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From Compliance to Circularity: A Design-Led Approach to Recyclable Packaging

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ABSTRACT

The transition to recyclable packaging is a strategic priority for the Fast-Moving Consumer Goods (FMCG) sector, aligning with the EU Packaging and Packaging Waste Regulation (PPWR). Adapting to regulatory uncertainty and integrating evolving recyclability criteria require not only technical innovation but also organisational transformation and cross-functional alignment. This paper investigates how FMCG companies can develop dynamic capabilities to embed recyclability into packaging design, balancing sustainability, functionality and business viability. This paper aims to develop and validate design-led toolkits that enable FMCG companies to integrate recyclability and regulatory compliance into packaging innovation in alignment with the EU PPWR. Drawing on a mixed-methods approach combining literature review, stakeholder interviews and a case study within the case company's packaging division, we develop and validate strategic and tactical roadmaps and a recyclable-ready design process template. The toolkits support managerial decision-making by enabling regulatory preparedness, sustainable innovation and enhanced collaboration across R&D, marketing and supply chain functions. By framing recyclability as both a design and strategic organisational challenge, this paper positions PPWR compliance readiness as a dynamic capability and offers actionable frameworks for FMCG companies' transition towards circular packaging in a complex regulatory landscape. The findings contribute to sustainability-oriented innovation literature and provide practical recommendations and solutions to managers and decision-makers aiming at sustainable packaging transitions while maintaining competitive advantage.

1 | Introduction

Sustainability has become a key strategic challenge for firms in resource-intensive sectors, driven by intensifying regulatory pressures, evolving consumer expectations and environmental imperatives reshaping business models (Panigrahi et al. 2025; Santa-Maria et al. 2025; Stewart and Niero 2018). Within the Fast-Moving Consumer Goods (FMCG) sector, packaging is a significant contributor to environmental impact, particularly through waste generation and plastic consumption, making sustainable packaging innovation a priority for competitive advantage and regulatory compliance (Ding and Zhu 2023; Hellström and Olsson 2016; Mura et al. 2024; Niero 2023; Nwabekee, Abdul-Azeez, Agu, and Ignatius 2024).

The European Union's Packaging and Packaging Waste Regulation (PPWR) (European Commission 2022) emphasises the growing regulatory focus on circular economy (CE) principles (Niero et al. 2017). Mandating graded recyclability standards by 2030 and restricting non-compliant materials, the PPWR creates significant uncertainty and complexity for FMCG companies operating across diverse markets (EUR-LEX 2025; Nilsson et al. 2024). Addressing these challenges requires not only dynamic organisational capabilities that

integrate regulatory foresight, cross-functional collaboration and design innovation but also the capability to balance sustainability practices with cost, functionality and consumer appeal (Amui et al. 2017; Eisenhardt and Martin 2000; Teece et al. 1997).

Despite growing research on CE and sustainable packaging (Kirchherr et al. 2017; Zhu et al. 2022), gaps remain in understanding how FMCG companies operationalise compliance readiness as a dynamic capability, embedding recyclability early in packaging design and organisational processes. Much of the prior studies focus on technical or environmental assessments, with limited integration of strategic management perspectives on regulatory adaptation and organisational transformation (Bertassini et al. 2021; Goodman et al. 2017; Granato et al. 2022). Moreover, the aim is to develop and validate a design-led toolkit that operationalises compliance readiness as a dynamic capability, supporting FMCG companies in embedding recyclability and regulatory foresight into packaging design and organisational processes. To achieve this aim and to address this void in the literature, this paper poses two research questions:

> RQ1: How can FMCG companies strategically prepare for the EU 2030 PPWR amid regulatory uncertainty while balancing sustainability, functionality and business viability?
>
> RQ2: What roles do packaging designers and cross-functional teams play in enabling a successful transition to PPWR-compliant recyclable solutions?

To answer these questions, we employ a qualitative mixed-methods approach combining literature review, in-depth stakeholder interviews and a case study within the company's R&D Foods Packaging division. The case company under investigation is a global leader in FMCG based in the Netherlands; has a diverse portfolio across food, beverages, home care and personal care; and is committed to sustainable and circular packaging. Its scale, product diversity and strategic emphasis on environmental responsibility make it an idea case to investigate packaging innovation under the EU PPWR. The objective is to capture real-world insights into how large FMCG companies manage the complex interplay of regulatory compliance, design innovation and cross-functional collaboration, while striving for circular packaging.

This research develops and validates a design-led toolkit including strategic and tactical roadmaps and a recyclable-ready design process template to position and operationalise compliance readiness as a dynamic capability, facilitating early-stage alignment, knowledge sharing and regulatory foresight across R&D, marketing, procurement and supply chain functions.

The contributions include a validated, scalable framework and practical design tools adaptable to diverse organisational contexts and product portfolios. By embedding recyclability considerations early and cross-functionally, FMCG companies are empowered to accelerate sustainable packaging transitions while maintaining competitiveness and consumer appeal. Theoretically, this research advances sustainability-oriented innovation and organisational transformation literature (Adams et al. 2016) within regulated environments by framing recyclability compliance as a strategic organisational challenge and PPWR compliance readiness as organisational dynamic capability (Bertassini et al. 2021; Lewandowski 2016). Practically, it provides actionable frameworks and tools that help practitioners and decision-makers at FMCG companies address regulatory complexity and position themselves as leaders in circular packaging.

The remainder of this paper is structured as follows: Section 2 details relevant literature; Section 3 outlines the methodology; Section 4 presents results, followed by the design phase illustrating the design-led toolkit developed in Section 5. Section 6 discusses and elaborates on the results, and Section 7 concludes with the contributions, limitations and directions for future research.

2 | Literature Review

This section synthesises key domains relevant to sustainable packaging innovation within FMCG companies, focusing on the intersection of CE principles, packaging design and recyclability, regulatory frameworks and organisational transformation. By reviewing existing knowledge and identifying gaps, the review lays the foundation for the development of an integrated framework that guides FMCG companies in preparing for compliance with the EU 2030 PPWR. The review also informs the empirical investigation and design-led tools' development presented in the later sections.

2.1 | Sustainability and the CE: A Strategic Perspective

The EU PPWR is grounded in CE principles, which seek to replace traditional linear 'take-make-dispose' models with regenerative systems emphasising reducing, reusing, recycling and recovery of materials along supply chains, leading to a systemic shift towards sustainable development (Bocken et al. 2014; Kirchherr et al. 2023). Central to CE is eco-efficiency, which emphasises both minimising waste and resource consumption and promoting closed-loop systems that encourage durability, reuse and recyclability (Kara et al. 2022). CE operates across micro, meso and macro levels, involving diverse stakeholders such as firms, consumers, suppliers, manufacturers and waste management organisations, requiring coordinated action across these stakeholders and value chains (Ellsworth-Krebs et al. 2021; Kirchherr et al. 2017; Zhu et al. 2022).

Despite its promise, CE implementation comes with challenges such as material limitations, technological constraints in reprocessing and socio-economic inequities (e.g., marginalisation of voices from the Global South), highlighting the complex socio-technical systems nature of circular transitions (Bertassini et al. 2021; Corvellec et al. 2021). From a strategic perspective, firms must develop dynamic capabilities to address these complexities and regulatory landscapes, leveraging CE as a source of competitive advantage (Amui et al. 2017; Konopik et al. 2021).

2.2 | Packaging Design and Sustainable Innovations

Packaging is classified into primary, secondary and tertiary types (Jain and Hudnurkar 2022), with primary packaging contributing to most of the waste and sustainability challenges due to its direct interaction with consumers and regulatory constraints (Ncube et al. 2021). The multifunctional roles of primary packaging, including containment, protection and convenience, complicate its transition towards sustainability and recyclability, necessitating innovative design solutions to align environmental requirements with business objectives (Annadur and Jain 2023; Boz et al. 2020). Recent innovations such as sustainable and green packaging (SOGP) (Han et al. 2018), combined with active, intelligent and smart packaging technologies, show promise but create technical, cost and scalability challenges (Firouz et al. 2021). Importantly, Grönman et al. (2012) emphasise that the environmental impact of packaging must be assessed within the broader context of waste reduction, highlighting the need for strategic lifecycle thinking in packaging innovation. From a business strategy standpoint, packaging innovation not only advances environmental goals but also serves market differentiation and brand positioning, requiring cross-functional integration of R&D, marketing and sustainability teams to deliver consumer-appealing, regulation-compliant solutions (Iglesias et al. 2022; Piller et al. 2011).

2.3 | Key Dimensions for Packaging Recyclability and Compliance

To comprehensively address the challenges of recyclable packaging under evolving regulations, this research organises recyclability and compliance into three interrelated dimensions: sortability, contamination (Jakobs and Kroell 2024) and PPWR regulatory requirements[1] (EUR-LEX 2025). These dimensions represent key factors shaping packaging design, recycling processes and organisational strategies for compliance.

i. Sortability refers to the packaging's capacity to be efficiently collected, identified and separated within recycling systems. It includes compactability (influenced by shape and form), detectability (the ability of sorting technologies to recognise labels and materials) and materials separability (ease of disassembling multicomponent packaging). Effective sortability is crucial to reduce contamination and maximise recycling efficiency by facilitating accurate sorting and processing (Hildebrandt et al. 2017; Kriwet et al. 1995; Ragaert et al. 2017). These factors collectively define the technical feasibility of recycling and are central to the packaging's end-of-life performance. Their integration into a unified framework is essential for guiding actionable design decisions.

ii. Contamination addresses substances or materials that interfere with recycling processes and reduce recyclate quality. This includes label-related contamination such as inks, adhesives and in-mould labels (IMLs) and material contamination from incompatible polymers or multimaterial components that complicate recycling streams. Minimising contamination is essential to preserve material integrity and recyclability standards (Ncube et al. 2021; Vogt et al. 2021). Contamination minimisation directly affects recyclate quality and compliance, emphasising a holistic consideration alongside sortability.

iii. PPWR Regulatory Requirements represent the legislative mandates driving packaging recyclability and sustainability. The EU PPWR imposes specific requirements including minimum recycled content, packaging minimisation to reduce material use and harmonised labelling to standardise consumer and recycling sector information. These regulations drive both constraints and innovation

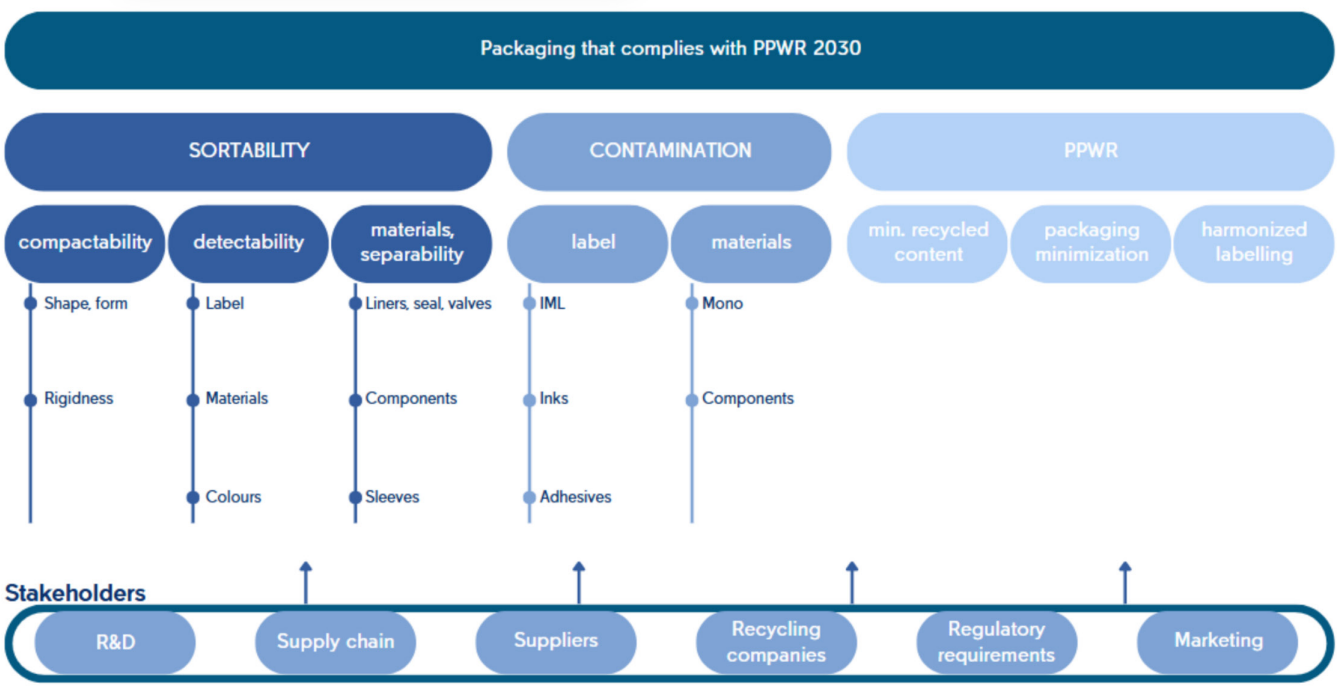

FIGURE 1 | Recyclable packaging compliance framework.

drivers, requiring strategic alignment across design, supply chain, marketing and compliance functions (Bertassini et al. 2021; EUR-LEX 2025).

To synthesise these key dimensions visually, Figure 1 presents a comprehensive framework integrating sortability, contamination and PPWR regulatory requirements with the diverse stakeholders involved in packaging innovation. The framework illustrates the multilevel complexity of achieving PPWR-compliant packaging and highlights the interconnectedness of technical, regulatory and organisational factors. Although extant literature often addresses these aspects separately, there is a clear gap in integrated conceptualisation that links design, compliance and cross-functional collaboration. This research fills that gap by empirically exploring how FMCG companies manage these interdependencies to drive circular packaging solutions.

2.4 | Recyclability and Waste Management

Designing packaging materials that can be recycled efficiently multiple times without significant degradation is critical to advancing circularity (Zhu et al. 2022). This highlights the importance of developing materials optimised for both initial recyclability and quality retention over successive recycling loops. Packaging design must also incorporate principles of disassembly, where modular components allow easier separation during recycling processes, reducing sorting complexity and improving material recovery rates (Bogue 2007; Kriwet et al. 1995; Zhu et al. 2022). Moreover, the success of recycling systems depends heavily on precise categorisation and characterisation of materials. Key factors determining recycling compatibility include the primary polymer type, product form, polymer design facilitating separation and material colour, all influencing sorting efficiency and recycling success (Ncube et al. 2021; Van Caneghem et al. 2024). Notably, post-industrial waste typically presents fewer recycling challenges compared with post-consumer waste, which is often contaminated or mixed, posing operational and economic barriers (Vogt et al. 2021).

Regulatory environments further shape recycling outcomes by establishing and mandating standards that promote recyclability and innovation. The PPWR, for example, aims to harmonise packaging recyclability criteria across EU member states, fostering standardisation and market incentives for sustainable packaging design (EUR-LEX 2025; Tumu et al. 2023). However, beyond regulatory compliance, businesses must proactively adopt advanced technology and sustainable practices to improve recyclability continuously. Complementarily, consumer education on responsible disposal is important to ensure packaging enters recycling streams effectively and closing the loop on circular packaging systems (Ncube et al. 2021). Through strategic management of material selection, design for disassembly and regulatory alignment, FMCG companies can meet compliance demands while creating a competitive advantage via innovation in sustainable packaging design.

2.5 | Organisational Transformation

Organisational transformation is essential for sustainability, requiring firms to proactively adapt to regulatory shifts like the PPWR and evolving market demands (Wiesmeth 2020). Firms may take reactive or proactive approaches, with competitive advantage increasingly linked to early integration of eco-innovation and sustainable practices that enhance brand legitimacy and customer appeal (Giacomarra et al. 2019; Hu and Zeng 2024).

Moreover, sustainable innovation requires stakeholder engagement encompassing internal teams and external partners to support cocreation, knowledge exchange and system-wide alignment (Goodman et al. 2017; Loureiro et al. 2020). In parallel, developing internal capabilities and fostering a culture of openness towards knowledge sharing is equally important for innovation (Lam et al. 2021). Networks bridging internal teams and external partners enable valuable cocreation opportunities and drive long-term sustainability (Piller et al. 2011).

In addition, economic drivers, including profitability from sustainable product differentiation and consumer demand, motivate organisational change, alongside increasing pressure from employees and business-to-business startups emphasising ethics and responsibility (Iglesias et al. 2022; Onjewu et al. 2023). Transformational strategies typically balance 'Grow' approaches focused on collective learning and 'Drive' approaches involving top-down leadership, requiring a dual focus on short-term performance and long-term sustainability (Chawane et al. 2003; Sugarman 2007). Employee mindset and behaviour are also critical to embedding sustainability (Mishra et al. 2018), supported by developing dynamic capabilities to sense opportunities, mobilise resources and reconfigure organisational assets (Amui et al. 2017; Bogers et al. 2019).'

Strategic management involves managing uncertainty and building distinctive competencies difficult for competitors to imitate, with timing and adaptability key to sustaining advantage (Eisenhardt and Martin 2000; Jalonen 2012; Teece et al. 1997). The concept of resource interaction, combining and codeveloping resources, also drives innovation and competitive advantage (Laursen and Andersen 2022). In fast-changing environments, learning by doing is essential and strategy is more about creating adaptable systems and gaining unpredictable advantages through timing rather than static planning (Eisenhardt and Martin 2000).

2.6 | Summary

The evolving PPWR introduces significant technical and regulatory challenges for FMCG companies designing recyclable packaging,[2] including material compatibility, sorting limitations and trade-offs among functionality, consumer appeal and recyclability (Granato et al. 2022; Mielinger and Weinrich 2024). Beyond technicalities, transitioning to circular packaging demands organisational shifts that transcend reactive compliance, integrating sustainability into core design strategies (Benn et al. 2006; Kirchherr et al. 2023). This requires cross-functional collaboration, stakeholder engagement and dynamic capabilities to anticipate and adapt to regulatory shifts and market complexity (Attah et al. 2024; Bertassini et al. 2021; Nwabekee, Abdul-Azeez, Agu, and Ijomah 2024).

Moreover, effective sustainable packaging innovation requires broad stakeholder engagement across internal teams and external partners, including R&D, marketing, supply chain, regulatory bodies and recycling organisations, each playing a key role in aligning design, compliance and market needs. Current literature often isolates recyclability, packaging innovation or organisational transformation without sufficiently addressing how firms can strategically manage regulatory uncertainty while redesigning packaging for compliance (Keränen et al. 2021; Wikström et al. 2019). These perspectives are integrated into the proposed framework (Figure 1), providing an actionable toolkit for FMCG companies preparing for compliance with the 2030 PPWR.

3 | Methodology

This paper employs a qualitative, multimethod approach that integrates a case study performing a detailed analysis of packaging portfolio, semistructured stakeholder interviews and participatory design processes to develop and validate actionable toolkits that embed recyclability into packaging design and organisational strategy. To contextualise and operationalise the proposed framework of PPWR-compliant packaging (see Figure 1), three packaging categories from the case company's portfolio were selected for in-depth evaluation: rigid packaging with IMLs, plastic pots with carton sleeves and composite cans. These categories reflect common packaging formats with distinct material and recyclability challenges. Each was assessed against current PPWR guidelines using industry-recognised recyclability assessment tools, including RecyClass[3] (for plastic packaging), 4evergreen[4] and CITEO[5] (for fibre-based packaging). This comprehensive evaluation facilitates the identification of technical design constraints and opportunities, directly informing subsequent toolkit development.

3.1 | Stakeholder Interviews

Semistructured interviews were conducted in January 2025 with 13 key stakeholders actively involved in transitioning to PPWR-compliant packaging. Building on literature insights and preliminary portfolio analysis results, the interview protocol (see Appendix A) was designed to elicit rich, context-specific perspectives on regulatory adaptation, design innovation and cross-functional collaboration (Ahlin 2019; Ruslin et al. 2022). Three standardised questions applicable to all participants, supplemented by three to five role-specific questions tailored to each stakeholder group's expertise, were developed (Simms and Trott 2014). Participants were recruited from the case company's employees and professional networks to represent six key stakeholder groups:

- Sustainability leads/designers ($N=3$), focusing on strategic initiatives and design influence
- Packaging designers/engineers ($N=2$), addressing design challenges and technical feasibility
- Supply chain professionals ($N=2$), providing insights on logistical, cost and operational considerations
- Suppliers ($N=2$), contributing expertise on material innovation and manufacturing constraints
- Recycling experts ($N=3$), offering knowledge on recycling infrastructure and material processing
- Marketing specialists ($N=1$), highlighting marketing requirements and consumer engagement.

The interviews explored participant roles in PPWR-compliant packaging development, organisational transformation experiences and the challenges and enablers of embedding recyclability in packaging design. All interviews were recorded, transcribed verbatim and analysed using content analysis to identify key thematic categories supporting the iterative development, refinement and validation of the design-led toolkit.

Prior to data collection, formal authorisation was obtained from the case company to conduct this research. All participants provided informed consent, and the company reviewed the research scope to ensure that no confidential or commercially sensitive information would be disclosed. The research was conducted in compliance with ethical research standards and confidentiality agreements.

4 | Results

The following sections present the detailed results of portfolio and interview analyses, illustrating how empirical evidence and stakeholder feedback converged to produce actionable tools for FMCG companies addressing PPWR compliance and sustainable packaging innovation. In addition, an overview of the design processes (e.g., cocreative validation process and design recommendations) is presented at the end of this section.

4.1 | Portfolio Analysis

The case company's packaging portfolio analysis resulted in the development of two practical, material-specific design frameworks: one for Rigid Plastic Packaging (Figure 2a) and one for Fibre-based Paper Packaging (Figure 2b). These frameworks synthesise technical recyclability criteria, evolving regulatory requirements and empirical evidence from industry practices into actionable guidance for packaging design and organisational decision-making. They offer structured guidance by mapping out the key factors influencing the end-of-life performance of packaging materials, with a clear prioritisation system indicating critical impact levels (knock-out, high and moderate impact) to support informed decision-making.

The portfolio analysis revealed two overarching factors, sortability and contamination, as key determinants of packaging recyclability. Sortability encompasses components such as compactability, detectability and material separability, with particular attention to technological challenges like carbon-black pigmentation that significantly limit near-infrared (NIR) detection systems in plastic packaging. Contamination primarily concerns substances that interfere with recycling processes and degrade the quality of post-consumer recycled (PCR) materials, including inks, adhesives, labels and multimaterial components. The analysis highlighted that material separability in multicomponent packaging such as closures, seals and lamination is the key factor affecting recyclability

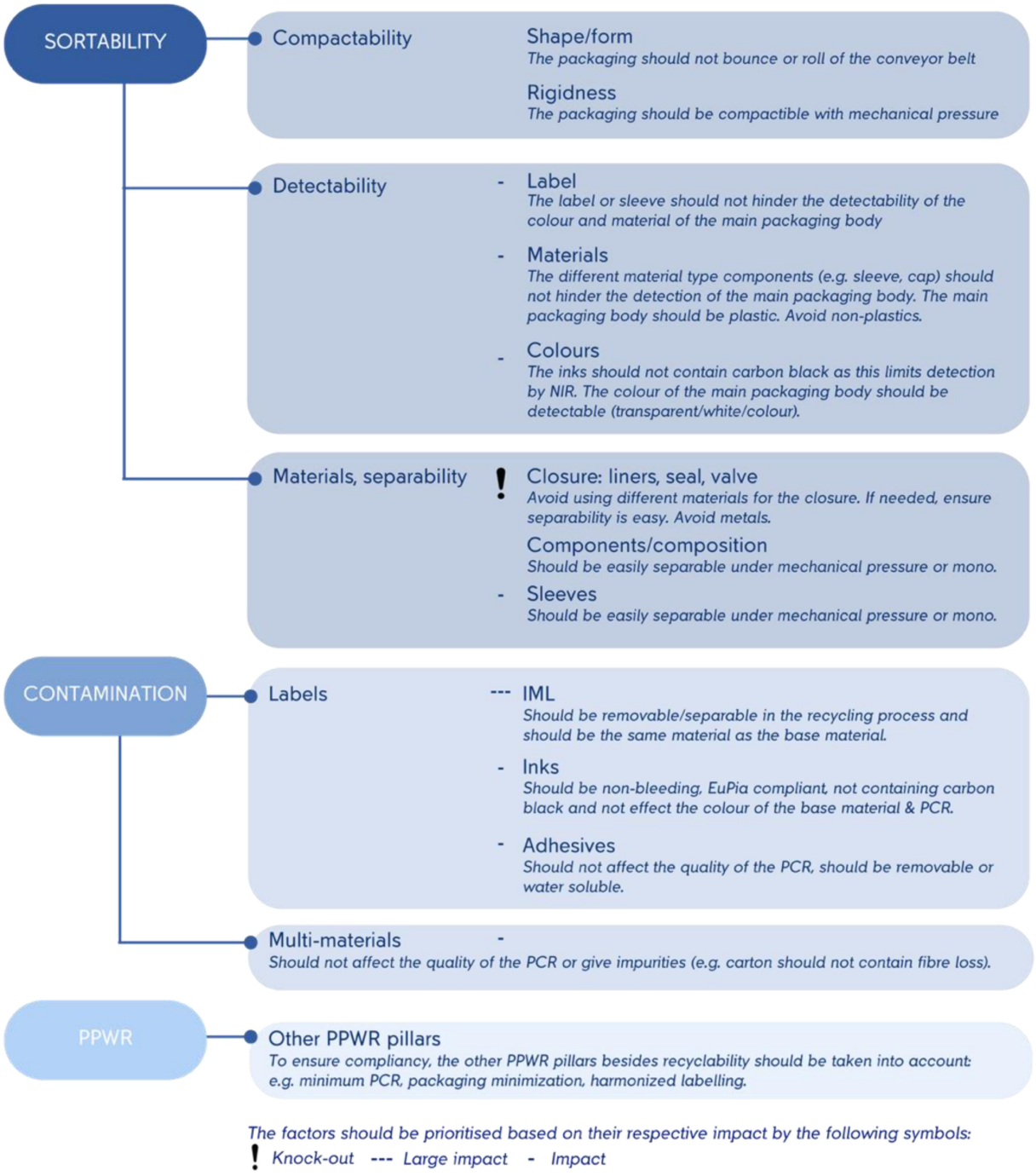

FIGURE 2 | (a) Frameworks for plastic packaging. (b) Frameworks for paper packaging.

in both plastic and paper. For fibre-based packaging, reducing lamination and ensuring adhesive removability are crucial to preserving fibre integrity and maintaining recyclate quality.

Figure 2a,b visualises the frameworks in detail, highlighting material-specific challenges, associated regulatory requirements and prioritised actions based on their impact. Additionally, the figures map relevant stakeholders, including R&D, supply chain, suppliers, recycling companies, regulatory bodies and marketing, clarifying the importance of cross-functional collaboration required to operationalise these frameworks effectively across organisations.

Strategically, these frameworks serve a dual role: as diagnostic tools assessing packaging recyclability relative to current and forthcoming standards and as prescriptive guides informing cross-functional teams during product development and innovation cycles. Integrating technical, regulatory and strategic priorities, the frameworks enable FMCG companies to proactively align packaging innovation with the 2030 PPWR, facilitating

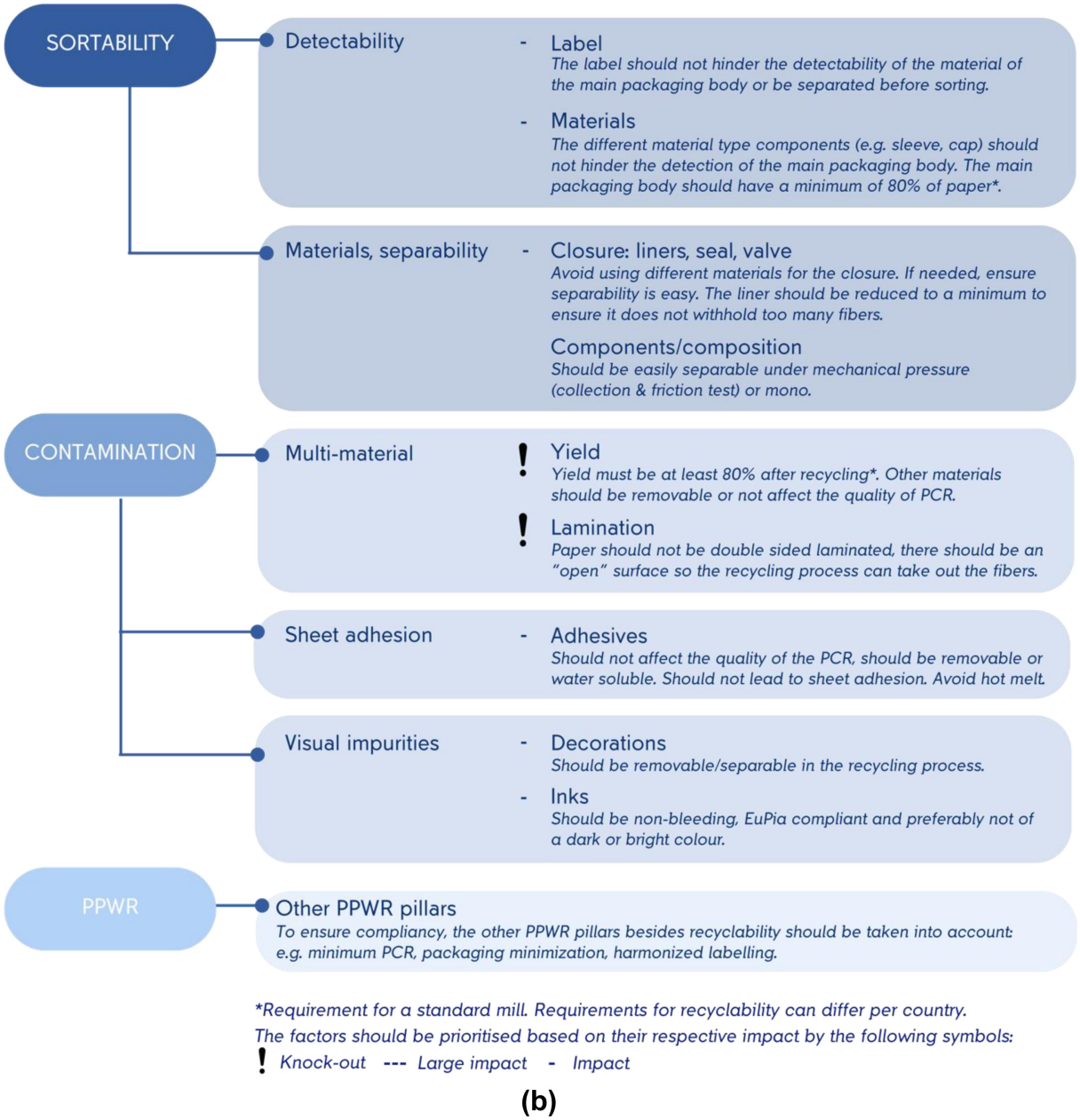

FIGURE 2 | (Continued)

regulatory compliance and supporting competitive advantage through sustainable innovation and operational efficiency.

The iterative portfolio evaluation also refined the initial conceptual framework, ensuring practical relevance in FMCG packaging innovation contexts.

4.2 | Qualitative Analysis

Through a systematic three-stage content analysis (Miles and Huberman 1994), initial coding assigned first-order codes to transcript segments, which were then grouped into categories and further refined into higher order categories. Both selective and inductive coding techniques were employed (Strauss and Corbin 1998) to ensure alignment with existing literature and the case company's context, while allowing new, unanticipated categories to emerge. This process generated categories that advance our understanding of organisational transformation under regulatory pressures and contextualised packaging recyclability challenges within FMCG companies, directly informing the development of the strategic and tactical roadmaps, as well as the recyclable-ready design process checklist.

The interview analysis revealed several key categories reflecting diverse perspectives of stakeholders involved in packaging design and sustainability efforts, highlighting varied perspectives on the balance between recyclability standards and PPWR compliance. These insights had helped us in the toolkit development phases, ensuring that design decisions are fully grounded in the practical realities of packaging development, regulatory complexity and market demands.

Moreover, stakeholders identified a notable disconnect between actual recyclability, the effective, real-world recycling of packaging and theoretical recyclability, which is defined solely by material properties. Interviewees highlighted the tension between current recycling infrastructure capabilities and the increasing complexity of multimaterial packaging solutions. As one expert stated, 'Recyclability in theory means little if there is no infrastructure to support it' (S2), whereas another emphasised the importance of scalability: 'Think about design and recycling at scale' (S11). These insights highlight the need for an integrated design approach that aligns theoretical material properties with existing local and global recycling infrastructures, emphasising that packaging compatibility with current recycling technologies is as important as material selection itself.

Economic viability emerged as another critical category, indicating that while sustainability and environmental impact remain key priorities, the cost-effectiveness of recycling processes and incorporation of post-consumer recycled (PCR) materials significantly influence packaging design decisions. As one stakeholder noted, 'We need to balance the quality of our product with simplicity, efficiency, and sustainability requirements' (S8). This highlights how economic realities of recycling, including market demand and quality considerations of PCR materials, require careful integration of cost-efficiency into packaging design strategies. Furthermore, it became clear that the case company's packaging designers continuously face tension between preserving the functional and aesthetic appeal of packaging while meeting sustainability objectives. 'You cannot sacrifice the consumer experience entirely to achieve sustainability' (S3).

The analysis also revealed a significant knowledge gap regarding packaging recyclability. Many stakeholders expressed the need for greater clarity and certainty about which materials can be recycled efficiently and which pose challenges within the recycling systems. As one recycling expert noted, 'We must generate technical knowledge and share that openly with everyone' (S10), highlighting collaboration and transparency as crucial for informed design solutions within the recycling industry. This emphasises the importance of knowledge-sharing among diverse stakeholders and the necessity for reliable, up-to-date information to guide effective packaging design decisions. This is further elevated by uncertainty surrounding the PPWR regulations, which are expected to be clarified by 2028. Several stakeholders reported difficulty in setting clear strategic directions amid this ambiguity: 'The urgency should become clear which is difficult, because we do not know the direct impact and there is no official legislation' (S13).

The interview analysis also identified critical design factors influencing both recyclability and PPWR compliance. These factors highlight the complex balance packaging designers must maintain among technical feasibility, economic viability and regulatory requirements. For instance, the mono-material approach was frequently emphasised as the most effective strategy to enhance recyclability, since single-material packaging just facilitates easier sorting and processing compared with multimaterial alternatives, one expert stated, 'Mono-material designs are the most effective for streamlining sorting and recycling' (S5). This preference aligns with a broader industry trend towards simplification in packaging design, aiming at reducing recycling system complexity and improving the likelihood of successful material recovery. However, the transition to mono-material packaging demands careful material selection to maintain product functionality without compromising recyclability (de Mello Soares et al. 2022; Guerritore et al. 2022).

Another recurring category was sortability, a critical determinant in the recycling process. The detection and separation of packaging materials during recycling present significant challenges, as the ease of material identification and sorting directly influences recyclability. Several interviewees highlighted concerns regarding labels and inks, particularly carbon black inks, which optical sorting systems cannot detect. One participant noted, 'Labels and inks, particularly carbon black inks, are problematic as they cannot be detected by optical sorting systems' (S9). This emphasises the importance of designing packaging with clear labelling, avoiding inks or adhesives that hinder sorting and using label materials that are easily detachable or water-soluble to facilitate efficient recycling.

Contamination during the recycling process was also identified as a major challenge. Packaging contaminated by other materials, adhesives or incompatible inks complicates recycling operations and degrades the quality of recycled materials. As one expert noted, 'Contamination is one of the main barriers to effective recycling' (S3). This indicates that packaging design must prioritise minimising contamination risks by selecting materials and design features that prevent contamination both during use and after consumer disposal.

The mechanical separation of materials emerged as a key category influencing recyclability. Several stakeholders emphasised that packaging is considered more recyclable if mechanical pressure, such as pressing, can effectively separate its components. As one expert explained, 'If a consumer can simply apply pressure to the product and materials separate, that is acceptable in recyclability terms' (S6). However, relying on consumers to separate components is problematic: 'You cannot expect consumers to separate components; packaging must be designed to allow mechanical separation by sorting machines' (S11) and 'Consumers are often unaware or unmotivated to separate waste' (S12). This challenge is particularly relevant for multimaterial packaging, where layers of different materials are combined. When these materials are difficult to separate manually, they pose significant challenges to recyclability. Packaging designed for easy detachment, whether by consumers, sorting facilities or during waste collection, significantly improves the chances of proper recycling. As one expert noted, 'If you can prove that during the collection and sorting the sleeve is removed from the container due to mechanical stress, then we can approve' (S10).

4.2.1 | Summary of the Analysis

Together, these technical and organisational insights suggest that effective packaging design for recyclability requires a holistic approach that integrates mono-material solutions, prioritises sortability, facilitates easy material separation and actively mitigates contamination risks. These findings align with the literature emphasising that circular packaging design must consider

both technical recyclability and the operational and market realities (Bertassini et al. 2021; Ragaert et al. 2019; Ragaert et al. 2017). The results also indicate that designers should balance both technical and regulatory factors with aesthetics, cost-efficiency and consumer experience, reflecting the strategic challenges of sustainability-oriented innovation (Goodman et al. 2017).

Furthermore, the identified key stakeholders across the value chain demonstrated highly interconnected perspectives and roles, each contributing to unique expertise and priorities of recyclable packaging development. This aligns with the growing recognition in sustainability research that collaborative innovation and stakeholder integration are essential for addressing complex environmental transitions (Bertassini et al. 2021; Goodman et al. 2017). For example, sustainability experts emerged as knowledge holders who align recyclability goals with the practical limitations and opportunities of existing recycling infrastructure. They emphasised that design solutions must be grounded in the realities of sorting and processing capabilities, noting that theoretical recyclability holds little value without supporting infrastructure (Nilsson et al. 2024; Van Caneghem et al. 2024).

Packaging designers play a central role in developing technically feasible solutions that address sustainability requirements. They need to collaborate with suppliers and R&D teams to ensure that new materials and formats are both recyclable and compatible with manufacturing processes and evolving legislative frameworks. Such collaborations demonstrate and enhance the dynamic capabilities of the organisations (Eisenhardt and Martin 2000). Also, supply chain managers and suppliers act as significant enablers of implementation, focusing on aligning packaging design changes with operational efficiencies, including production line upgrades. Suppliers contribute to innovations that are both functionally efficient and recycling-compatible, highlighting the role of resource interaction and codevelopment in sustaining competitive advantage (Laursen and Andersen 2022).

We found consistent findings with the works of Bertassini et al. (2021) and Kirchherr et al. (2017) in CE transitions that recycling experts and waste managers provide evidence-based insights into packaging performance during end-of-life processing, advocating for improved design practices and emphasising the importance of viable end markets for recycled materials. Lastly, the analysis highlights the role of marketing specialists, who focus on ensuring that sustainable packaging is aligned with consumer needs and expectations. Their role bridges technical feasibility and market acceptance, utilising consumer insights to guide product and packaging design decisions. This is consistent with the earlier results of Goodman et al. (2017) and Granato et al. (2022) on sustainability-oriented innovation and consumer engagement.

Collectively, stakeholder perspectives demonstrate that advancing packaging recyclability is not the responsibility of any single function but a collaborative effort that integrates technical, operational, regulatory and consumer dimensions into a unified design approach, reflecting the systemic shift and multidimensional nature of sustainability challenges in business (Bertassini et al. 2021; Kirchherr et al. 2023; Piller et al. 2011).

4.3 | Linking the Analysis Insights to the Framework

The PPWR-compliant packaging framework developed in the previous chapter (see Figure 1) provided a structured approach to address key factors influencing recyclability, including sortability, contamination and quality management, mono-material usage and compliance with evolving regulatory standards. These core dimensions are closely aligned and consistent with stakeholder insights, highlighting the necessity of designing packaging that is compatible with existing recycling infrastructure, capable of producing high-quality post-consumer recycled (PCR) materials and optimised for effective detection and sorting within recycling systems.

However, the interview analysis also revealed practical challenges that, while not necessitating fundamental revisions to the framework, require careful consideration during its application to packaging design outcomes. For instance, the framework's strong emphasis on mono-materials and harmonisation may conflict with the equally critical need to balance product functionality and consumer appeal, dimensions that, although not explicitly captured in the framework's visual representation, remain significantly important in real-world design decision-making.

Furthermore, although the framework does not explicitly map the roles and the influence of various stakeholders in detail, recognising these actors and their decision-making dynamics is essential to ensure the framework's successful adoption and implementation within complex organisational contexts. Given the complexity of incorporating diverse factors and stakeholder perspectives into a single framework, maintaining a simplified and clear representation is essential, particularly for those involved in early-stage design. An accessible and intuitive visual serves as a practical tool for translating the framework into actionable guidance. Moreover, recognising key complexity drivers such as cost, time, consumer preferences and technical feasibility enables designers and decision-makers to effectively weigh trade-offs and make informed choices. In the following section, we integrate these criteria in the design phase to ensure packaging solutions that are both PPWR-compliant and feasible and aligned with broader value chain realities.

5 | Design Phase

5.1 | Design Recommendations

Building on the insights derived from the case company's packaging portfolio analysis, stakeholder interviews and the development of the PPWR-compliant packaging framework, this section presents design recommendations aimed at translating theoretical findings into practical tools. To ensure these recommendations address real-world challenges and stakeholder needs, a preliminary cocreation workshop was held at the case

company's facilities to test early concepts and refine design requirements. Following this, a final validation session was held to evaluate the usability and applicability of the design outputs.

To do so, packaging designers, supply chain specialists and marketing professionals participated in these sessions, providing critical feedback that helped tailor the deliverables to effectively support decision-making throughout the packaging development process. Although the framework was primarily shaped through strong empirical analysis, these collaborative validation efforts were also important to confirm the relevance, user-friendliness and practical alignment of the design recommendations with industry realities.

Building on the collaborative sessions and grounded in stakeholder insights and recyclability analyses, several key design recommendations have emerged to support FMCG packaging designers and organisations in aligning with PPWR requirements and advancing CE objectives. Central to these recommendations is the necessity that packaging solutions be compatible with existing recycling infrastructure. This entails prioritising mono-material formats, avoiding problematic features such as carbon black inks and nondetachable components and designing with scalability and the 'lowest common denominator' principle in mind to ensure consistent functionality across diverse regional recycling systems. Early engagement with recyclers during the design process further enhances alignment with sorting and processing technologies, increasing the likelihood of achieving high recyclability performance under the EU PPWR.

Equally important is the need to bridge knowledge gaps across the value chain. FMCG companies are encouraged to invest in cross-functional training and create strong communication channels between design, sustainability, procurement and external recycling experts. Understanding the recycling process, from disposal to material recovery, is also crucial. Mapping this journey for each packaging type helps designers tailor solutions effectively, whether dealing with plastic, paper or hybrid streams. For example, innovations such as IMLs that remain durable during use yet break down during recycling illustrate how performance and recyclability can go hand in hand. Moreover, embedding recyclability goals early in project planning is critical to ensure that sustainability is integrated throughout the product development lifecycle. Incorporating sustainability criteria in early decision-making, aligning pilot trials with end-of-life considerations and encouraging collaboration between business leaders and design teams help prevent costly redesigns and strengthen business cases.

For supply chains, anticipating machinery trials or operational changes offers opportunities to simultaneously test new packaging formats and recyclability features under real production conditions. This coordinated approach ensures recyclability is a core design priority rather than an afterthought. Simplification and standardisation strategies such as minimising components, adhesives and coatings further enhance recyclability, whereas modular and reusable packaging formats present promising long-term solutions. Together, these recommendations enable FMCG companies to move beyond mere compliance, positioning them as leaders in developing practical, circular and future-ready packaging solutions.

5.2 | Design Results

This section details the structured development of design interventions guided by the Double Diamond framework,[6] a widely adopted model that facilitates iterative exploration and refinement of design solutions (Owen 2007). In the context of this research, the use of the Double Diamond model is appropriate as it guides the development of design outcomes through four iterative phases:

> Discover: Insights from literature were revisited alongside new exploratory inputs from stakeholders to identify key challenges in recyclable packaging design. This phase confirmed the importance of recyclability criteria such as sortability, contamination, mono-material usage and regulatory readiness.
>
> Define: The insights were synthesised into clear design requirements. Key directions emerged, highlighting the need for practical decision-support tools that integrate sustainability goals with technical and organisational realities of packaging development, especially in its early stages.
>
> Develop: Multiple initial design concepts were generated. Strategic and tactical roadmaps and a process template for embedding recyclability into packaging development were identified as the most promising by stakeholders. These concepts were examined iteratively and refinement was informed by expert feedback and continuous alignment with stakeholder needs.
>
> Deliver: The selected concepts were consolidated into a coherent, practical design-led toolkit aimed at supporting designers and decision-makers in addressing the complex requirements of PPWR compliance. The final design outputs balance simplicity with sufficient depth, ensuring usability and relevance with evolving regulatory and operational constraints. Collectively, this phase of the research demonstrates how a human-centred, iterative design approach (Calabretta et al. 2025) can translate theoretical insights and stakeholder knowledge into actionable tools that drive recyclable packaging innovation. These developed tools provide a foundation for the validation activities presented in the following subsection.

5.3 | Design Validation

The validation process comprised two distinct stages to ensure that the developed tools were relevant, practical and closely aligned with stakeholder needs. The initial prevalidation session, conducted during the development phase, engaged a small group of experts to guide the direction of the design outputs. This session focused on identifying key complexity drivers, refining promising concepts and sharpening design requirements, providing early insights into which tools held the greatest potential and shaping the subsequent development of the design toolkit.

Following this, a validation session was conducted with nine participants, predominantly from the R&D team, who represent the primary end-users of the final design outputs. During this session, participants were walked through the main design

deliverables, including the strategic roadmaps and process template, and provided structured feedback, assessing each tool's clarity, usability and relevance within real-world packaging development workflows. The participants appreciated the tools' usefulness and practicality, highlighting their effectiveness in addressing existing gaps between recyclability objectives and packaging development processes.

Notably, the toolkits were valued for facilitating early-stage decision-making, enabling cross-functional collaboration and embedding regulatory foresight into packaging design. Feedback also identified areas for improvement, including simplifying technical terminology, enhancing adaptability to diverse project types and better integrating the tools with existing business processes. These insights helped to perform the final refinements and to confirm the toolkits' potential to support FMCG companies in achieving PPWR compliance through design-led, strategically informed approaches.

5.4 | Design Deliverables: Strategic Roadmap

Building on stakeholder feedback and insights, two complementary roadmaps, strategic and tactical, were developed to guide FMCG companies. The strategic roadmap articulates a long-term vision guiding FMCG organisations towards PPWR-compliant packaging, emphasising that the development of dynamic organisational capabilities is essential for sustainable innovation addressing the regulatory uncertainty (see Figure 3). It unfolds across four sequential phases:

Documentation and risk mapping (pre-2028)

This foundational phase focuses on building internal knowledge, mapping regulatory and operational risks and embedding PPWR awareness throughout the organisation. Early detection of regulatory gaps and piloting high-risk packaging categories are prioritised. These efforts embody proactive organisational sensing and preparation, essential for addressing complex sustainability transitions (Eisenhardt and Martin 2000). The focus includes reducing non-mono elements, inks and adhesives while aligning project processes and collecting detailed data on packaging complexities.

Development of data-driven decision tools (2028–2030)

With PPWR enforcement anticipated by 2028, this phase prioritises creating decision-support tools leveraging real-time data, recyclability insights and evolving regulatory frameworks. These tools exemplify strategic balance (Teece 2007) by integrating the exploitation of existing knowledge with the exploration of emerging compliance challenges, facilitating agile and informed packaging design decisions. This phase involves simplifying and harmonising the packaging portfolio, accelerating speed to market and integrating AI and smart software solutions.

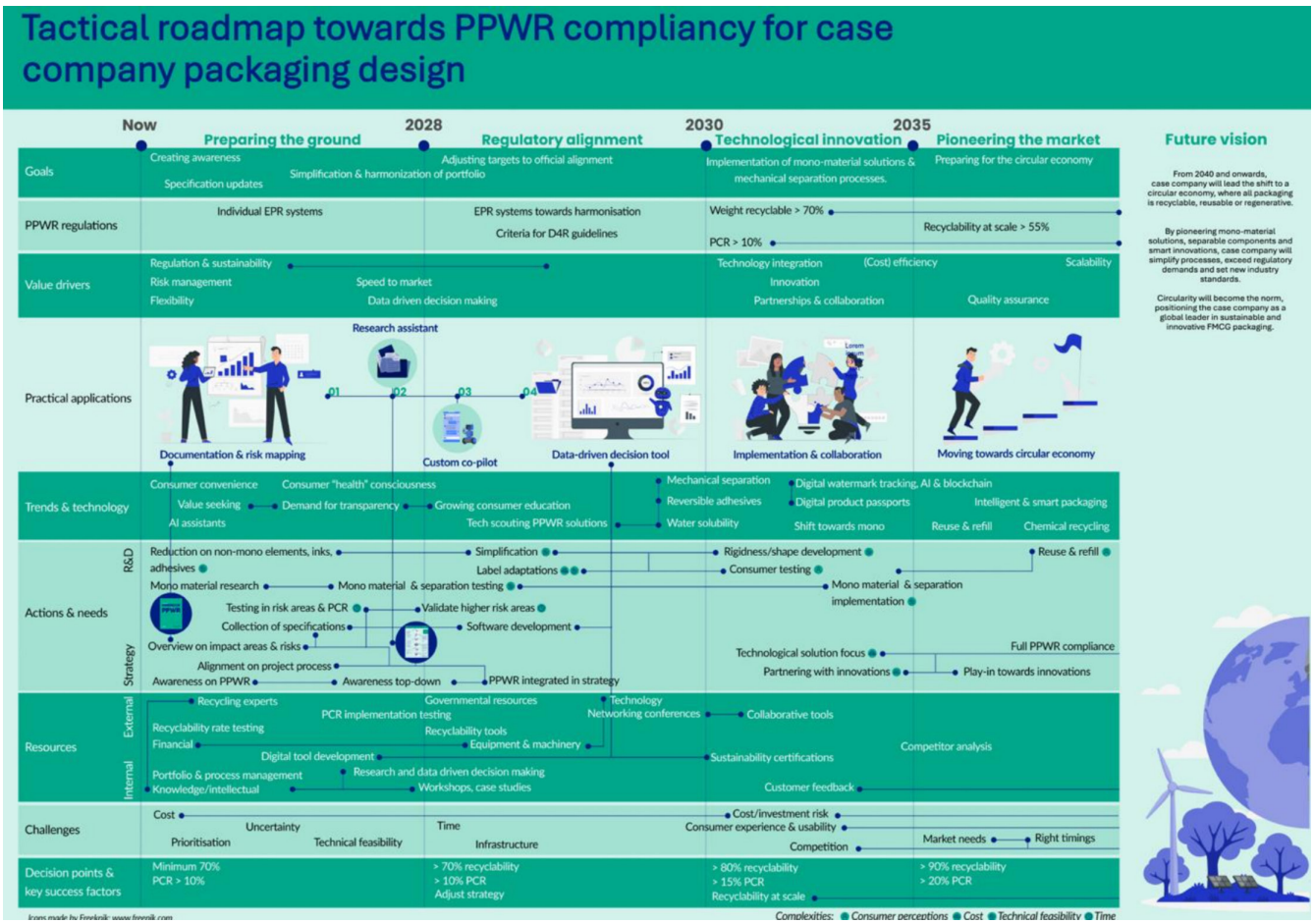

FIGURE 3 | Strategic roadmap towards PPWR compliancy.

Implementation and collaboration (2030 onwards)

Following regulatory activation, the focus shifts to validating compliant packaging solutions, scaling innovations across product lines and extending collaborative partnerships with technology providers, recyclers and cross-functional teams. This phase reflects coevolutionary organisational transformation, where continuous learning and stakeholder engagement reinforce sustainable competitive advantage (Goodman et al. 2017). Key activities include mono-material implementation, mechanical separation, consumer testing and expanding partnerships.

Transition to CE leadership (long-term vision)

Looking beyond compliance, this phase envisions FMCG companies, like the company used in this research, leveraging digital technologies, reusable packaging formats and systemic innovation to lead CE practices. This vision aligns with the strategic priority of embedding sustainability as a core organisational capability that drives innovation and industry transformation (Bertassini et al. 2021). Future priorities include smart technologies, reuse and refill models and setting new industry standards for circularity.

Together, these phases provide a comprehensive tool that facilitates regulatory compliance while enabling long-term value creation through sustainability-oriented innovation and organisational agility.

5.5 | Design Deliverables: Tactical Roadmap

The tactical roadmap complements the strategic roadmap by operationalising high-level goals into concrete, actionable steps (see Figure 4). It outlines interventions according to their implementation timelines and links them to specific activities such as pilot testing and supplier engagement, highlighting their anticipated impact on packaging recyclability. This phased approach aligns with established theories on strategy implementation and organisational change, emphasising the importance of translating vision into coordinated operational actions (Hrebiniak and Joyce 2005).

The tactical roadmap integrates considerations of industry trends and system interdependencies by mapping value drivers, potential risks and sequential dependencies across organisational functions. Such mapping is consistent with dynamic capabilities frameworks (Teece 2007), which stress sensing, seizing and transforming as key processes for responding to complex and evolving regulatory and market environments, and the emphasis on cross-functional coordination and risk management aligns with literature on managing complexity and uncertainty

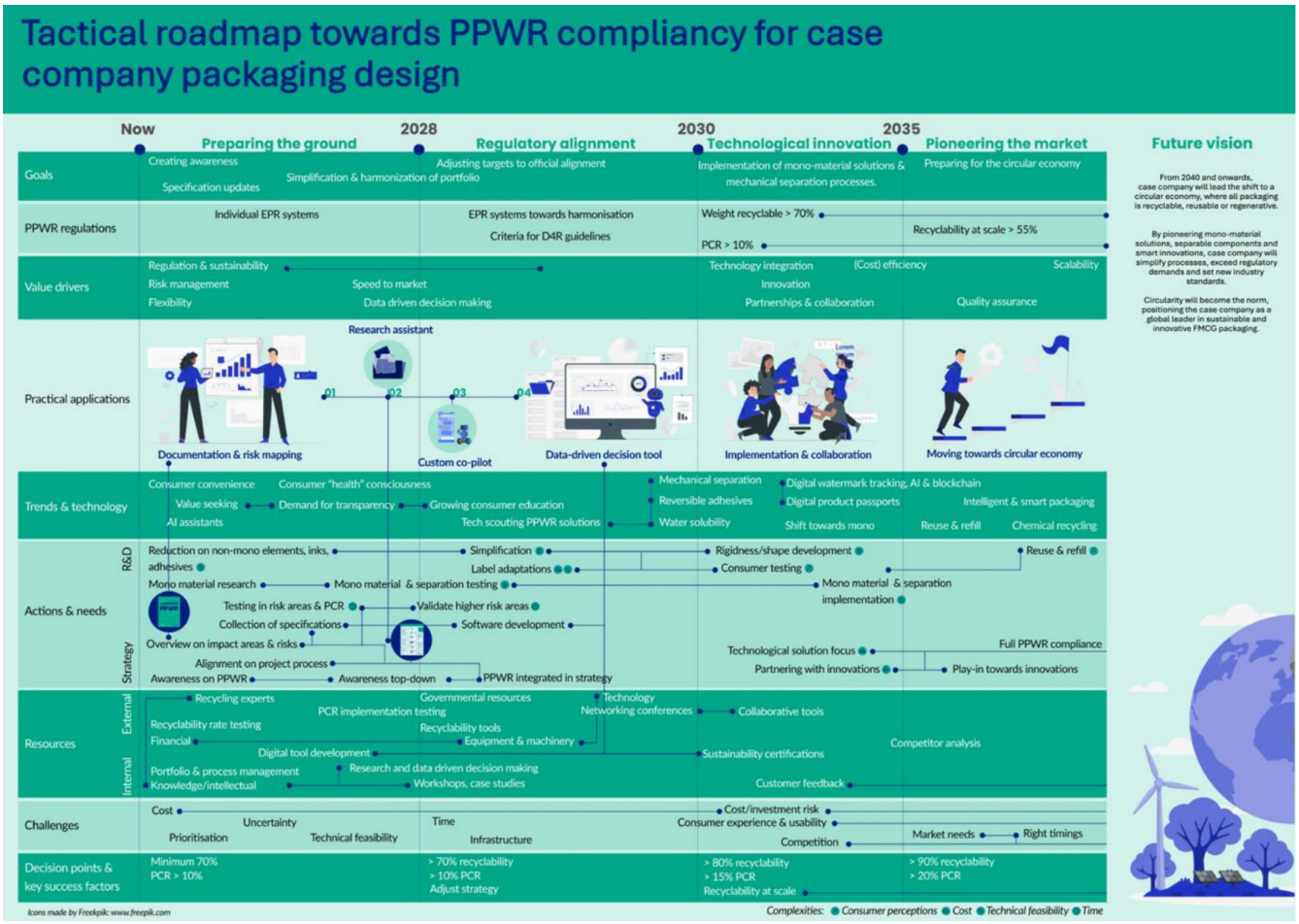

FIGURE 4 | Tactical roadmap towards PPWR compliancy.

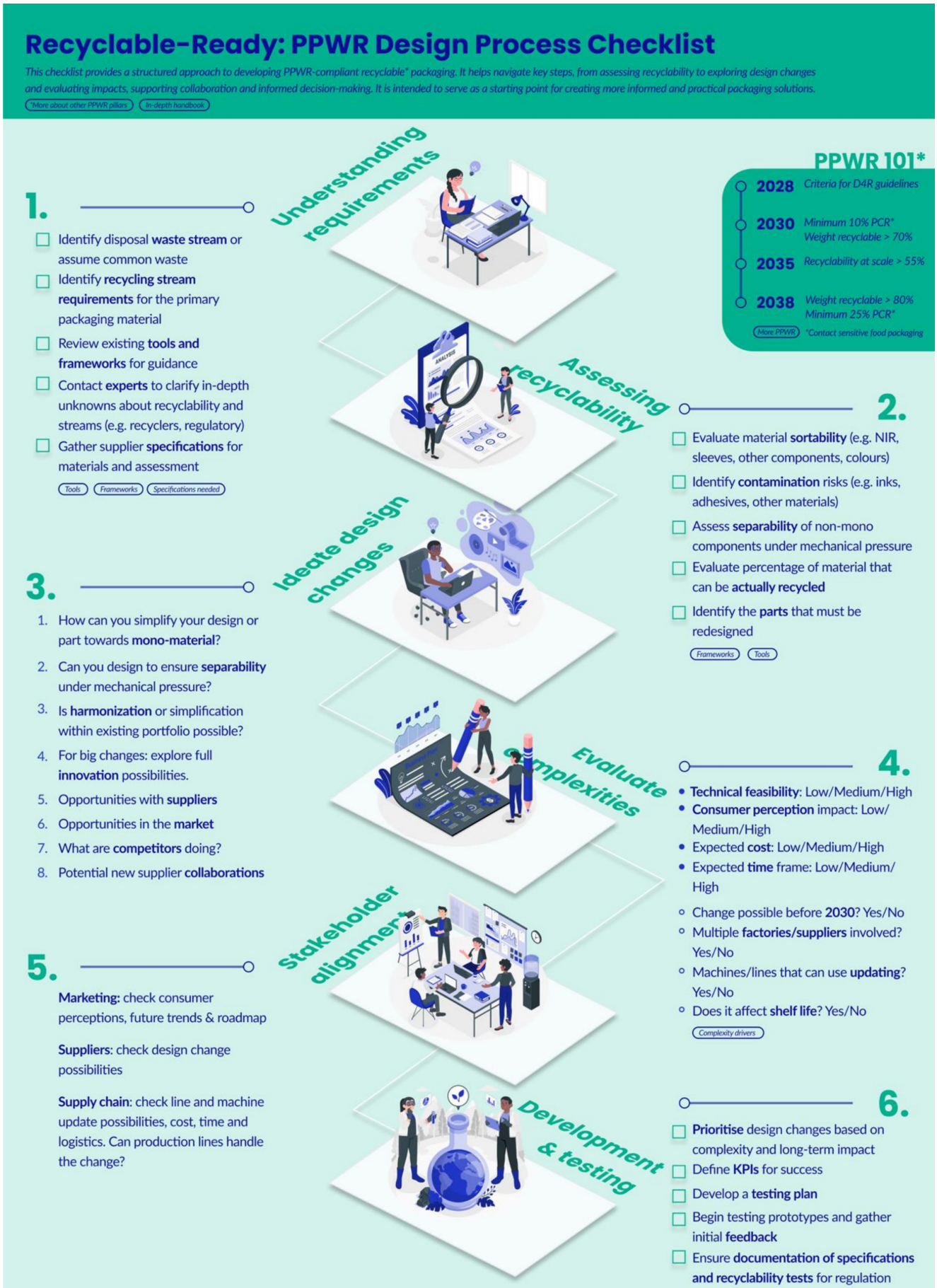

FIGURE 5 | Legend on next page.

FIGURE 5 | Recyclable-ready: PPWR design process checklist.

in sustainability transitions (Linnenluecke and Griffiths 2010; Piller et al. 2011).

The strategic and tactical roadmaps collectively offer a cohesive, phased framework that bridges visionary organisational transformation with practical operational execution. This approach supports FMCG companies in building organisational agility and resilience, enabling them to maintain competitive advantage in CE transitions (Bertassini et al. 2021). The strategic roadmap outlines the overarching vision and developmental phases for building dynamic capabilities and long-term circular leadership, whereas the tactical roadmap translates this vision into detailed, time-bound actions and cross-functional interventions. This integration enables FMCG companies to advance from early regulatory preparedness and innovation exploration to scalable implementation and market leadership. The integrated strategy supports effective management of regulatory complexity and sustainability transitions to remain agile, resilient and competitive in evolving CE landscapes (Bertassini et al. 2021; Hrebiniak 2013; Linnenluecke and Griffiths 2010).

5.6 | Design Deliverables: Designer Process Checklist

Building upon the roadmaps, the Recyclable-Ready Design Process Checklist (see Figure 5) was developed to provide FMCG packaging designers a practical, stepwise guide to overcome the complex requirements of PPWR-compliant recyclable packaging development. It operationalises the conceptual frameworks and stakeholder insights developed earlier by structuring the packaging design process into six interconnected phases that ensure comprehensive coverage of technical, regulatory and organisational considerations. Designed as a user-centred practical tool, it requires attention to key considerations throughout the packaging development lifecycle from interpreting regulatory constraints to identifying feasible design modifications and evaluating their broader organisational and environmental impacts. By embedding PPWR guidelines, established recyclability frameworks, complexity drivers and relevant real-world packaging examples directly within the tool, the checklist empowers designers and cross-functional teams to make informed, context-sensitive decisions early in development, fostering alignment between sustainability objectives, regulatory compliance and operational feasibility.

1. The checklist begins with Understanding Requirements, where designers identify relevant disposal and recycling streams, gather supplier specifications and consult external experts to clarify uncertainties around recyclability and local recycling infrastructure. This phase positions the design process within the realities of waste management systems and regulatory expectations.
2. Next, Assessing Recyclability focuses on evaluating material sortability (e.g., compatibility with Near Infrared sorting), contamination risks from inks and adhesives and separability of non-mono components under mechanical pressure. It also involves quantifying the proportion of material that can be effectively recycled, enabling designers to identify critical areas for improvement.
3. The third phase, Creating Design Changes, encourages simplification towards mono-material packaging, harmonisation within existing portfolios and exploration of innovation opportunities. Designers are prompted to engage with suppliers and monitor competitor developments, ensuring design decisions are informed by market and technological trends.
4. Evaluating Complexities provides a multidimensional assessment of proposed design changes. It incorporates technical feasibility, consumer perception, cost implications, timeframes and other complexity drivers such as shelf-life impact and machinery compatibility. This holistic evaluation supports prioritisation and risk management, aligning closely with the dynamic capabilities highlighted in earlier sections.
5. Effective Stakeholder Alignment is critical to the success of the design process. The checklist highlights the importance of cross-functional collaboration, prompting communication and coordination among marketing, suppliers and supply chain teams. This alignment ensures that packaging innovations are both technically viable and commercially feasible and aligned with consumer expectations.
6. The final phase, Development and Testing, guides teams through prioritising design changes, establishing key performance indicators, developing testing plans, prototyping and documenting specifications to meet regulatory standards. It facilitates iterative learning and continuous improvement, embedding sustainability considerations into packaging development workflows. An integrated PPWR timeline runs alongside the checklist, reminding designers of key regulatory milestones and recyclability targets, thus maintaining alignment with evolving compliance requirements.

Overall, the checklist serves as a living, user-friendly tool that translates theoretical and strategic insights into actionable guidance. By embedding recyclability thinking early and throughout the packaging development cycle, it facilitates informed decision-making, cross-team collaboration and practical alignment with PPWR compliance and CE ambitions (see Figure 5).

6 | Discussion

The interview findings, proposed design-led toolkits and frameworks developed, collectively advance our understanding of how FMCG companies can strategically embed recyclability and regulatory compliance into packaging innovation. By conceptualising recyclability as a dynamic organisational capability

and emphasising cross-functional collaboration, this research aligns with literature on sustainability-oriented innovation and organisational transformation (Adams et al. 2016; Bertassini et al. 2021). The proposed frameworks offer actionable tools that support managers in navigating regulatory uncertainty while balancing technical, economic and stakeholder demands and enable compliance readiness and competitive advantage within CE transitions (Goodman et al. 2017). The design-led toolkits, strategic and tactical roadmaps together with a design process checklist, provide a structured, systemic response to the complex challenges of the recyclability of packaging.

Central to this approach is the importance that recyclability must be treated as a system-level design challenge, extending beyond material or technical considerations. This aligns with recent literature emphasising the importance of synchronising packaging innovation with recycling infrastructure capabilities, regulatory foresight and consumer usability (Kumar et al. 2021; Patel 2023). Given these insights, stakeholders across roles, from designers and sustainability leads to recyclers and suppliers, highlight the necessity for cross-functional collaboration, early-stage decision-making (Braungart et al. 2007; Saari et al. 2021) and continuous knowledge exchange throughout the value chain, consistent with theories of dynamic capabilities and organisational learning (Ademi et al. 2024; Eisenhardt and Martin 2000; Goodman et al. 2017; Köhler et al. 2022).

The strategic roadmap synthesises these insights into a phased vision for organisational readiness, emphasising early risk mapping, iterative capability development and long-term investment in innovations such as reusable and smart packaging solutions. In parallel, the tactical roadmap translates strategic intent into practical, function-specific interventions that bridge the gap between vision and operational execution.

Although developed within the context of one single FMCG company, these roadmaps offer a transferable framework for other FMCG companies dealing with similar regulatory and innovation landscapes. Complementing these, the recyclable-ready design process checklist provides actionable, context-aware guidance, functioning as a stage-gate tool that embeds recyclability considerations throughout the packaging development lifecycle (De Souza and Borsato 2016).

Validation sessions demonstrate that the toolkits are not only theoretically grounded but also practically relevant. Participants confirmed their potential to foster cross-functional alignment, clarify regulatory expectations and facilitate sustainable innovation within real-world constraints. However, feedback also highlighted the necessity of maintaining flexibility, ensuring user-friendliness and achieving seamless integration with existing workflows for successful adoption and sustained impact (Bertassini et al. 2021).

Collectively, these outcomes suggest that achieving recyclable and regulation-ready packaging goes beyond a purely design or compliance issue; it is fundamentally an organisational transformation process. Success relies on building dynamic capabilities and cross-functional collaboration, embedding regulatory awareness into everyday design routines and investing in tools that enable sustainability, actionable and transparent. Moreover, knowledge sharing must extend beyond internal alignment, as organisations benefit from active learning with external experts, peers and even competitors to anticipate evolving standards and emerging best practices (Linnenluecke and Griffiths 2010).

Although the research is grounded in a single-case context, the underlying mechanisms and capabilities identified, such as cross-functional collaboration, iterative learning and regulatory foresight, are transferable to other organisations driving comparable regulatory and sustainability transitions. The proposed roadmaps and checklist are designed to be adaptable across industries facing complex compliance requirements, offering a generalisable structure for integrating design-led innovation with organisational transformation.

Importantly, the toolkits developed in this research are not a static prescription but a flexible, scalable foundation adaptable to diverse organisational contexts, product types and packaging formats. The use of visual aids and interactive resources strengthens communication, enables early-stage alignment and facilitates knowledge sharing across teams. Thus, the toolkits remain a living asset, evolving alongside regulatory developments and business needs, supporting FMCG companies on the path towards circular, regulation-ready packaging.

7 | Conclusion

This research advances sustainable packaging innovation in FMCG companies by developing and validating a comprehensive design-led toolkit that integrates strategic and tactical roadmaps with a recyclable-ready design process checklist. We address RQ1 by demonstrating how FMCG companies can strategically prepare for the EU 2030 PPWR through the development of dynamic organisational capabilities and design-led tools that integrate regulatory foresight, innovation and cross-functional collaboration. Through the case company, the research shows how proactive alignment between design, sustainability and operations enables firms to balance regulatory compliance with business viability and innovation.

In response to RQ2, the research reveals the critical roles of packaging designers and cross-functional teams, including sustainability leads, supply chain managers and recyclers, in translating regulatory and sustainability goals into actionable design outcomes. Their collaboration informed the creation of the strategic and tactical roadmaps and the recyclable-ready design process checklist, showing how cocreation and shared knowledge accelerate compliance readiness and organisational transformation.

Although the case company served as the empirical foundation, the toolkit's structure and principles are broadly transferable to other organisations seeking to align packaging innovation with evolving regulatory frameworks such as the PPWR. Together, these tools support informed, regulation-aligned packaging innovation and position recyclability as a dynamic organisational capability. The findings highlight the importance of cross-functional collaboration, early-stage and forward-thinking design decision-making and regulatory foresight in managing

the complexities of the EU 2030 PPWR. Compliance emerges not simply as a technical challenge but as an organisational transformation requiring design-led thinking, cross-functional alignment and proactive engagement with evolving regulatory landscapes.

FMCG companies can prepare by embedding recyclability considerations into early-stage packaging development, guided by frameworks and practical tools that balance sustainability, functionality and operational feasibility. Designers play key roles as technical contributors and as system enablers, translating complex requirements into tangible, compliant solutions. Importantly, PPWR compliance depends on both material choices, such as mono-materiality, component separability, contamination reduction, sortability and strong internal coordination across packaging, R&D, marketing and supply chain functions.

The results provide broadly applicable principles for aligning design and regulatory compliance within the CE. It reframes packaging from a waste management issue to a strategic design opportunity and circular innovation pathway. Adoption of the proposed design-led, system-aware approaches can transform regulation from a constraint into a catalyst, enabling FMCG companies to meet compliance requirements and lead the transition towards a more sustainable packaging future.

7.1 | Theoretical Contributions

The main contribution of this research lies in the development of tangible tools and in demonstrating how a design-led methodology, grounded in stakeholder insights and systems thinking, can empower FMCG companies to effectively manage regulatory complexity and accelerate their transition towards circular packaging futures (de Mello Soares et al. 2022). This integrated approach aligns with the contemporary emphasis on dynamic capabilities, strategic innovation and cross-functional governance as key drivers for sustainability transitions (Ortiz-Avram et al. 2024).

Moreover, the findings provide theoretical grounding for digitalisation in design for recycling by proposing design-oriented tools that integrate recyclability scoring, portfolio alignment and regulatory foresight. These tools emphasise the role design plays in supporting and improving packaging systems during regulatory transitions, expanding current theories on how innovation emerges under uncertainty (Eisenhardt and Martin 2000; Teece et al. 1997). By addressing compliance through real-world design practices, this research extends the theoretical foundations of circular innovation in FMCG packaging and offers a scalable contribution to design theory, sustainability transitions and the practical application of policy-driven recycling frameworks.

By applying the design processes, we operationalise circularity principles in a context-sensitive manner, providing empirical support for emerging literature on design-driven sustainability transitions (Calabretta et al. 2025; Kirchherr et al. 2017; Lewandowski 2016). Furthermore, this research responds to calls for integrated, practical frameworks that bridge design, compliance and resource efficiency (Geissdoerfer et al. 2016). Importantly, we position the concept of compliance readiness as a dynamic capability, highlighting the organisational adaptations necessary to translate evolving regulatory demands into functional, scalable design strategies. This extends existing literature on innovation management within regulated sustainability domains (Eisenhardt and Martin 2000; Lewandowski 2016).

7.2 | Practical Implications for FMCG Companies

Strategically, the proposed frameworks offer FMCG managers actionable guidance to align packaging innovation with regulatory demands, while balancing technical feasibility, economic considerations and consumer expectations. This approach facilitates organisational adaptability and enables them to transform compliance challenges into opportunities for competitive advantage within CE transitions. The validated and adaptable design toolkits enable packaging teams to translate complex regulatory requirements into structured, context-specific design strategies. By embedding recyclability considerations early in the development process, the tools facilitate improved material selection, minimisation of contamination and enhanced packaging sortability, all of which are critical for achieving high recyclability performance grades under the EU 2030 PPWR.

Beyond technical support, the recyclable-ready design process checklist serves as a key internal alignment mechanism, bridging sustainability, R&D, marketing and supply chain functions. This cross-functional integration aligns consistent compliance efforts with collaboration across organisational boundaries, strengthening the overall packaging innovation process.

Ultimately, this research supports practitioners within FMCG companies in transitioning from reactive adaptation towards strategic innovation. These practical insights are particularly valuable for multinational FMCG brands operating across diverse markets, where harmonisation of recyclability standards and infrastructure continues to pose significant challenges.

7.3 | Limitations and Future Research

Despite its contributions, this research has limitations, primarily stemming from its focus on a single multinational FMCG company and a limited range of packaging formats. Although this approach enabled in-depth exploration and iterative development of the toolkits, the findings reflect specific industrial and regulatory contexts. As such, the proposed toolkits should be viewed as a flexible foundation rather than a universally prescriptive model. Broader application in other FMCG companies, product categories and regulatory environments will likely require contextual adaptation and validation.

Additionally, evolving regulatory landscapes and rapid technological advancements require continuous updates to the tools and frameworks presented here to maintain their relevance and effectiveness. Future research should investigate the scalability and adaptability of the toolkits in different sectors, geographies and packaging types. Studies exploring the integration of emerging digital technologies for real-time recyclability assessment could enhance the toolkits' responsiveness and precision.

Furthermore, quantifying the business and environmental impacts of adopting design-led approaches would provide empirical support for their value.

Longitudinal research embedding the toolkits within real-time packaging development cycles is further needed to evaluate its usability, scalability and cost–benefit performance in practice. Moreover, examining the interplay between consumer behaviour, circular packaging adoption and organisational decision-making will enrich both theoretical understanding and practical implementation. Future work can develop a data-driven decision-making tool to automate and enhance packaging recyclability assessment aligned with the PPWR requirements. The development of such a tool should aim to streamline the currently manual, time-intensive evaluation process by integrating regulatory compliance, design complexity, technical feasibility and sustainability objectives within a unified digital platform.

Finally, comparative studies across markets with diverse waste infrastructures and policy interpretations would enhance the global applicability and robustness of design-led compliance tools. As regulatory pressures and circularity targets intensify worldwide, expanding the evidence base for such tools will be essential for fostering more harmonised, effective and resource-efficient packaging systems.

Endnotes

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[2] https://foodpackagingforum.org/news/consumer-perspectives-on-switching-to-reusable-packaging.

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Appendix

Background Questions

Could you briefly describe your role within, or in relation to, the case company, 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 the forthcoming packaging regulations (PPWR requirements)?

For example, 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 the most important challenge 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 for 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?
2. What are the biggest challenges to meet both functional and sustainability requirements for product [X]?
3. What elements of current packaging (branding, materials) do you think are most important to maintain (for consumer and product needs)?
4. How do you perceive the importance of your role as a designer in the PPWR ecosystem (follow-up of influence and challenges question)?
5. 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 the 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 IMLs for [X]/or recyclable materials?
2. What technical innovations should be explored to improve the recyclability?
3. How would you collaborate with recyclers to ensure materials and processes align with sustainability targets?

Recycling Expert

1. What challenges do IMLs and their inks pose for detectability and recyclability?
2. Why do multimaterial components complicate the recycling process?
   a. When is it okay to have multimaterial components?
   b. 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?
   c. What trends do you see in the recycling process (that could make it more possible for 2030)?
3. How do compatibility, rigidness and packaging shape affect sorting and recyclability in existing waste management systems?
   a. How do you see innovations for the future around this?
4. What changes to design or materials would most improve the recyclability of these packaging types?

Marketing Specialist

1. How important are sustainability and packaging regulations for marketing strategy?
   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 might influence recyclability and design decisions?
5. If we would have to go into a totally different packaging due to sustainability reasons, how might marketing respond?
   a. What would you see as a direction for solutions?

Common Part: Closing, Additional Recommendations

1. If you would have to think about solutions or directions for improving packaging recyclability, what can you think of?
2. Are there any recommendations or insights you wish to share?