects you can use the last two columns in the table below to refer to specific points in your Data Management Plan (DMP) and Informed Consent Form (ICF) – **but this is not compulsory**.

It's worth noting that you're much more likely to need to resubmit your application if you neglect to identify potential risks, than if you identify a potential risk and demonstrate how you will mitigate it. If necessary, the HREC will always work with you and colleagues in the Privacy Team and Data Management Services to see how, if at all possible, your research can be conducted.

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
A: Partners and collaboration						
1. Will the research be carried out in collaboration with additional organisational partners such as: • One or more collaborating research and/or commercial organisations • Either a research, or a work experience internship provider[1] [1] *If yes, please include the graduation agreement in this application*	**Yes**		The research will be carried out in collaboration with Unilever R&D Nutrition (Wageningen) as I am a graduate intern there. Potential risks include: 1. Risk: Participants might share sensitive or proprietary information about Unilever's operations or strategies. • Mitigation: I have signed a confidentiality agreement with Unilever regarding sensitive data. My supervisor from Unilever will review the interview outcomes and advise on what can be included in the base report and what should be placed in the confidentiality appendix. This ensures sensitive information remains confidential. Additionally, data will be anonymized to protect identities and sensitive information. An informed consent form will be provided to participants, detailing the study's purpose and how the data will be used. 2. Risk: Unauthorized access to collected data could lead to breaches. • Mitigation: All data will be stored on Unilever's protected Teams environment to ensure security.		
2. Is this research dependent on a Data Transfer or Processing Agreement with a collaborating partner or third party supplier? *If yes please provide a copy of the signed DTA/DPA*		**No**				
3. Has this research been approved by another (external) research ethics committee (e.g.: HREC and/or MREC/METC)? *If yes, please provide a copy of the approval (if possible) and summarise any key points in your Risk Management section below*		**No**				
B: Location						
4. Will the research take place in a country or countries, other than the Netherlands, within the EU?		**No**				
5. Will the research take place in a country or countries outside the EU?		**No**				
6. Will the research take place in a place/region or of higher risk – including known dangerous locations (in any country) or locations with non-democratic regimes?		**No**				

H: More on Informed Consent and Data Management

NOTE: You can find guidance and templates for preparing your Informed Consent material(s) here

Your research involves human participants as Research Subjects if you are recruiting them or actively involving or influencing, manipulating or directing them in any way in your research activities. This means you must seek informed consent and agree/ implement appropriate safeguards regardless of whether you are collecting any PIRD.

Where you are also collecting PIRD, and using Informed Consent as the legal basis for your research, you need to also make sure that your IC materials are clear on any related risks and the mitigating measures you will take – including through responsible data management.

Got a comment on this checklist or the HREC process? You can leave your comments here

IV. Signature/s

Please note that by signing this checklist list as the sole, or Responsible, researcher you are providing approval of the completeness and quality of the submission, as well as confirming alignment between GDPR, Data Management and Informed Consent requirements.

Name of Corresponding Researcher (if different from the Responsible Researcher) (print)

Signature of Corresponding Researcher:

Date: 21-11-2024

Name of Responsible Researcher (print)

Signature (or upload consent by mail) Responsible Researcher:

Date:

V. Completing your HREC application

Please use the following list to check that you have provided all relevant documentation

Required:

- **Always:** This completed HREC checklist
- **Always:** A data management plan (reviewed, where necessary, by a data-steward)
- **Usually:** A complete Informed Consent form (including Participant Information) and/or Opening Statement (for online consent)

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
C: Participants						
7. Will the study involve participants who **may** be vulnerable and possibly (legally) unable to give informed consent? (e.g., children below the legal age for giving consent, people with learning difficulties, people living in care or nursing homes,).		**No**				
8. Will the study involve participants who **may** be vulnerable under specific circumstances and in specific contexts, such as victims and witnesses of violence, including domestic violence; sex workers; members of minority groups, refugees, irregular migrants or dissidents?		**No**				
9. Are the participants, outside the context of the research, in a dependent or subordinate position to the investigator (such as own children, own students or employees of either TU Delft and/or a collaborating partner organisation)? *It is essential that you safeguard against possible adverse consequences of this situation (such as allowing a student's failure to participate to your satisfaction to affect your evaluation of their coursework).*		**No**				
10. Is there a high possibility of re-identification for your participants? (e.g., do they have a very specialist job of which there are only a small number in a given country, are they members of a small community, or employees from a partner company collaborating in the research? Or are they one of only a handful of (expert) participants in the study?		**No**				
D: Recruiting Participants						
11. Will your participants be recruited through your own, professional, channels such as conference attendance lists, or through specific network/s such as self-help groups	**Yes**		Participants for this study have been recruited through my supervisor's connections and through individuals I have met in meetings. Potential risks associated with this recruitment method include: 1. Risk: Participants might be concerned about their privacy and the confidentiality of their responses, especially given the professional connections involved. • Mitigation: To address this, all participants will be provided with detailed information			

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
			about the study, including how their data will be used and protected. Anonymization techniques will be employed to ensure that individual responses cannot be traced back to specific participants. Additionally, informed consent will be obtained from all participants, ensuring they are fully aware of their rights and the measures in place to protect their privacy. 2. Risk: Participants might provide responses they believe are expected or desired, rather than their true opinions, due to their professional relationship with the researcher or the organization. • Mitigation: To minimize this risk, the importance of honest and unbiased responses will be emphasized. Participants will be reminded that their responses will be anonymized and that there are no right or wrong answers. The study will also include a diverse range of participants to balance perspectives and reduce the impact of any individual biases.			
12. Will the participants be recruited or accessed in the longer term by a (legal or customary) gatekeeper? (e.g., an adult professional working with children; a		**No**				

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
community leader or family member who has this customary role – within or outside the EU; the data producer of a long-term cohort study)						
13. Will you be recruiting your participants through a crowd-sourcing service and/or involve a third party data-gathering service, such as a survey platform?		**No**				
14. Will you be offering any financial, or other, remuneration to participants, and might this induce or bias participation?		**No**				
E: Subject Matter *Research related to medical questions/health may require special attention. See also the website of the CCMO before contacting the HREC.*						
15. Will your research involve any of the following: • Medical research and/or clinical trials • Invasive sampling and/or medical imaging • Medical and *In Vitro Diagnostic Medical* Devices Research		**No**				
16. Will drugs, placebos, or other substances (e.g., drinks, foods, food or drink constituents, dietary supplements) be administered to the study participants? *If yes see here to determine whether medical ethical approval is required*		**No**				
17. Will blood or tissue samples be obtained from participants? *If yes see here to determine whether medical ethical approval is required*		**No**				
18. Does the study risk causing psychological stress or anxiety beyond that normally encountered by the participants in their life outside research?		**No**				
19. Will the study involve discussion of personal sensitive data which could put participants at increased legal, financial, reputational, security or other risk? (e.g., financial data, location data, data relating to children or other vulnerable groups) *Definitions of sensitive personal data, and special cases are provided on the TUD Privacy Team website.*		**No**				
20. Will the study involve disclosing commercially or professionally sensitive, or confidential information? (e.g., relating to decision-making processes or business strategies which might, for example, be of interest to competitors)	**Possibly**		The study may involve disclosing commercially or professionally sensitive information, such as decision-making processes or business strategies. Potential risks and mitigation strategies include:			

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
			1. Risk: Participants might share sensitive information about Unilever's operations or strategies. • Mitigation: My Unilever supervisor will review the interview outcomes to identify confidential information, which will be placed in a confidential appendix. Data will be anonymized to protect identities, and participants will receive an informed consent form detailing the study's purpose and data usage. It will be mentioned at the start of the interview that participants do not have to share sensitive information.			
21. Has your study been identified by the TU Delft Privacy Team as requiring a Data Processing Impact Assessment (DPIA)? *If yes please attach the advice/ approval from the Privacy Team to this application*		**No**				
22. Does your research investigate causes or areas of conflict? *If yes please confirm that your fieldwork has been discussed with the appropriate safety/security advisors and approved by your Department/Faculty.*		**No**				
23. Does your research involve observing illegal activities or data processed or provided by authorities responsible for preventing, investigating, detecting or prosecuting criminal offences *If so please confirm that your work has been discussed with the appropriate legal advisors and approved by your Department/Faculty.*		**No**				
F: Research Methods						

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
24. Will it be necessary for participants to take part in the study without their knowledge and consent at the time? (e.g., covert observation of people in non-public places).		**No**				
25. Will the study involve actively deceiving the participants? (For example, will participants be deliberately falsely informed, will information be withheld from them or will they be misled in such a way that they are likely to object or show unease when debriefed about the study).		**No**				
26. Is pain or more than mild discomfort likely to result from the study? And/or could your research activity cause an accident involving (non-) participants?		**No**				
27. Will the experiment involve the use of devices that are not 'CE' certified? *Only, if 'yes': continue with the following questions:*		**No**				
• Was the device built in-house?						
• Was it inspected by a safety expert at TU Delft? *If yes, please provide a signed **device report***						
• If it was not built in-house and not CE-certified, was it inspected by some other, qualified authority in safety and approved? *If yes, please provide records of the inspection*						
28. Will your research involve face-to-face encounters with your participants and if so how will you assess and address Covid considerations?	**Yes**		The research will involve both virtual and face-to-face interviews. Most interviews will be conducted via Teams; however, interviews with the R&D team, with whom I work on Tuesdays and Thursdays, will take place face-to-face. - Mitigation: we will follow all current guidelines on health and safety.			
29. Will your research involve **either:** a) "big data", combined datasets, new data-gathering or new data-merging techniques which might lead to re-identification of your participants **and/or** b) artificial intelligence or algorithm training where, for example biased datasets could lead to biased outcomes?		**No**				
G: Data Processing and Privacy						
30. Will the research involve collecting, processing and/or storing any directly identifiable PII (Personally Identifiable Information) including name or email	**Yes**		The research will involve collecting, processing, and storing directly identifiable PII, such as names and			

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
address that will be used for administrative purposes only? (eg: obtaining Informed Consent or disbursing remuneration)			email addresses, for administrative purposes only, including obtaining informed consent. Potential risks and mitigation strategies include: 1. Risk: Unauthorized access to PII could lead to breaches of confidentiality and privacy. • Mitigation: PII will be stored securely within the protected Unilever Teams area. Access to PII will be restricted to me only. All PII will be stored for the duration of the graduation thesis and will be deleted or fully anonymized afterward. Participants will be aware of the fact that their information will be anonymized to readers.			
31. Will the research involve collecting, processing and/or storing any directly or indirectly identifiable PIIRD (Personally Identifiable Research Data) including videos, pictures, IP address, gender, age etc and **what other Personal Research Data** (including personal or professional views) will you be collecting?		**No**				
32. Will this research involve collecting data from the internet, social media and/or publicly available datasets which have been originally contributed by human participants		No				
33. Will your research findings be published in one or more forms in the public domain, as e.g., Masters thesis, journal publication, conference presentation or wider public dissemination?	**Yes**		Yes, my research findings will be published as part of my Master's thesis. The thesis will include a confidentiality appendix, where any sensitive information will be placed. This confidential information will be reviewed by my supervisor from Unilever to ensure that it is appropriately handled and protected. This approach ensures that while the main findings are publicly accessible, any proprietary or sensitive information remains confidential.			

			If YES please complete the Risk Assessment and Mitigation Plan columns below.		*Please provide the relevant reference #*	
ISSUE	**Yes**	**No**	**RISK ASSESSMENT – what risks could arise?** *Please ensure that you list ALL of the actual risks that could potentially arise – do not simply state whether you consider any such risks are important!*	**MITIGATION PLAN – what mitigating steps will you take?** *Please ensure that you summarise what actual mitigation measures you will take for each potential risk identified – do not simply state that you will e.g. comply with regulations.*	**DMP**	**ICF**
34. Will your research data be archived for re-use and/or teaching in an open, private or semi-open archive?		**No**				

Designing a strategic framework to guide Unilever towards EU's Packaging and Packaging Waste Regulations for 2030

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

The data for my project was discussed with my supervisor and mentor. I have also been in contact with Jeff Love, the data steward from IDE.

2. Date of consultation with support staff.

2024-11-21

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Interviews (raw)	.mp3	Face-to-face and online Teams interview.	To validate a created framework from literature and get insights on stakeholders' role and influence on PPWR-compliant design	Unilever Microsoft Teams area	Just me
Interviews (transcriptions)	.txt		To collect findings and insights for my report	As above	Me and my thesis supervisors

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- Other - explain below
- Methodology of data collection

Methodology for how I collected my data will be included in my graduation thesis.

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- Another storage system - please explain below, including provided security measures

In the protected Microsoft Teams area from Unilever.

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, first ask your Faculty Data Steward for advice. You can also check with the privacy website . If you would like to contact the privacy team: privacy-tud@tudelft.nl, please bring your DMP.

- Yes

About a person's role within the packaging design process.

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward for advice.

- Yes, confidential data received from commercial, or other external partners

Probably not the case, however it could be that some specific parts of discussing a packaging type could be confidential. This will not be included in the findings in the report and only if necessary be in the confidential appendix (otherwise it will be anonymised/deleted).

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager when answering this question. If this is not the case, you can use the example below.

Data will be stored in the protected Microsoft Teams area from Unilever, which is not openly accessible and owned by myseld. In the master thesis report, data will be anonymized and confidential data will be stored in the confidential appendix.

10. Which personal data will you process? Tick all that apply

- Signed consent forms
- Email addresses and/or other addresses for digital communication
- Names and addresses

11. Please list the categories of data subjects

The data subjects will include 8 people that work within Unilever, varying from marketing function to design function. 4 People are external and are experts in recycling or suppliers of Unilever.

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

People I interview will sign an adapted form of the consent form provided by TU Delft (HREC).

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).
If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.
If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.
If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Personal research data will be destroyed after the end of the research project

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- All other non-personal data (and code) underlying published articles / reports / theses

29. How will you share research data (and code), including the one mentioned in question 22?

- My data will be shared in a different way - please explain below

My data will be shared as part of my graduation report in the TUD education repository.

30. How much of your data will be shared in a research data repository?

- < 100 GB

31. When will the data (or code) be shared?

- At the end of the research project

32. Under what licence will be the data/code released?

- CC BY

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

This graduation thesis is in collaboration with Unilever Nutrition R&D EU.

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

My project - along with all of its data - will likely be deleted if I leave the university. If I am working with anyone who wishes to continue the work, I will leave a copy of the data with my supervisor, Shahrokh Nikou.

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

None - I will handle all data management on my own using resources provided by the university.

Date 01-Dec-2024
Correspondence hrec@tudelft.nl

TU Delft

Human Research Ethics
Committee TU Delft
(http://hrec.tudelft.nl)

Visiting address
Jaffalaan 5 (building 31)
2628 BX Delft

Postal address
P.O. Box 5015 2600 GA Delft
The Netherlands

Ethics Approval Application: Designing a strategic framework to guide Unilever towards EU's Packaging and Packaging Waste Regulations for 2030
Applicant: Bronsky, Tessa

Dear Tessa Bronsky,

It is a pleasure to inform you that your application mentioned above has been approved.

Thanks very much for your submission to the HREC which has been conditionally approved. Please note that this approval is subject to your ensuring that the following condition/s is/are fulfilled:

1. Please find an alternative mitigation to the risk identified in HREC Checklist, item E20: the company supervisor should not be in charge of deciding for the 20% included that are not employed by Unilever.

In addition to any specific conditions or notes, the HREC provides the following standard advice to all applicants:
• In light of recent tax changes, we advise that you confirm any proposed remuneration of research subjects with your faculty contract manager before going ahead.
• Please make sure when you carry out your research that you confirm contemporary covid protocols with your faculty HSE advisor, and that ongoing covid risks and precautions are flagged in the informed consent - with particular attention to this where there are physically vulnerable (eg: elderly or with underlying conditions) participants involved.
• Our default advice is not to publish transcripts or transcript summaries, but to retain these privately for specific purposes/checking; and if they are to be made public then only if fully anonymised and the transcript/summary itself approved by participants for specific purpose.
• Where there are collaborating (including funding) partners, appropriate formal agreements including clarity on responsibilities, including data ownership, responsibilities and access, should be in place and that relevant aspects of such agreements (such as access to raw or other data) are clear in the Informed Consent.

Good luck with your research!

Sincerely,

Dr. Ir. U. Pesch
Chair HREC
Faculty of Technology, Policy and Management

F. Interview protocol

The purpose of this interview is to test a preliminary framework designed to identify and prioritise factors critical for PPWR (Packaging and Packaging Waste Regulation)-compliant packaging. Specifically, the interview aims to understand how these factors influence sustainable packaging design, assess the role of different stakeholders, and rank these factors in order of their influence on the design process. As specific stakeholders are connected to specific packaging types, there are 2 common questions for all stakeholders and 3(+) more specific questions dedicated to the stakeholder and the packaging type.

Pilot testing
This interview was pilot tested with an expert and a fellow student to ensure smooth flow and clarity. Based on the pilot, several adjustments were made to the original protocol. For instance, the introduction now provides more context and specifics, some redundant questions were removed, and other questions were modified to allow for more open-ended responses.

List of interviewers, areas of expertise (N=12)
From the stakeholder analysis in chapter 2.4, important stakeholders have been mapped. Through explorative conversations, 6 stakeholder types have been chosen to interview with a total of 13 people. These are the following:

1. Sustainability expert (N=3)
2. Packaging designer or engineer (N=2)
3. Supply chain (N=2)
4. Suppliers (N=2)
5. Recycling expert/waste manager (N=3)
6. Marketing specialist (N=1)

COMMON PART

Introduction

Introduction of the thesis
My name is Tessa, and I am currently a graduate intern under Marije Luijendijk, Sustainable Packaging Manager for EU Nutrition at Unilever. My research focuses on assessing the recyclability of part of Unilever's current product portfolio in alignment with the Packaging and Packaging Waste Regulation (PPWR) targets for 2030. The PPWR are a set of regulations that are being created by the European Commission to reduce packaging pollution and to create a more circular economy. My goal is to identify factors that influence packaging recyclability and provide actionable recommendations to transition towards a fully recyclable packaging portfolio.

Purpose of the Interview

Over the past weeks, I have analysed and assessed several packaging types, including [specific packaging for this interview - explaining current problems for that type of packaging]. I have developed a framework to guide the design and implementation of recyclable packaging and aim to test and refine this framework through interviews with key stakeholders like you, involved in packaging design and sustainability. The insights gathered will help identify the most critical factors to consider when creating PPWR-compliant packaging.

Confidentiality

This interview will be recorded and transcribed purely for analysis. Responses will remain confidential and findings will be anonymised in the final analysis. Give out and explain the consent form.

Duration

The interview will take approximately 30 minutes.

Background questions

Professional background

- Could you briefly describe your role within (or towards) Unilever and how it connects to packaging and sustainability efforts?

Influence and challenges

- In your role, how do you perceive your influence on the design, implementation or recyclability of packaging?
  - What key challenges do you face in aligning with sustainability goals?

Critical factors and risks

- What do you believe are the most critical factors or risks that need to be addressed to ensure successful compliance with PPWR requirements [ensure PPWR has been explained in introduction]?
  - For example whilst maintaining functionality and performance of the current packaging?
  -

SUSTAINABILITY LEAD

1. What are the biggest barriers to transitioning packaging types to fully recyclable designs?
2. What is most important in the transition to meeting sustainability targets?
   a. How do you balance meeting sustainability targets with the practical challenges of packaging design and functionality?
3. What were wishes from others that were not pursued due to sustainability, why?
   a. What were the considerations and what was the decisive factor?
4. What role do you see other stakeholders in shaping packaging innovation for recyclability/where do other stakeholders come into play?

PACKAGING DESIGNER

1. What are primary design considerations for product [X] and how does sustainability factor into these decisions?
1. What are the biggest challenges to meet both functional and sustainability requirements for product [X]
2. What elements of current packaging (branding, materials) do you think are most important to maintain (for consumer and product needs)?
3. How do you perceive the importance of your role as a designer in the PPWR ecosystem? (follow-up of influence and challenges question)
4. How can designers be better supported in creating packaging that is both PPWR-compliant and consumer-friendly?

SUPPLY CHAIN

1. How important is sustainability and the PPWR law for P&I?
2. How do material/recyclability choices influence sourcing, logistics and production?
3. What role does supply chain play in addressing trade-offs between recyclability and operational efficiency
4. What events create barriers to achieving higher recyclability for these packaging solutions? What about opportunities?

SUPPLIERS

1. What are the specific challenges you face in producing in-mould labels for [X]/ or recyclable materials?
2. What technical innovations should be explored to improve the recyclability?
3. How would you collaborate with Unilever/Recyclers to ensure materials and processes align with sustainability targets?

RECYCLING EXPERT

1. What challenges do in-mould labels and their inks pose for detectability and recyclability, particularly for [X] → Inks & IML & 50% surface recyclability challenges for detectability
2. Why do multi-material components complicate the recycling process?

- When is it okay to have multi-material components? → Recovered energy of certain materials
- For plastic with a paper sleeve, the sorting lies with the consumer (paper detection vs plastic on the inside). What do you think of this?
- What trends do you see in the recycling process (that could make it more possible for 2030?)?

- How do compatibility, rigidness and packaging shape affect sorting and recyclability in existing waste management systems?
  - How do you see innovations for the future around this?
- What changes to design or materials would most improve the recyclability of these packaging types?

MARKETING SPECIALIST

1. How important is sustainability and the PPWR law for marketing?
   a. How does marketing see sustainability as usable for strategy? [For example promotion options.]
2. What role does marketing play in educating consumers about proper disposal and recycling of these packaging types?
3. From a marketing perspective, what are the most critical factors to maintain in packaging design when making it more sustainable?
4. What future strategy direction are the mini-meals moving into that have influence on recyclability and design decisions?
5. If we would have to go into a totally different packaging due to sustainability reasons. Why is packaging X as it is now? [Explained problems like IML, no black colour, label surface 50%]
   a. What would you see as a direction for solutions?

COMMON PART

Closing

Additional recommendations

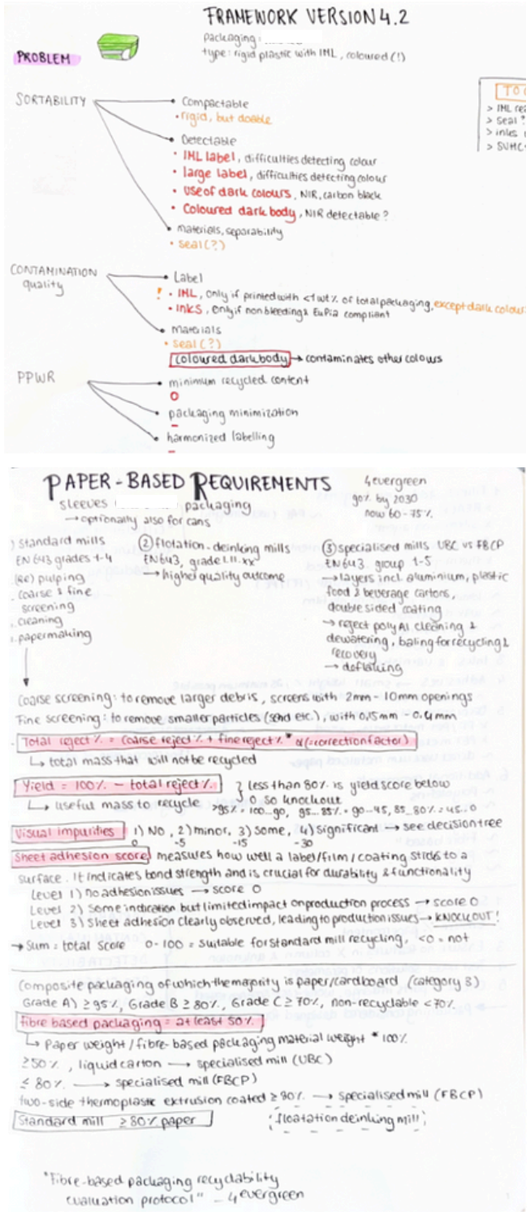
- If you would have to think about solutions or directions for product [X], what can you think of?
- Are there any recommendations or insights you wish to share?

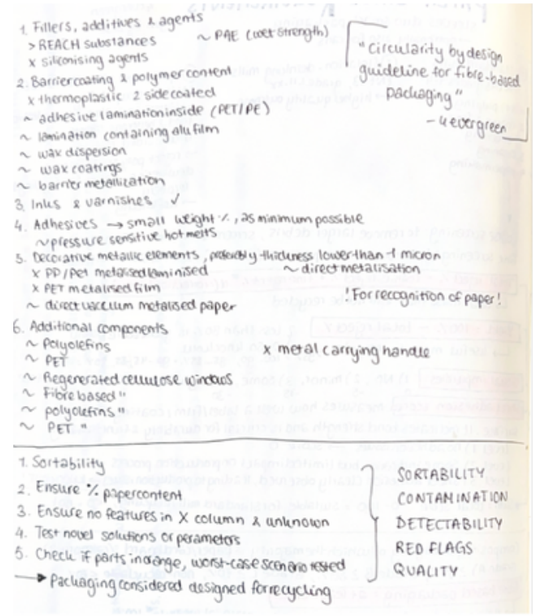
Follow-up

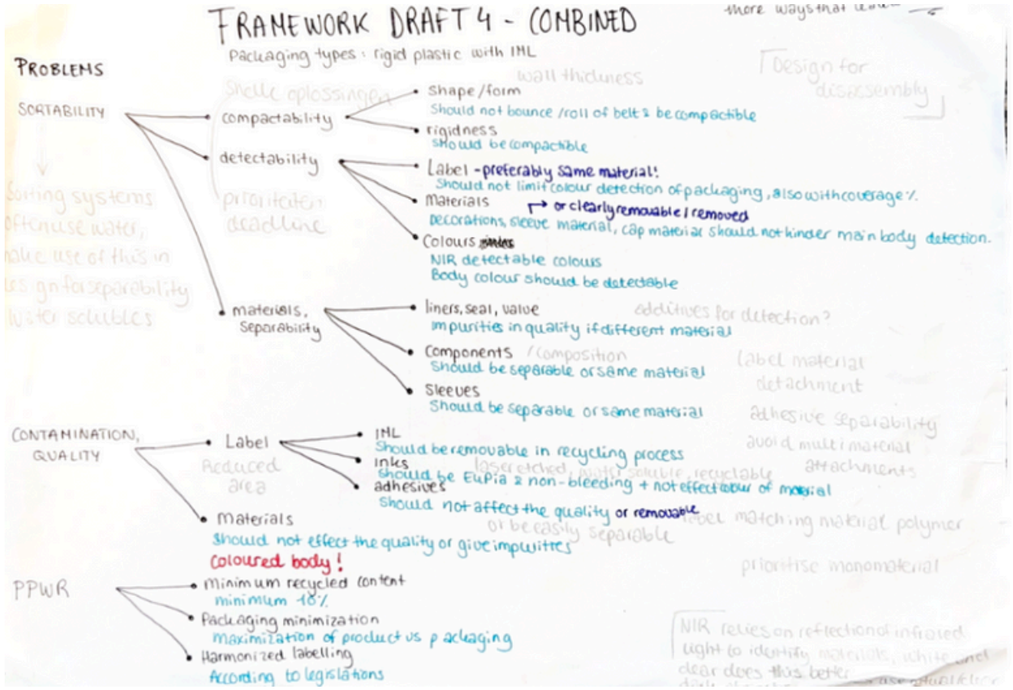
- Can I reach out if additional questions arise and for design validation?
- Thank you for your time and insights. If you have any further questions or insights that pop-up later, please do not hesitate to contact me.

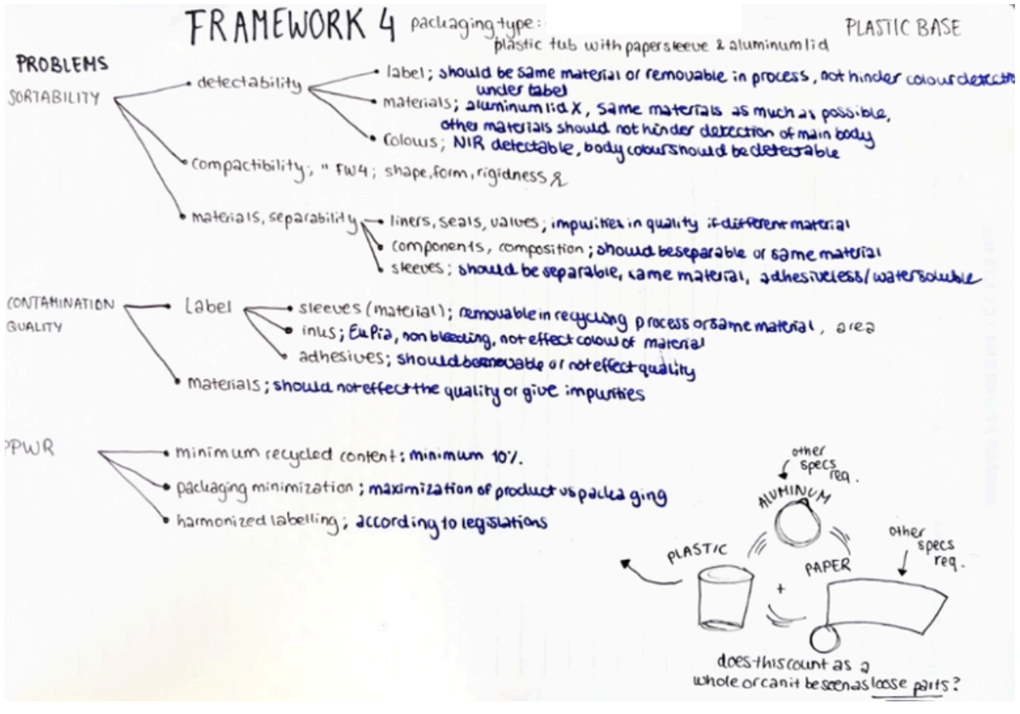
G. Draft frameworks

Please see confidential appendix for extra drafts









H. Score component breakdown for paper recycling

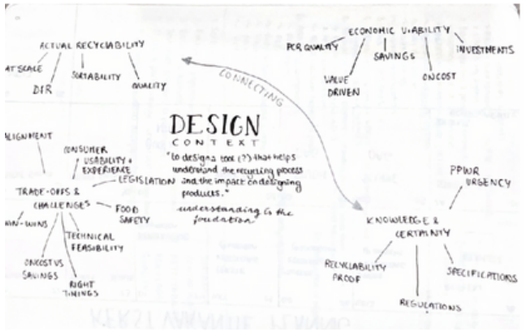
Total score	Standard Mill Recyclability	SCORE COMPONENT BREAKDOWN										
			YIELD			VISUAL IMPURITIES				SHEET ADHESION			
			SCORE	DESCRIPTION		LEVEL	SCORE	DESCRIPTION		LEVEL	SCORE	DESCRIPTION
/100	0-100 Suitable for Standard Mill recycling	TOTAL SCORE COMPOSED	100 - 90	The method indicates that the packaging is expected not to pose any repulpability issues in the standard mill and is therefore considered **Best in Class**.	AND	LEVEL 1	0	Poses **no visual quality issues**.	AND	LEVEL 1	0	Poses **no adhesion issues**.
			89 - 70	The method indicates that the packaging has **minor repulpability issues** that could have limited impact on the recyclability in the standard mill.		LEVEL 2	-5	Poses **minor visual quality issues** that can be acceptable in the mix.		LEVEL 2	0	Poses **minor adhesion issues** that can be acceptable in the mix.
			69 - 50	The method indicates that the packaging has **some repulpability issues** that affect the process in the standard mill and should therefore not be abundant.		LEVEL 3	-15	Poses **some visual quality issues** that can be acceptable in the mix for certain types of production.				
	<0 Not suitable for Standard Mill recycling. Potentially recyclable in other mill types*		49 - 0	The method indicates that the packaging has some **significant repulpability issues** that have a significant impact on the process in the standard mill and should therefore be avoided when possible.		LEVEL 4	-30	Poses **significant visual quality issues** that can be problematic in the mix. Sample is at risk of receiving a KO in future versions of the Evaluation Protocol**		LEVEL 3	KO	Poses **significant adhesion issues** that can have a significant impact on the process in the standard mill
			<0	The method indicates that the packaging has **major repulpability issues** which could stop the process at a standard mill and therefore are not suitable for this mill. It is recommended to evaluate this product with either Part II or III.								

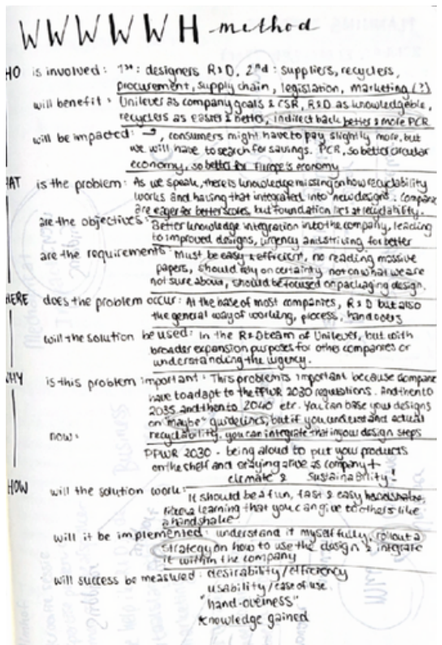
I. Design process

This section shows the design thought process more extensively.

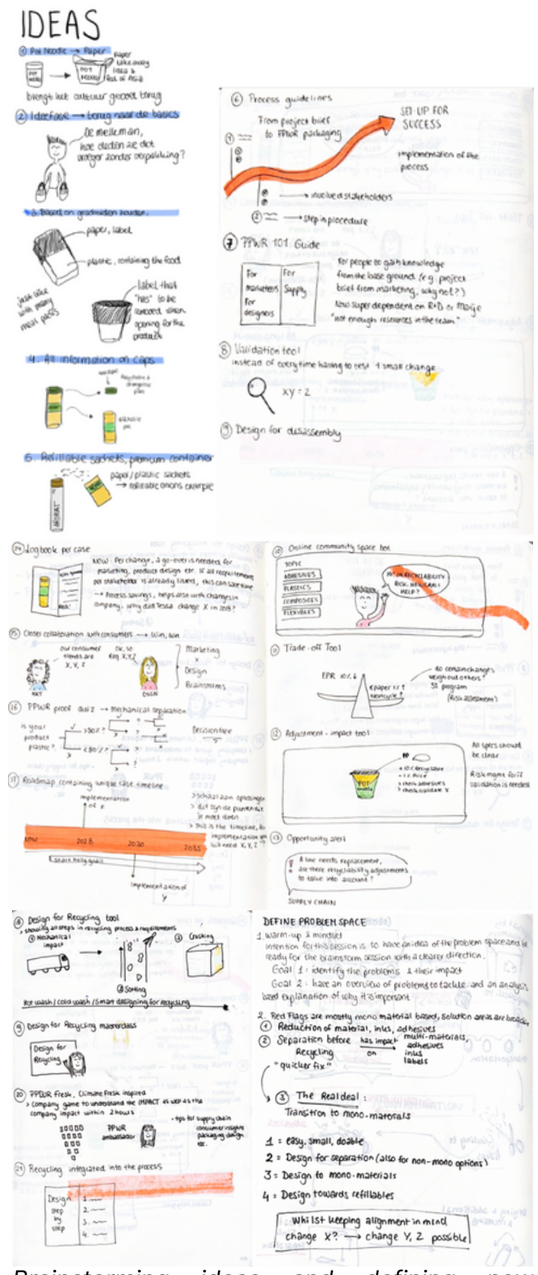
I.1 Design process

The detailed process is thoroughly explained in Chapter 7. This section aims to provide a glimpse into the thought process behind the work. As such, this appendix includes images from my "sketchbook," accompanied by a brief description to offer context and insight.

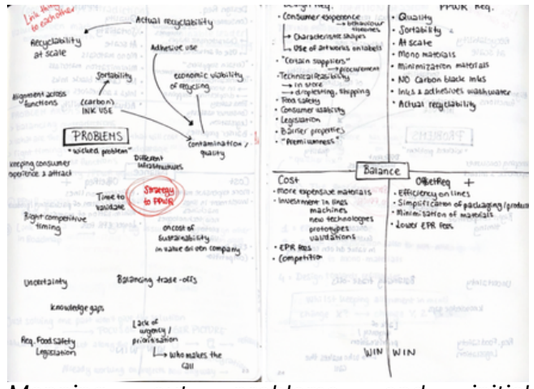




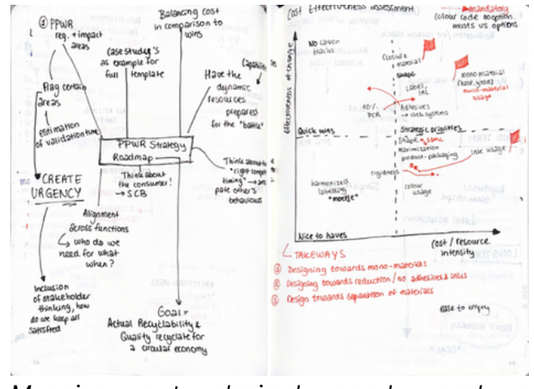
Initial design context and WWWH for first scoping.



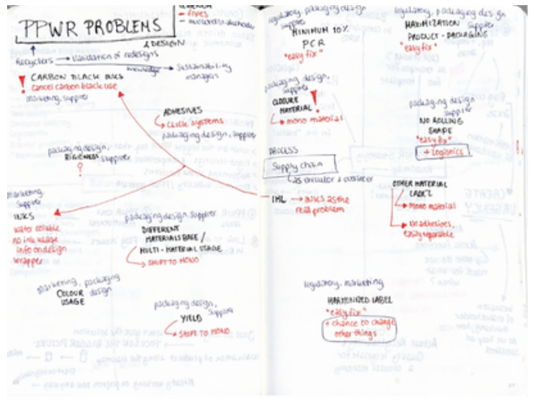
Brainstorming ideas and defining new problem space



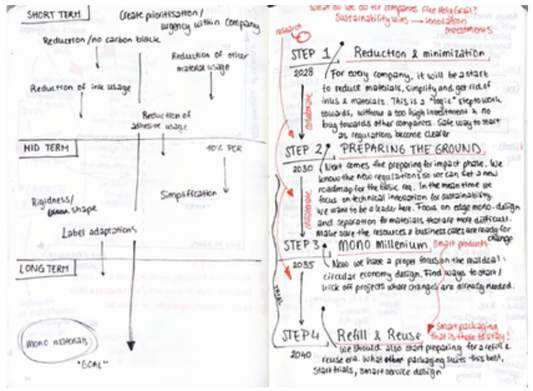
Mapping out problems and initial requirements



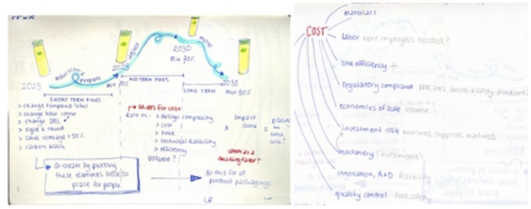
Mapping out desired needs and a cost/resource intensity vs effectiveness of change matrix



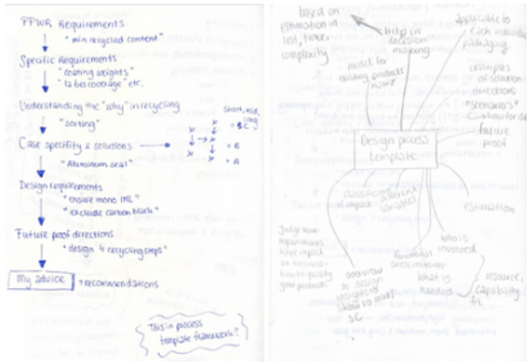
Mapping out PPWR general requirements and design changes



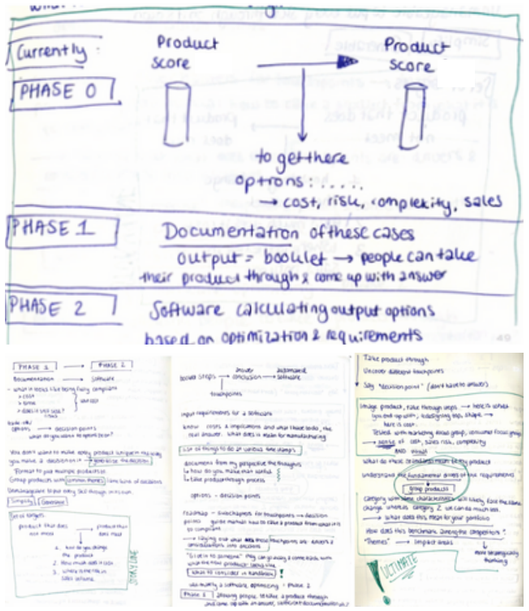
Translating into short- mid- and long term goals, leading to roadmap pillars



Mapping ideas for showing complexities



Brainstorming design process template ideas



Building into phases and complexity as decision points

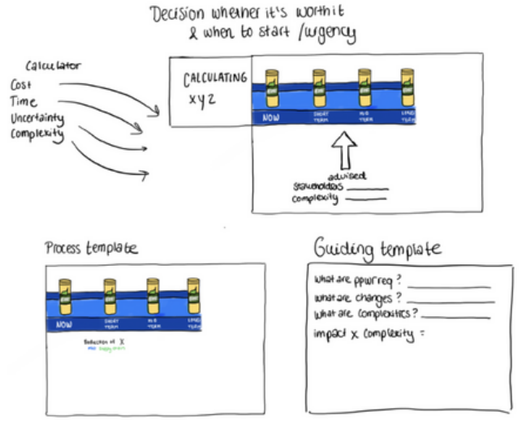
I.2 Analysing different cases

All cases were analysed broadly on possible design changes based on current requirements. These were mapped in the cost-effectiveness matrix and translated to short- mid- and long term factors.

Please see confidential appendix

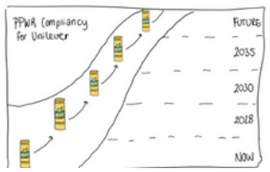
I.3 Solution visual forming iterations

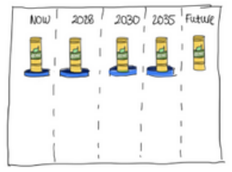
The drawings below show the visualisation process for some of the ideas. Mostly they were focused on a process template and decision making tool.

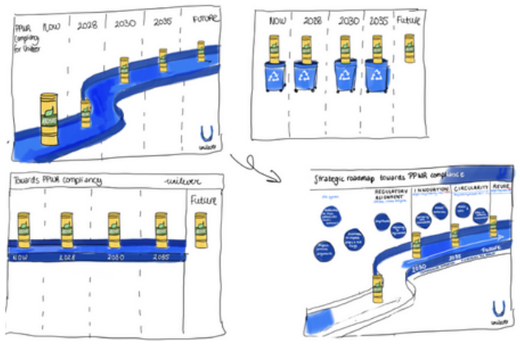


I.4 Roadmap visual iterations

The images below show some iterations on the roadmapping. Eventually a different style was chosen that fits better with Unilever's style







J. Complexity transition score

To prioritise design changes, you can develop complexity to transition scoring. This score is based on internal discussions and would need further research and refinement. However, for now it can be a good help when having to make complex decisions whilst comparing packaging design changes.

Cost impact (C): includes production cost changes, supplier investments, and potential cost savings.
Scale: 1 (low cost impact) to 10 (high cost impact).

Time to implement (T): accounts for design development time, supply chain adaptation, and validation cycles.
Scale: 1 (short time frame) to 10 (long time frame).

Consumer perception change (P): evaluates how significant the change is from the consumer's perspective, such as usability or visual appeal.
Scale: 1 (minor change, easily accepted) to 10 (major change, potential resistance).

Technical feasibility (F): measures how easily the change can be achieved within existing technical constraints, including machine adaptability and material compatibility.
Scale: 1 (technically simple) to 10 (technically challenging).

Complexity Drivers (CD): the secondary drivers mentioned in the previous section can be assigned additional scoring

Transition score = $wC \cdot C + wT \cdot T + wP \cdot P + wF \cdot F + wCD \cdot CD$

Where (wC,T,P,F,CD) are weights assigned to the importance of each factor summing to 1 to your liking. CD can also be left out of the calculation.

If a design change has a high transition score but is mandatory (e.g., for regulatory compliance), it should be flagged as a strategic priority for immediate focus.

This scoring system can provide a structured approach to evaluating and prioritising packaging design changes, helping to streamline the decision-making process and highlight areas requiring additional attention.

Limitations
Since each case is unique, it is challenging to provide accurate cost and time estimates prior to trialling, and these may still be subject to change. Further research into the complexity drivers is necessary to determine the appropriate weightings and requirements, which will then inform the development of a data-driven decision tool. Therefore, this 'transition score' serves as a preliminary concept to aid decision-making, but it requires further development.

K. Validation session 2

This appendix section gives the more extensive results on the validation session.

Handbook

- Include PPWR main regulations, timeline, rules, scores and basics
- What does it mean for our portfolio
- Handbook is maybe more for beginners or if you want to look back in depth if you have not been in the project for long. Good reminder, but a bit too much. Something in between would be better
- Nice place to store learnings together.
- Handbook what we have already done and where we are now vs handbook creating something new
- Can be part of the 'research assistant' so we can ask questions about PPWR/what is in the document - AI to check the handbook

Roadmaps

- We already do savings & taxations now, along with other things that need to start earlier. Bring it forward.
- What pops up now, what data do we need for the tool, makes me start thinking. User friendly.
- Data driven decision tool is something we should get into our system. It would need many updates so to incorporate the checklist is difficult.
- Our specifications need to be adopted and set up for recyclability. Originally specs were not created for recyclability to this level. It should be clear what is good and not good with regards to the specifications. Also needed to comply with the regulations
- 2028 will be more concrete so makes sense for the tool
- The tools keep evaluating so indeed we are constantly behind unless we automate it.
- Are our specifications enough specified; there keep coming more questions, specifics etc. Important for the regulations as well.
- We already need to know what is needed in 3 years time
- Nice that you are system thinking; PPWR as a system
- Decision tree algorithm based on steps
- Difficult when you are ahead of the curve to make investments etc. Can sometimes also be a lack of importance/urgency.
- DDDT: software should be able to pick up assemblies and look at the full packaging if you need to do the recyclability testing.
- In-between step could be a decision tree, can be AI or a flow of work
- How are we going to show to the regulations that something is compliant; do we have a system
- We need a place to store the data that is needed for the regulations, a system indeed, but garbage in = garbage out, so should incorporate the right data

Good	To improve	Other
Clear, 1-6 nice Reminders about factories etc Use it as checklist Digital use Clear 6/7 Use 6/7	Check Unilever colours, make it feel a bit more Unilever Add interactivity Look into [confidential] Images are a tad busy and detailed, see if you can simplify or make it more Unilever	Quite some text but doable
Right order Check boxes work Nice that there are also images, makes visually attractive Digital to reuse for every project, ability to add comments on the go, possibility to share with others Clear 5/7 Use 6/7	Put a deeper explanation, bit more in-depth somewhere e.g. opportunities with suppliers; what is meant Make the visuals in-between a bit more relatable to the text; e.g. marketing clearly marketing. Bold/highlight sections Link to different documents, test plans etc. clickable	
Pleasing to the eye Nice order Draws my attention Very clear that it is a flow Visual reminder if it hangs somewhere A nice tool to also push others from other departments to say this is our way of working/our process so we need to comply to this → feedback on others Boxes make you tick them off in your head Useful as infographic Also nice for newbees Clear: 6/7 Use 6/7	Link to where you can find it online; everything linked or like a living document that you can edit as PPWR keeps changing. Clickable option to go deeper to the question or the reasoning behind something.	If you brief it correctly it is really something we could use Also very handy for newcomers, but then it would be useful to add more links e.g. what you mean with certain terms or how to analyse things [confidential] gets used for large innovation projects
Nice that is still semi-open, makes people think further for themselves Nice for newbees Clear 6/7 Use 7/7 Very complete	Contact recycling experts = also regulatory experts Link to things or further explanation Some things might be a bit double e.g. 4; technical feasibility, but not sure, also fine Expert could also be someone who has already done the process in project team	This could be our new way of working, we can put it on the Teams and use it as a team.

Complete Clear 6/7 Use 5/7 (links, templates etc)	Also take into account the consumer disposal in step 1; what type of waste stream is that or explain this one is for common Technical feasibility could be a bit broad Material costs vs costs for the line vs oncosts… Portfolio simplifications & harmonization for design ideas Add links/documents for example through PowerPoint, a used format, not too complex See if you can put it in the time frame of 5 years, which is our deadline as obstacle	[confidential] system where you can establish this
Clear Like the visuals	Maybe you can add one example template where you did that for a product packaging Add a short introduction on PPWR/timeline indication, what when how	
This should be part of our process for every packaging innovation We can activate a field to make things PPWR compliant, to follow this path as kind of a short course/part of the training; make obligatory field in our software specs currently	Maybe make a start for a decision tree kind of tool as an in-between step Make it interactive to tick boxes or click links Maybe it can start with the first question, then go to the next and then the next	Design your own co-pilot to make this checklist (would take a month) Suggest your ideas and propose it, someone else can take it from there. We can visualise the data in dashboards as well

Convincing tool to present to stakeholders	Other stakeholders should be aligned instead of just delivering input Challenge to also really understand the NO-GO's, should be in the design brief from the beginning to clarify to other stakeholders Build in the shelf-life Maybe something on how to overcome the blockers; e.g. not understanding PPWR, prioritisation setting. Other pillars of PPWR: ensure you have a link to it and change this title to Recyclability so people do not forget the other pillars!	Concern about no official guidelines yet; how to make it standardized so it does not need changing every 3 months
Clear This could be something for also outside foods	Make it clear that you do not have to change the full design, you can also change parts that do not work. We also need the test measurements for regulatory For the critical points in the process you can highlight or use exclamation marks Also include the option to fully innovate e.g. no more sachets but a refillable machine. Show the critical points in the process; what do you really need to do to go further; quality criteria for the process.	What is the future of recycling (what can our suppliers do vs what can recyclers do)