Strategic Report and Roadmap on ***Codesigning Circular Packaging*** Retail Systems

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Co-funded by the European Union

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Strategic Report and Roadmap on Codesigning Circular Packaging Retail Systems

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Free Copy
Published online by BOFA, October 2025; Revised edition: April 2026

Forword

"Although Coop Denmark undeniably operates in a highly competitive market of fast moving consumer goods, we continuously strive to reduce our environmental footprint in all our activities.
This report provides examples of practical knowledge that helps retailers move from ambition to implementation—without losing sight of food safety, affordability, or consumer trust.
It has always been financially sound not to use more material than what is feasibly needed, but questions of sustainability continue to arise with increasing urgency. Therefore, we must trust that we can use our resources more intelligently while still strengthening the support of our customers, suppliers, stakeholders, and ultimately achieving financial benefits.
This work makes a valuable contribution to that balance.
Coop proudly contribute to the Relooped project by engaging in dialogue with project partners and sharing valuable insights from the retail sector.
Additionally, we've introduced a living lab on Bornholm, where we got valuable insights on the potential of bulk sales of dried goods from dispensers and reuse of packaging brought by consumers."

Adam Engberg Johannsen, Packaging Project Manager, Coop Denmark

"Modern retail is facing one of the greatest challenges in its history: the transition from a linear model to a truly circular one. This transformation requires not only new technologies and material solutions, but above all close cooperation between business, academia, and the public sector. The RELOOPED project is a practical example of such a partnership.
At Żabka Polska, we believe that responsibility for packaging begins at the design stage and only ends when the material is given a chance for a new life. That is why we actively participate in initiatives that allow us to test new operating models in real store environments—from reusable systems and return schemes to more efficient recycling solutions. Our stores, operating as Living Labs, make it possible to test innovations in the context of everyday customer behavior, enriching the entire process of developing circular packaging systems.
Participation in RELOOPED gives us the opportunity to exchange knowledge with partners from different countries, jointly design future solutions, and access unique data on how materials perform in circulation. It also represents a tangible contribution to building a European circular economy, in which the role of the retail sector is becoming increasingly important.
We believe that the findings and recommendations presented in this report will help us further improve how we design systems that reduce waste, enhance recycling quality, and support customers in making more sustainable choices. This is an important step toward delivering on our responsibility strategy and our ambition to develop the retail of the future—convenient, modern, and environmentally friendly."

Rafał Skawski, Circularity Manager, Żabka Polska

Abbreviations

BPA: bisphenol A

EPS: expanded polystyrene

EVOH: ethylene vinyl alcohol

HDPE: high-density polyethylene

LDPE: low-density polyethylene

PC: polycarbonate

PE: polyethylene

PEF: polyethylene furanote

PEN: polyethylene naphthalate

PET / PETE: polyethylene terephthalate

rPET / rPETE: recycled polyethylene terephthalate

PETG: polyethylene terephthalate glycol

PP: polypropylene

PS: polystyrene

PVC: polyvinyl chloride

PVdC: polyvinylidene chloride

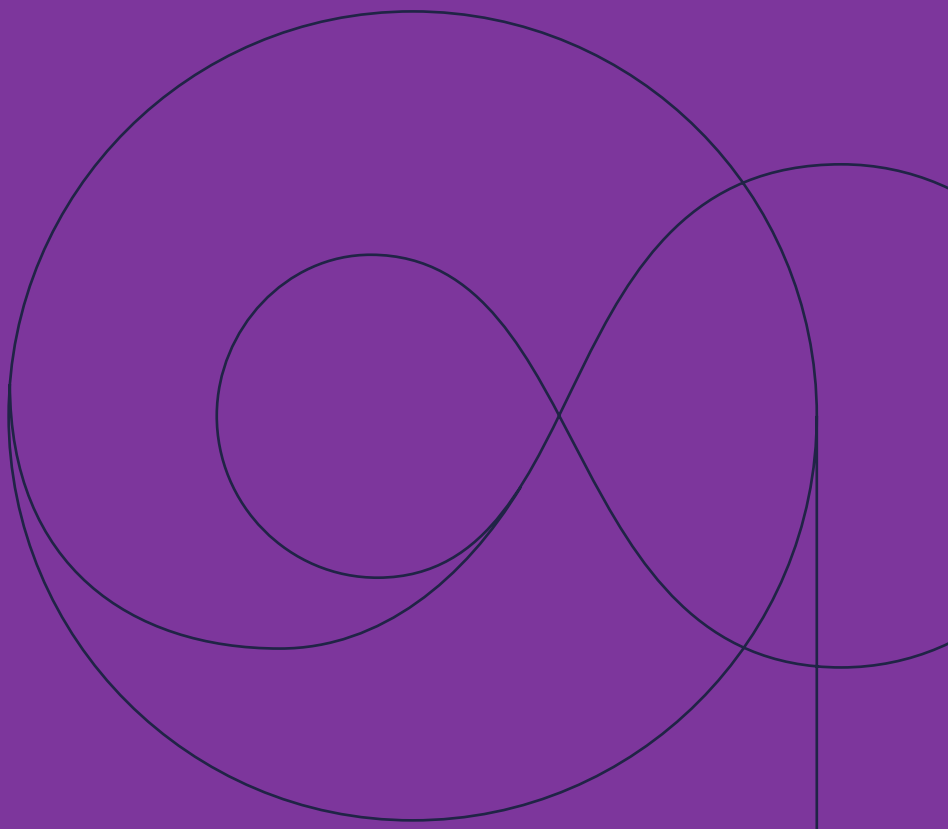
PVdD: polyvinylidene chloride

XPS: extruded polystyrene

Summary

CHAPTER 1

Transitioning to ***circular retail systems***



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The transition toward circular retail systems is accelerating across Europe, driven by a combination of consumer demand, policy pressures, and corporate sustainability ambitions. The RELOOPED project seeks to contribute to this shift by developing and testing circular packaging systems in Denmark and Poland using real-world experimentation, stakeholder engagement, and business-model innovation in Denmark and Poland.

This report presents diverse perspectives and research in seven thematic chapters that collectively examine the complexity and opportunities of circular food-packaging systems. These include: material trends, design innovations, user behaviour, business-model transformation, and co-design methodologies—all centred around the practical realities of packaging systems in retail environments.

The transition is not uniform. Retailers, producers, and consumers are navigating a rapidly evolving landscape of legal frameworks, materials, environmental responsibilities, packaging design, and shifting societal norms. For example, the European Union's revised Packaging and Packaging Waste Regulation is a key driver, mandating reductions in packaging waste, targets for reuse, and clearer standards for design, but varying national implementation creates uncertainty. Simultaneously, digitalisation, self-service models, and ESG reporting mechanisms are shaping how circular systems are evaluated and implemented.

Plastic packaging remains a central paradox: it prolongs shelf life and shields food from contaminants, but it is fossil-based and frequently ends up in landfills or incinerators. Reusing traditional plastic or composting biodegradable versions are two ways to sidestep this paradox, but concerns about hygiene, challenging collection logistics, and slow consumer acceptance pose considerable barriers. Chapters 2 and 3 explore these dynamics in depth, highlighting trends in materials science and collection infrastructure, from bio-based packaging to digital watermarks that enable intelligent sorting.

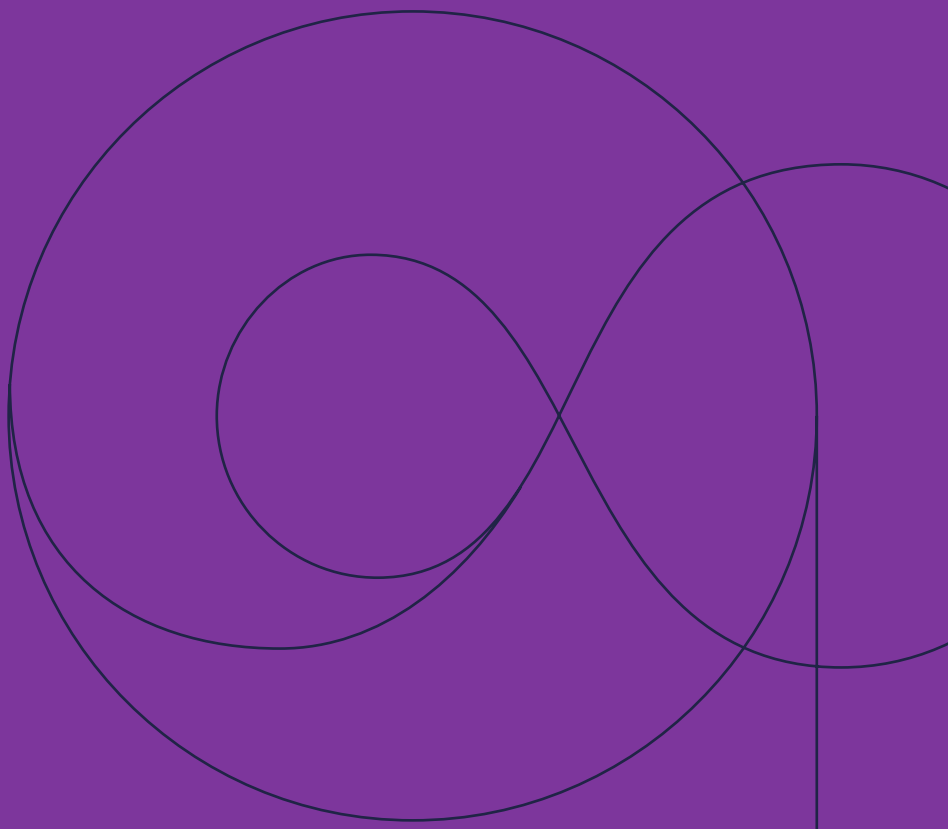
User behaviour is critical to circular transition. Chapter 4 details consumer perceptions of packaging sustainability in Poland and Denmark, as well as what can be done to motivate consumers to return or reuse packaging and how refill stations, deposit schemes, and other retail initiatives can support behavioural change. Chapter 5 goes on to examine the business models that could support these changes, including reverse logistics systems, subscription services, and white-label initiatives for circular packaging.

Building on this systemic understanding, chapters 6 and 7 outline the RELOOPED project's innovation roadmap. These chapters detail a design-led, living-lab approach that integrates stakeholders in identifying, developing, and testing solutions. This includes design sprints with cross-disciplinary teams, collaborative prototyping, and real-life trials in canteens, stores, and sorting facilities. Co-design is used both as a method and mindset to navigate complexity and align technological, regulatory, and human factors.

Ultimately, this report serves as a snapshot of current practices and as a roadmap for further progress. It highlights the urgent need for retailers, policymakers, designers, and consumers to work together to come up with packaging systems that are sustainable, functional, and scalable. The RELOOPED project provides concrete insights and tested tools that can inspire broader action toward circular retail futures.

CHAPTER 2

Key trends and *industry outlook*



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Plastic food packaging is ubiquitous, protecting everything from fresh produce to take-away meals. It is lightweight, durable, and incredibly functional. But it is precisely these strengths that also make it one of the biggest environmental headaches of our time.

How do we deal with a material that's both essential and problematic? This report explores not just the problems related to plastic food packaging, it also seeks to identify solutions by understanding what plastics are made of and how they move through our economy, evaluating their environmental footprint and looking at what tomorrow's packaging might be made of.

Through six focused chapters, we look at facts, dilemmas, design strategies, and real-life examples. Along the way, we explore how the food system could shift toward smarter, more circular packaging—where sustainability and practicality go hand in hand.

UNDERSTANDING THE PLASTIC PACKAGING SYSTEM

Plastics dominate despite recycling challenges

Worldwide, some 430 million tonnes of plastic are produced each year, with an estimated 36% being used for packaging. Plastic food packaging makes up a significant portion of this, and is used to make everything from protective films to polyethylene terephthalate (PET, or sometimes PETE) bottles. The choice of material depends on its properties and recyclability. PET and high-density polyethylene (HDPE) are widely recycled; multi-layer laminated packaging is hard to recycle. Plastic recycling rates vary significantly from country to country. In the European Union, the rate is around 42%, but globally it is much lower. Many countries do not have a sufficiently developed infrastructure to effectively recover materials, leading to the accumulation of plastic waste in terrestrial and marine ecosystems. Another challenge is the quality of recycled plastic: it often contains contaminants that limit its reuse as food packaging.

Despite safety concerns, plastics remain the preferred choice for food packaging due to their affordability and superior properties compared with glass, tinplate, and other traditional materials. Modern packaging utilises some 30 different types of plastic, including polyolefins, polyesters, polyvinyl chloride (PVC), polystyrene (PS), polyamides. Polyolefins and polyesters are the most common due to their balance of durability, ease of processing, and functional advantages that include as thermosealability and microwavability. Furthermore, polymers in the food industry are defined by their barrier, migration, exposure and aesthetic characteristics.

Polyolefins refer to a group of plastics that include PE and polypropylene (PP), and are the most widely used food-packaging material, along with other less prevalent olefin polymers. These plastics are favoured due to their flexibility, strength, light weight, stability, resistance to moisture and chemicals, and ease of processing. Additionally, they are well-suited for recycling and reuse.

PET is produced by reacting terephthalic acid with ethylene glycol. It provides a strong barrier against gases (oxygen and carbon dioxide) and moisture, while also resisting heat, solvents, and acids. PET is widely used in beverage bottles due to its transparency, light weight, and resistance to shattering. It is also used for containers, thermoformed trays, and thin films for snack packaging. PET can exist in both amorphous (transparent) and semicrystalline (opaque) forms, with the latter offering higher strength and hardness. Recycled PET (rPET) is commonly repurposed for fibres, insulation, and non-food packaging. Since packaging with non-standard colours makes recycling difficult and reduces the value of plastic for re-sale, the process benefits from separating bottles by colour.

PC is a durable, clear, and heat-resistant polymer made from bisphenol A (BPA) and phosgene. It serves as a glass substitute in large refillable water bottles and sterilisable baby bottles. However, strong detergents can trigger the release of BPA, raising health concerns that have led to calls for further risk assessments.

PET bottles
(packagingnews.co.uk)

PC water bottle
(briowt.com)

PEN is a high-performance polyester that offers superior gas-barrier and moisture-barrier properties compared with PET. It withstands higher temperatures, making it suitable for refilling with hot liquids, rewashing, and reuse. However, its higher cost limits its use primarily to specialty applications such as beer bottles, where it prevents flavour and odour transfer.

PVdC is a polymer known for its exceptional barrier properties against moisture, gases, and oils. It is used in flexible packaging, either as a monolayer film, coating, or part of co-extruded packaging. PVdC is commonly applied in packaging for poultry, cured meats, cheese, snack foods, coffee, tea, and confectionery. However, like PVC, its high chlorine content presents challenges for incineration and disposal. PVdC is widely used in pipes and connections for transporting water in homes.

PVdC vacuum packaging
(advanmatchpac.com)

PS food containers
(alibaba.com)

PS, a rigid and brittle polymer, has a relatively low melting point and can be processed through extrusion, injection moulding, or foaming. Foamed PS is used for lightweight, impact-resistant packaging such as egg cartons, disposable cups, plates, trays, and protective packaging. Expanded PS (EPS) is used in non-food applications and can be recycled or incinerated.

Polyamides, commonly known as nylon, were initially developed for textiles but are now used in packaging. These polymers are formed through condensation reactions between diamines and diacids, with different types identified by the number of carbon atoms in the monomers. Nylon-6, commonly used in food packaging, has properties similar to PET, and is used to make the bags for boil-in-bag cooking. Nylon is also durable, highly resistant to chemicals, and non-permeable.

Nylon packaging
(plasticstoday.com)

EVOH packaging
(europlas.com.vn)

EVOH is a copolymer of ethylene and vinyl alcohol that provides excellent barriers against oxygen, oils, and fats. However, its sensitivity to moisture limits its use to multilayered films, where it is protected from direct contact with liquids.

Laminates and co-extrusions are multiple types of plastic that are used in combination to enhance their individual properties. Lamination involves bonding multiple layers of plastic or plastic with aluminium, paper, or another type of material using adhesives or heat. This process enables reverse printing, protects graphics from abrasion, and improves heat-seal ability. Co-extrusion, on the other hand, merges multiple layers of molten plastics during film production, offering a more efficient manufacturing process than lamination. However, these multilayered structures complicate recycling. Despite this drawback, laminates and co-extrusions reduce overall packaging material use while leveraging the strengths of different materials, making them valuable in modern packaging solutions.

Plastic is a highly versatile and functional food-packaging material, and has become the most commonly used packaging material in the food industry, due to its ability to protect products and prolong their shelf life, as well as its low cost. Its unique properties—light weight, resistance to moisture, formability, and the ability to be hermetically sealed—make it irreplaceable in many applications.

Choosing plastic for food packaging can make sense from an objective standpoint when considering certain factors, such as:

- **Food safety and hygiene:** Plastic packaging provides a strong barrier against contaminants, moisture, and oxygen, helping to keep food fresh and safe from bacteria and spoilage. Its impermeability is crucial for preserving perishable items like fresh produce, dairy, and meats, as well as for reducing the risk of food-borne illnesses.

- **Durability and convenience:** Plastic is lightweight, flexible, and resistant to breakage, making it ideal for transport and handling. This durability helps prevent damage during shipping and storage, reducing waste and economic losses.

- **Cost-effectiveness:** Compared with materials like glass or metal, plastic is generally cheaper to produce and process. Its low cost allows manufacturers to minimise expenses, which can lead to lower food prices and greater accessibility for low-income communities.

- **Design flexibility:** Plastic can be moulded into a variety shapes and sizes, making it possibly to come up with packaging that improves shelf-appeal, portion-control, and ease-of-use. Features like resealable lids, microwave-safe containers, or vacuum-sealed packs are more easily achieved with plastic.

- **Extended shelf life:** The barrier properties of plastic help reduce spoilage. This reduces food waste at both the retail and the consumer levels, which is a significant environmental and economic benefit. It is important to understand the relationship between the use of a given packaging and product waste when developing a solution. In a packaging-product relationship, in many cases, the impact of the product is greater than that of the packaging.

- **Recycling and environmental considerations:** While plastics pose environmental challenges, advances in recycling technology and the development of biodegradable plastics make them a more sustainable option in certain contexts. Choosing recyclable plastics helps mitigate environmental impact when proper waste-management systems are in place. It is important to understand the maturity level of a given material's recycling chain when developing a new solution. Some materials are more easily reused than others, while others still need to form their recycling chain.

- **Specific use cases:** For certain products like liquids, frozen foods, or items requiring vacuum packaging, plastic is often the most practical material due to its sealing capabilities and flexibility.

From an objective viewpoint, plastic makes sense for food packaging by offering superior protection, convenience, cost savings, and design flexibility. This is especially true when its use is combined with sustainable practices like recycling, just as new innovations will decrease their environmental impact further, making plastic a continuously evolving choice in food packaging.

Reuse and recycling improve sustainability

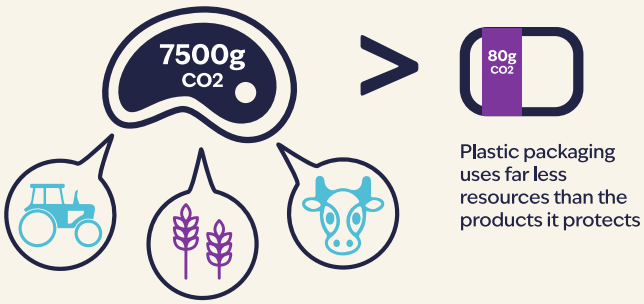
Plastic packaging plays a complex role in sustainability discussions. Often criticised for its environmental footprint, when viewed through the lens of life-cycle assessment, the picture is less one-sided, particularly in the case of reusable plastic packaging when there are systems in place to support reuse and recycling.

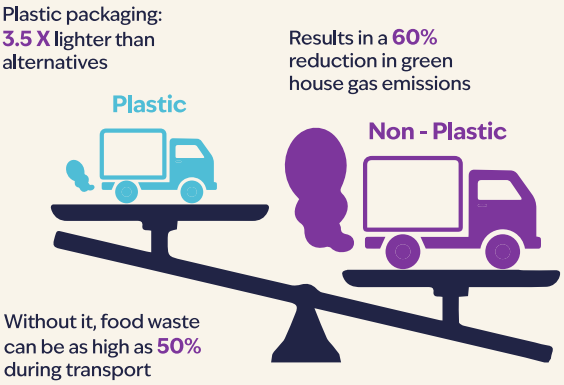
Single-use plastic packaging is typically lightweight, cost-effective, and able to adequately protect its contents with only a minimal amount of material. However, it crates a considerable amount of post-consumer waste. In theory, this waste is recyclable, but, in practice, recycling rates depend on local infrastructure and the conditions under which the packaging was discarded.

Reusable plastic packaging requires more resources to produce initially, but its environmental impact decreases with each use. Studies show that a reusable plastic bag can have a lower environmental footprint than a single-use bag after just eight uses. Similarly, reusable containers and packaging systems have been found to substantially reduce greenhouse-gas emissions when reused the intended number of times.

To demonstrate the role of plastic in reducing food waste and resource loss, the British Plastics Federation points to data showing that the packaging required for a 330g steak generates 80g of carbon dioxide emissions, while producing the steak itself generates 7,500g in emissions.

How is it good for the environment?





Lifecycle assessments show that packaging impacts the environment at every stage: raw-material extraction, manufacturing, distribution, use, and end-of-life disposal / recycling. Plastics tend to outperform glass, metal, and other types of packaging at some stages due to their light weight and the minimal amount of energy required to produce them.

Plastic packaging has been shown to reduce greenhouse-gas emissions by 60%, compared with non-plastic alternatives and, by extending food shelf-life, it can reduce food waste by up to 50% in some cases. An assessment of the entire lifecycle, rather than just post-use waste, would identify even greater benefits.

Reuse systems, such as deposit-and-return schemes and refillable packaging, are increasingly viewed as essential components of a circular economy. These systems can dramatically reduce the need for virgin materials and the environmental impact of plastic over time. In parts of Europe, bottle-deposit schemes achieve return rates above 90%, demonstrating the potential effectiveness of well-designed systems.

However, real-world implementation faces several challenges:

- A **high establishment cost** of cleaning, logistics, and tracking infrastructure.
- Success depends heavily on **consumer participation** and **proper use.**
- Collection, reverse logistics, and hygiene standards are **operationally complex** and can complicate reuse at scale.

Despite these barriers, reuse systems offer significant environmental advantages and are a promising path forward, especially when paired with effective recycling technologies and consumer information. However, before a reuse system is adopted, its local impact should be considered. For example, in areas where the water needed to clean reusable plastics is in short supply, such systems would ease one environmental burden but exacerbate another.

Plastic food packaging is at the crossroads of functionality, sustainability, and innovation. As environmental and regulatory pressures mount, the industry is compelled to rethink how packaging is designed, used, and recycled. Better material choices, improved recyclability, and a stronger focus on circularity can reduce the ecological footprint of plastic packaging without compromising its ability to prolong shelf life or improve efficiency. Collaboration among stakeholders—industry, policymakers, scientists, and consumers—will be key to unlocking the full potential of sustainable plastic packaging. The shift toward a circular economy is not just a technological challenge, it is also a systemic challenge—and it is already underway.

One way to address these challenges would be to develop products and packaging simultaneously, with an immediate aim of reducing environmental impact. We should be constantly asking whether packaging is necessary and where the business model is.


Fonte: AdobeStock

Contamination hinders sustainable plastic recycling...

The current landscape of food-grade plastics presents remarkable opportunities as well as significant challenges, particularly when it comes to recycling, contamination, and sustainable development. As plastics have become the dominant material for food packaging thanks to to their versatility, safety, and cost-effectiveness, and addressing their environmental footprint and advancing recycling technologies is critical for a sustainable future.

Technological advancements have made recycling PE, PP, PET, and other food-grade plastics more feasible. However, a key obstacle is contamination; food residues, additives such as plasticisers or stabilisers, and external pollutants often lower the quality of recycled material. These contaminants can affect food safety and alter the physical properties of recycled plastics, limiting their ability to be reused. To prevent this, sophisticated sorting and cleaning processes, along with enhanced filtration technologies, are employed to produce high purity recycles suitable for contact with food. Yet, ensuring consistent purity remains a challenge, especially with complex multilayer packaging or contaminated waste streams.

... but biological innovations offer circular potential ...

An innovative approach to managing contaminated plastics involves using insects and worms to break down complex polymers into simpler, valuable compounds such as proteins, fats, and chitin. Certain species, such as the greater wax moth (*Galleria melonella*), yellow mealworm *(Tenebrio molitor*), lesser mealworm (*Alphitobius diaperinus*), superworm (*Zophobas morio*), Singapore ant (*Monomorium destructor*), red flour beetle (*Tribolium castaneum*), and brown house moth (Hofmannophila pseudospretella), have demonstrated an ability to consume and degrade PE, PS, PP, polylactic acid (PLA), PVC, and other types of plastic. Remarkably, research indicates that some of these biological processes can produce nutrient-rich products that are free of microplastics, presenting a promising route for reducing plastic waste while at the same time recovering useful materials.

The insects and worms break down plastics by damaging, penetrating, or metabolising using specialised enzymes and physical processes. By optimising temperature, humidity, feedstock composition, and other parameters, scientists aim to develop scalable, environmentally friendly recycling pathways that complement traditional mechanical and chemical methods. Living organisms can help manage plastics that are unsuitable for standard recycling and can contribute to a circular economy by transforming waste into valuable resources. Continued investigation into these mechanisms will clarify whether they are suitable for large-scale implementation and offer an environmentally sustainable solution to the global plastic-waste crisis. These studies are in the early stages, and it is important to understand the potential side effects of these mechanisms before implementing them on a large scale.

No approach to sustainability can be comprehensive without integrating methods to reduce food waste reduction with plastic recycling. Food waste contributes significantly to global environmental degradation, and packaging often plays a dual role—protecting food on the one hand, yet contributing to waste if not properly managed. Incorporating food-waste management into the plastic lifecycle emphasises the importance of designing packaging that minimises waste and enhances recyclability. Strategies like biodegradable plastics, active packaging, and better waste sorting can help close the loop, reducing overall material footprints and conserving resources.

PLA and other forms of bioplastic are touted as sustainable alternatives to conventional plastics, but they can complicate recycling. If mixed with conventional plastics, bio-based plastics can compromise the quality of the recycled plastic, just as their biodegradability can hinder recycling processes. Additionally, cultivating maize, sugarcane or other crops for use as bio-based plastics raises concerns about land use, competition with food crops, and resource-intensive agriculture.

... while systemic innovation shapes future packaging

Looking forward, innovative materials such as next-generation bioplastics derived from non-food sources—like algae, seaweed, or other maritime resources—offer promising solutions. Ocean farming, or 'seaweed agriculture', can produce biomass without competing for arable land or freshwater resources, making it attractive as sustainable raw material. These marine-based bioplastics could potentially be cultivated at scale, providing a renewable, environmentally friendly feedstock that reduces reliance on terrestrial crops and minimises ecological footprints. Moreover, advancements in bioengineering and materials science could lead to bioplastics with enhanced mechanical properties, controlled biodegradability, and improved compatibility with existing recycling infrastructure.

The future of plastics for food packaging hinges on balancing functionality, safety, and environmental sustainability. Recycling technologies are advancing, but contamination remains a significant hurdle. Biological methods offer a novel, environmentally friendly pathway to eliminating plastic waste and recovering valuable nutrients, potentially transforming waste into a resource. However, for circular economies to succeed, they must integrate food-waste reduction, sustainable bioplastics from ocean farming, and improved material design. Advances in research will make it likely these strategies can contribute to a future in which food packaging not only protects and preserves but also aligns with ecological and societal needs for a healthier planet.

A systemic and multidisciplinary approach is recommended for the development of new solutions. Packaging is a complex system, and a small change in a design can lead to a major change in one or more stages in its lifecycle.

The EU is driving progress

Reusable-packaging systems are gaining momentum across Europe as a cornerstone of circular-economy strategies. Supported by the EU's Waste Framework Directive and the Packaging and Packaging Waste Directive, these systems aim to reduce resource consumption, greenhouse-gas emissions, and packaging waste. The European Commission's Circular Economy Action Plan explicitly promotes reuse over single use, creating opportunities for innovation and sustainability.

One major possibility lies in the harmonised deposit return schemes and refill systems that have already contributed to high return rates in Germany and the Netherlands, among other countries. Reusable packaging in retail and food services—such as durable takeaway containers or refill stations—is also being tested in various cities in the EU, often backed by municipal or national incentives.

Significant challenges remain, however.

- **Hygiene and food safety** are critical concerns. EU regulations such as the General Food Law (Regulation (EC) No 178/2002) require strict compliance in cleaning, handling, and transport of reusable food packaging. This adds logistical and operational complexity.

- **Legislative fragmentation** across member states complicates cross-border reuse systems. While EU-level goals exist, implementation varies significantly, affecting scale and consistency.

- **Consumer behaviour** and expectations of convenience are often barriers to adoption. Without adequate education or incentives, consumers will continue to act as they always have.

- **Significant investment** will be needed to establish the reverse-logistics networks, washing facilities, tracking technologies and other infrastructure reuse systems require. The larger and more densely populated the city, the more complex it will be to implement a reuse system.

Despite these challenges, the EU continues to strengthen legislative support for reuse, including through its proposal for a revised Packaging and Packaging Waste Directive that sets binding reuse targets for certain industries. With the right policy support and industry collaboration, reusable packaging has the potential to significantly reduce Europe's environmental footprint.

In short, less is more

Eliminating the use of packaging, reducing the amount of materials and promoting design for disassembly are important paths towards the development of sustainable packaging.

The Nine Golden Design Rules is a set of guidelines developed by the Consumer Goods Forum in collaboration with the Polish Plastics Pact to close the loop on plastic packaging by promoting best practices for environmentally friendly packaging design. These rules focus on eliminating unnecessary packaging, increasing recyclability, and reducing the use of virgin plastics.

Each of the nine rules provides practical recommendations for packaging design that are based on the Polish market and the technologies that are in place there. The document is primarily intended to give packaging designers, manufacturers, and retailers a way to harmonise packaging-design requirements globally. The elements aimed at reducing packaging use would significantly contribute to circular economies by offering a tangible and measurable path to eliminating excessive packaging. The recycling elements contribute by promoting packaging that is easier to recycle, contributing to higher rates of recycling.

The transition towards a circular economy for plastic packaging hinges significantly on how packaging is designed. The Nine Golden Design Rules provide a harmonised framework aimed at improving the recyclability and sustainability of plastic packaging. These guidelines offer both opportunities and challenges when it comes to designing packaging for disassembly and effective recycling. They are not exhaustive; instead, they present some solutions and encourage packaging designers to develop sustainable packaging.

The primary opportunity lies in harmonised design standards as a means to increase the recyclability of packaging globally and locally. Clear design rules—such as eliminating PVC, PVdC, EPS, and other problematic materials; avoiding multi-material structures; and using transparent PET or mono-material packaging—are intended to make disassembly easier and sorting more efficient,

Rules 1 (Increase value in PET recycling) and 5 (Improve recyclability of thermoformed PET trays) emphasise the importance of choosing materials and labels that are compatible with existing recycling technologies. Similarly, Rules 6 (Increase recycling value in flexible consumer packaging) and 7 (Increasing recycling value in rigid HDPE and PP) promote mono-material designs in flexible and rigid packaging, which greatly facilitates mechanical recycling.

Another major opportunity is reduced material complexity. This benefits recyclers as well as producers, since simpler packaging formats lead to reduced waste-management costs and higher recovery rates for valuable materials. Rule 9 (On-pack recycling instructions) recognises that informed consumers are the key to improved sorting and cleaner recycling streams.

For us to make the most of these opportunities, we must overcome several hurdles. One of biggest is the technology and infrastructure gap present in many places, including Poland. Some packaging materials that are technically recyclable are left unprocessed due to a lack of facilities or economically viable processes. For instance, flexible packaging and PET thermoforms are still under-recycled; design improvements would make them easier to recycle.

Another challenge is the loss in functionality that new designs would bring about. Packaging must continue to protect food, extend shelf-life, and meet regulatory standards. Eliminating certain materials or shifting to mono-material formats may compromise barrier properties or shelf-life, especially for foods.

Cost and market pressure is a third challenge. Transitioning to new packaging formats, inks, adhesives, and labelling systems can be costly, particularly for small and medium-sized enterprises. Moreover, recycled content is often more expensive than virgin plastic, and its availability is limited.

Lastly, consumer behaviour and perception are not always aligned with environmentally friendly design. Consumers may resist changes such as switching from opaque to transparent packaging if they associate colour or appearance with quality.

Designing packaging for disassembly and recycling requires a holistic approach that balances environmental, economic, and functional considerations. The Nine Golden Design Rules provide a strong foundation for standardising and improving packaging recyclability. While challenges exist—particularly in terms of infrastructure, costs, and technical limitations—the opportunities for innovation, resource savings, and environmental impact reduction are substantial. Long-term success will depend on continued collaboration all along the packaging value chain, public-policy support, and consumer engagement.

Less is more. Eliminating the use of packaging, reducing the amount of materials and promoting design for disassembly are important paths towards the development of sustainable packaging.

Fonte: AdobeStock

The Nine Golden Design Rules

1. Increase the value in PET recycling

Use clear, colourless (preferred) or clear blue or green PET in PET-bottle production to facilitate recycling. Replacing coloured PET with transparent will have a positive impact on the supply of high-quality PET recyclate and ensure there is an efficient waste-management pathway back from the consumer to marketers.

2. Remove problematic elements from packaging

Eliminate difficult-to-recycle materials such as undetectable carbon dye, PVC and PVdC, EPS and extruded PS (XPS), PET glycol (PETG) used in grid packaging, and oxo-degradables. Black and dark carbon-dye packaging is difficult to sort; PVC and PVdC interfere with PET recycling and compromise recyclate quality; EPS and XPS lack effective large-scale mechanical recycling; PETG does not separate from PET flakes in flotation and therefore contaminates the feedstock stream; and oxo-degradables decompose into microplastics, cannot be composted, impede recycling of other plastics, and have no proven environmental benefits.

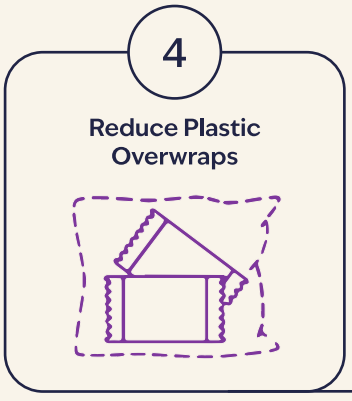
Removing these materials from circulation prevents contamination of secondary raw materials, increases recycling efficiency, and improves the quality of recovered materials.

3. Eliminate excess headspace

In some products, empty space serves a purpose by helping to reduce breakage during storage and transport. However, eliminating unnecessary headspace reduces the need for virgin raw materials and the overall amount of plastic. Moreover, smaller packages are more easily optimised for transport.

4. Eliminate unnecessary plastic overwraps

Removing protective films from product packaging when they are not necessary to maintain product quality, or replacing them with another material, reduces the need for virgin materials and the overall amount of plastic.



5. Increase recycling value for PET thermoformed trays and other PET thermoformed packagingIncrease

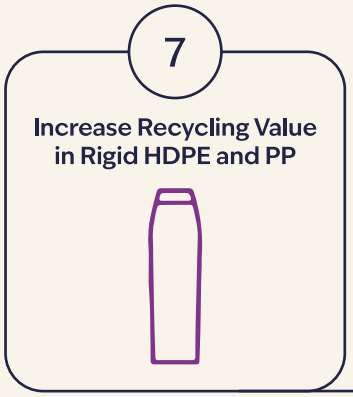
PET thermoformed packaging is currently not recycled on a large scale, but solutions are being developed in Europe to increase the quality of the plastic that is collected, making it more valuable for reuse. One way to make it easier to reuse is to make it with mono-materials that have not been dyed and have easily removable labels. Improving the identification of the type of polymer used in packaging facilitates the separation and recycling process.

6. recycling value in flexible consumer packaging

The principle of increasing recycling value in flexible consumer packaging made of plastics focuses on aligning packaging design with existing regional waste-management and recycling systems. For packaging not initially accepted in current systems, but which had a defined path for recyclability by 2025, specific requirements apply: material density should not exceed 1g / cm^3, barrier layers must be under 5% of total weight, and materials like PVC, PVdC, aluminium foil, and PET are prohibited. Packaging should preferably consist of at least 90% PE or 90% PP. If these levels are not possible, a minimum of 80% PE, 80% PP, or 80% mixed polyolefins is acceptable. These guidelines aim to improve compatibility with future recycling technologies. The goal is to make packaging more recyclable and reduce contamination in recycling streams.

The benefit of this system is that it increases the recyclability of flexible plastic packaging, which represents a significant and growing share of the packaging market. These design changes support better mechanical and chemical recycling, helping to build a more efficient recycling infrastructure. This can be accomplished by using homogeneous materials in film packaging. Due to their weight and volume, small packages are more difficult to recycle.

7. Increasing recycling value in rigid HDPE and PP



types of rigid plastic packaging requires careful selection of materials, adhesives, dyes, and closures to avoid disrupting recycling processes. Direct printing should be minimal, and fillers that raise material density above 1g / cm^3 should not be used. This rule enhances the recycling quality and output of HDPE and PP packaging, which are already widely recycled in many markets. In Poland a recycling infrastructure exists, but rates are still below 30%, making design improvements essential. Following these guidelines could lead to higher recycling rates and a greater availability of HDPE and PP recyclate, and have an impact on 20% of the global market for plastic packaging and 23.4% of packaging placed on the market by the members of the Polish Plastics Pact.

8. Reduce virgin plastic use in in B2B plastic packaging

Since B2B packaging typically doesn't require food-grade or barrier properties, it offers strong potential for incorporating recycled or low-impact materials. This can be accomplished by eliminating unnecessary material, using recycled content, and switching to reusable or alternative materials in plastic packaging that is not intended for packaging of retail products, including as transport packaging, stretch films, shrink wraps, and secondary packaging for bundling products. Benefits include reduced use of virgin plastics, higher recycled content in B2B packaging, less plastic waste, and lower greenhouse-gas emissions.

9. Use on-pack recycling instructions

Symbols and short instructions on labels can help consumers sort or reuse primary packaging properly. QR codes and other forms of online communication can be used to provide more detailed information. Similarly, Poland's Five Fractions Coalition seek to develop standardised, easy-to-understand sorting instructions to support both manufacturers and consumers. These sorts of initiatives recognise the vital role consumers play in the success of waste collection systems. Their success can improve the quality of waste streams destined for recycling and raise public awareness about proper sorting practices, ultimately increasing the availability of recyclable materials.

CASE STUDIES

Testing circular solutions in practice

Assessing single-use and reusable takeaway food containers

Life-cycle assessment is a method used to evaluate the environmental impact of products throughout their entire life cycle, from raw material extraction, production, and use to end-of-life disposal. A Nordic Council of Ministers study applied this methodology to compare the environmental consequences of single-use and reusable takeaway-food containers by considering key indicators such as carbon-dioxide emissions, energy and water consumption, and waste generation.

The study found that single-use containers have a lower environmental impact when used once, primarily due to their lighter weight and simpler structure. However, they generate large amounts of waste and rely heavily on non-renewable resources. In contrast, reusable

containers require more resources to produce, and must be cleaned, but, over the course of their lifetime, their carbon-dioxide emissions per use can be lower than for single-use. The same is true for waste generation. The decisive factor is the number of times they are used.

In terms of measurable outcomes, the study concluded that reusable containers outperform single-use in 11 out of 13 environmental-impact categories, including climate (44% lower), acidification (39% lower) and fossil-resource use (46% lower). The point at which reusable containers become the more sustainable option typically occurs after about six uses, although for land use, water scarcity and several other categories, the break-even point was 14 uses.

A critical factor in the overall performance of reusable containers is the efficiency of the return and reuse system. When containers are used frequently and cleaned efficiently, they outperform single-use. However, certain practices—such as handwashing with hot water or transporting returns by car—can increase their environmental footprint.

The study reiterates that the optimal solution locally depends on local infrastructure, consumer habits, and the availability of environmentally friendly washing and recycling systems. For reusable containers to truly deliver environmental gains, they must be part of well-designed systems that support convenience, hygiene, and consumer participation.

Both single-use and reusable containers have their merits, but the study clearly shows that reusable containers have the potential to offer substantial environmental advantages—provided they are implemented thoughtfully. Policymakers, designers, and food-service firms must consider factors such as logistics, cleaning methods, and consumer behaviour if a reuse system is to be not just functional, but truly sustainable.

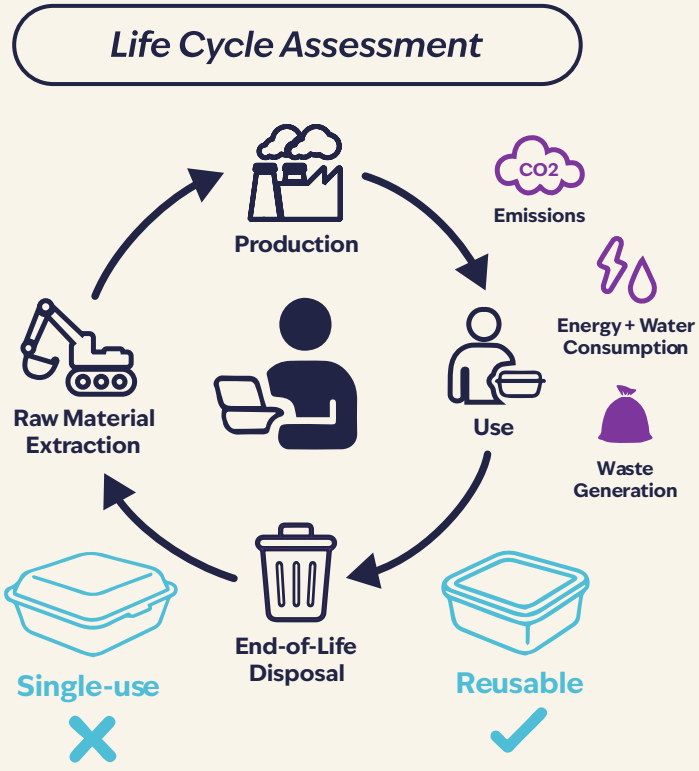



Photo: Freepik

Enabling food-grade plastics

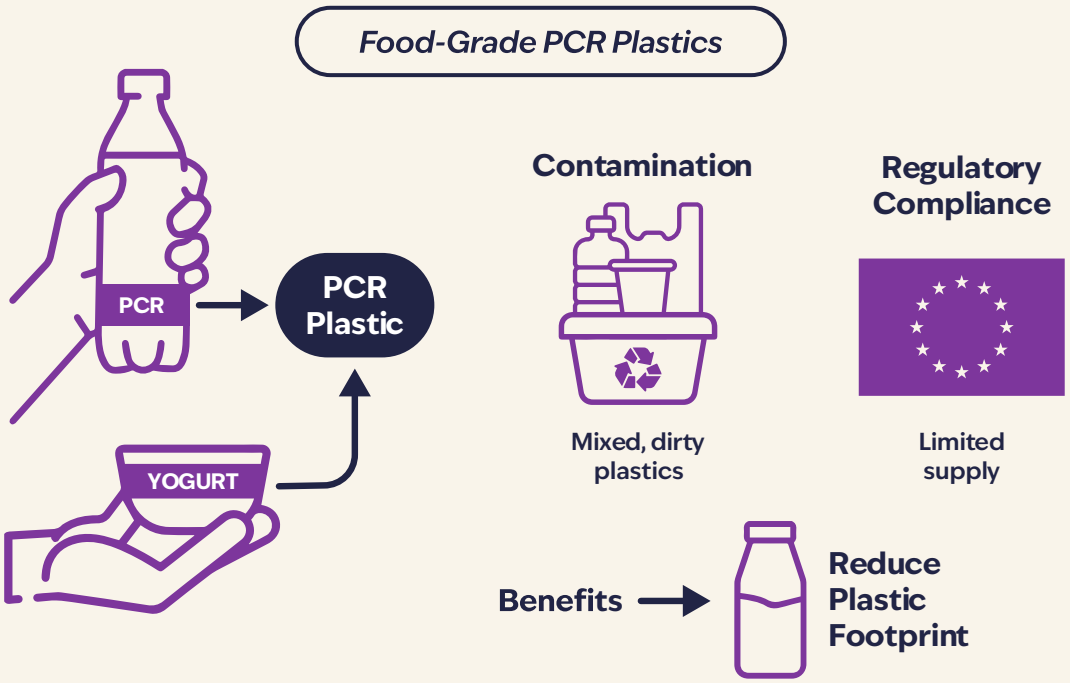
Imagine buying yogurt in a plastic cup that used to be a soda bottle. That's the promise of post-consumer recycled plastics for food packaging: a more circular system that allows plastics to live more than one life. But turning this promise into reality isn't as easy as it sounds.

Firstly, food-grade post-consumer recycled plastic must meet strict safety standards. After all, no-one wants yesterday's detergent bottle contaminating today's salad container. The problem is that plastics collected from households are often mixed, dirty, or come from unknown sources. Sorting and cleaning them to food-safe levels is technically complex and costly.

A second hurdle is regulatory compliance. In the EU, only plastics recycled using approved processes—often involving a 'super-cleaning' step or chemical recycling—are allowed to come in direct food contact with food. This limits the supply and drives up prices.

But the potential gains make the effort worthwhile. Using post-consumer plastic reduces the demand for virgin fossil-based plastic, cuts carbon-dioxide emissions, and keeps materials in the loop. Some companies are already showing how this can be done. A Danish dairy co-operative has introduced food-grade certified milk bottles, cutting its plastic footprint without compromising safety.

The path forward includes better collection systems, investment in advanced recycling, and clear regulations that balance safety and innovation. With the right support, food-grade post-consumer plastics could become a cornerstone of sustainable packaging—proving that today's plastic doesn't have to be tomorrow's waste.



Investing now shapes packaging's future

Food packaging is developing rapidly. As consumer demand for environmentally friendly, yet functional, options grows, manufacturers are responding by seeking alternatives to traditional materials.

Corrugated cardboard packaging is gaining popularity due to its durability, recyclability and attractive appearance. It has come to play a significant role in a market where consumers display increasing environmental awareness.

In Poland, packaging-production firms have responded to these changing consumer expectations–and been rewarded for it. The average annual growth rate for such firms is 6.8%. Export plays a key role in this growth, with an average annual increase in the weight of packaging exports of around 11% over the past eight years.

Packaging recycling is becoming an increasingly important element of their activities. However, the introduction of recycled food packaging is associated with technological, economic and legal challenges. Profitability is contingent on an efficient processing system that is capable of suppling high quality raw materials.

It is also important to understand which packaging is recyclable. And just because a material is technically recyclable does not meant that it is easy to do so, which highlights the need to inform consumers and investment in modern waste-treatment technologies.

The are any number of hurdles on the path towards improved food packaging, but opportunities also abound. For them to be realised, significant investments must be made in sustainable materials, efficient recycling processes and consumer information. Fortunately, several factors are aligning in favour of circular economies for food packaging.

- **Regulation:** The EU's Packaging and Packaging Waste Regulation mandates all packaging be recyclable by 2030, with rising targets for recycled content.

- **Technology:** Innovations in PLA and PHA bioplastics, nano-composites, and antimicrobial films promise better functionality and reduced impact.

- **Consumer behaviour:** Surveys show growing willingness to pay more for sustainable packaging—especially among younger and urban consumers.

- **Global frameworks:** The UN Environment Programme is convening and facilitating the Intergovernmental Negotiating Committee (INC) developing a legally binding global plastics treaty. As of August 2025, the INC has not yet reached consensus on a final treaty text, and deliberations will continue in future sessions. OECD models show policy co-ordination could cut plastic pollution by 96% by 2040.

Systemic issues—cost, infrastructure, and cultural habits—continue to hinder the transition to sustainability. While wanting to be sustainable is essential, merely appearing to be sustainable does not reduce environmental impact and can leave consumers less informed. In contrast, businesses that genuinely align with environmental trends are better positioned to meet regulations and gain consumer trust.

TOWARDS CIRCULARITY

The way we use plastic is crucial

Plastic food packaging is at the crossroads of functionality, sustainability, and innovation. As environmental and regulatory pressures mount, producers are compelled to rethink how packaging is designed, used, and recycled. Through smarter material choices, improved recyclability, and a stronger focus on circularity, producers can reduce its environmental footprint without compromising food safety or efficiency. Collaboration among firms, policymakers, researchers, consumers and other stakeholders will be key to unlocking the full potential of sustainable plastic packaging. The shift toward a circular economy is as much a systemic challenge as it is a technological challenge.

This shift is already underway. Promoting and disseminating knowledge about the development of reusable packaging is essential if we are to see the progress that will allow the shift to be successful. The ideal type of packaging would be one that fulfils its functions with the least possible environmental impact. Packaging is necessary for the maintenance of the planet's population, but the same packaging can also cause serious harm to the planet and its population. Fortunately, the problem is not the materials the packaging is made of; it is way the packaging is used.

Fonte: Freepik

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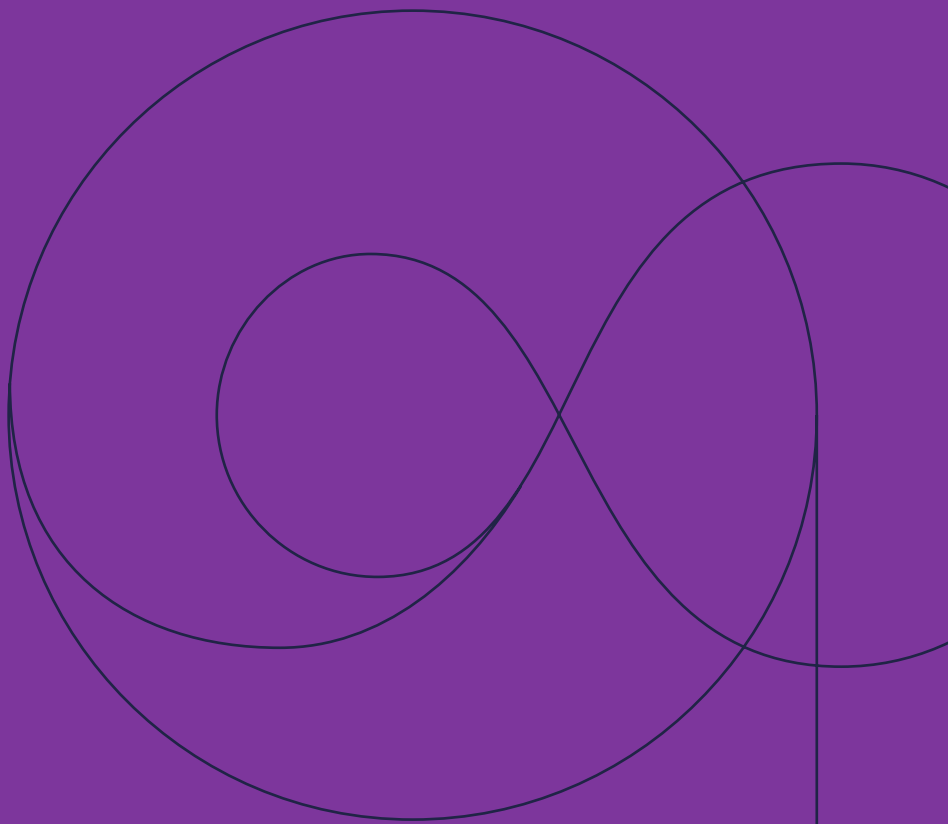
CHAPTER 3

Packaging innovations and new *circular return systems*



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Innovation in product design and materials and system innovations in the form of new return and recycling systems and other technologies within packaging are entering many parts of society, including food retail. The rise of automated production, smart distribution, materials innovation, and new return systems has demonstrated a vast amount of circular approaches that are relevant for retail foods (Ellen MacArthur Foundation, 2020; Nordic Council of Ministers, 2024). This chapter details innovations in packaging-technology in a range of industries in the hopes that it provides food retailers with the inspiration to phase circular models.

Product packaging is undergoing a radical transformation, as producers shift from disposable packaging and linear systems to circular, regenerative models in response to mounting environmental crises, tightening regulations, and evolving consumer demands (Ellen MacArthur Foundation, 2016). This revolution is unfolding across three critical fronts:

Phasing out single-use plastics

Global bans are accelerating the elimination of the most problematic plastics, with the European Union's Single-Use Plastics Directive setting the benchmark by banning items like cutlery, straws, and polystyrene containers (Report on Excessive and Problematic Packaging, Plastik Pact Poland, 2022). This year, Canada implemented a ban on certain single-use plastics, while India has enforced strict restrictions on 19 disposable plastic items (Global Plastic Laws Database). Even in the United States, where federal action lags, California, New York, and New Jersey, among other states, have enacted aggressive plastic-bag bans. Plastic grocery bags—once a symbol of convenience—are rapidly disappearing: France has banned them entirely; Chile was the first country in Latin America to do so; and Kenya's strict penalties have reduced plastic bag pollution there by 80% (WWF, 2021). In Brazil, regulations are being influenced by the European Union's guidelines, but the implementation process is slowed considerably by the country's size and cultural diversity. On the corporate side, Unilever is cutting virgin plastic use by 50%, Nestlé is transitioning to fully recyclable packaging, and Coca-Cola now incorporates 50% recycled content globally (Roadmap, Plastik Pact Poland, 2022).

Refill revolution

Refill systems are disrupting traditional packaging by eliminating waste at the source. In Chile, Algramo uses radio frequency identification (RFID)-enabled dispensers for detergent and rice, while Loop partners with Tesco, Walmart, and Carrefour to deliver products in durable, returnable containers (Making the Switch, Reloop Platform). The UK-based Refill Initiative has installed more than 300,000 refilling stations for water, coffee, and food containers, eliminating the need for 100 million pieces of plastic (WWF Basket, 2022). The EU's 2030 mandate requiring supermarkets to dedicate 20% of shelf space to refill stations signals that, rather than a niche trend, we are seeing a movement towards a permanently altered retail sector (From Single-Use Packaging to Reuse, 2021). Early adopters see 30% cost reductions in packaging and 60-70% lower carbon footprints for products like detergent.

Material innovation and systemic change

Beyond refills, the industry is embracing groundbreaking materials: Notpla produces seaweed-based films that decompose in weeks; Evocative's mycelium packaging is grown in moulds; Appel's edible coatings extend food shelf life. However, true circularity demands systemic collaboration; policymakers must enforce extended producer responsibility (EPR) laws, as is the case in Japan and South Korea. Corporations must redesign products for reuse, as P&G has done with its recyclable shampoo bars (9 Golden Design Rules, Plastik Pact Poland, 2023).

Consumers, for their part, must—and can—develop new habits: Germany's Pfand system achieves 98% bottle return rates. As Loop's Tom Szaky observes: 'The future of packaging is no packaging at all.' This revolution isn't just about removing plastic, it's about redefining consumption itself. In this sense, reduction is a tangible and quantifiable path. There is a significant amount of waste throughout the lifecycle of a product and its packaging. Another important factor is the unbridled consumption of unnecessary items.

WHY IT ALL MATTERS

The shift away from single-use plastics is an environmental imperative, but it also has an economic and geopolitical impact

Climate impact: Single-use plastics account for 40% of plastic waste worldwide, yet only 9% is recycled (OECD). Refill systems can reduce detergent carbon footprints by 60-70% (Ellen MacArthur Foundation, 2020).

Corporate risk: BP and Shell predict plastic taxes could cost the industry in excess of $100bn by 2040 if they do not adapt.

Regulatory momentum: Legislators at the local, national, and international levels are increasingly supportive of initiatives to reduce waste

- EU: SUPD and 2030 reusable-packaging targets
- China: Waste Import Ban forced Western countries to improve recycling.
- India: Plastic Waste Management Rules levies fines on non-recyclable packaging.
- US: While a laggard at the federal level, individual states are passing more ambitious legislation. Maine and Oregon, for example, have passed EPR laws for packaging.

Emerging Global South: Plastic pollution causes disproportionate harm to the Global South, but some countries are taking steps to address the problem.

- Indonesia, Philippines, and Vietnam are top contributors to ocean waste due to inadequate waste systems (WWF: Packaging Unwrapped, 2021).

- Africa is at the forefront of imposing bans, with 34 countries restricting single-use plastics.

- In Brazil, only a few cities have banned the use of plastic bags and some single-use items such as straws and plastic cups. Federal laws are a guide for designing local initiatives.

The packaging revolution is no longer optional, it is a competitive necessity. Companies and countries that resist will face regulatory penalties, consumer backlash, and stranded assets in a world moving toward zero-waste and circular economies.

The rapid emergence of zero-waste shops and refill-concept stores marks a significant shift in consumer behaviour toward sustainable, minimal-packaging solutions (From single-use packaging to reuse, 2021). These innovative retail models, including pioneers like Bulk Market, Package Free Shop, and Algramo's smart refill systems, address growing environmental concerns by eliminating single-use packaging entirely or implementing closed-loop refill systems for everyday products. Customers bring their own containers to purchase precisely measured quantities of bulk goods ranging from dry foods to cleaning products, simultaneously reducing household waste and often saving money through bulk pricing (WWF Basket, 2022).

This movement reflects broader societal changes: heightened awareness of plastic pollution thanks to documentaries like 'The Story of Plastic', increasing government bans on single-use plastics (Report on Excessive and Problematic Packaging, Polish Plastics Pact, 2022), and major brands developing packaging-free alternatives. While challenges such as higher up-front costs and the need for changed consumer habits remain, the number of options is rapidly expanding and now includes compostable materials, retailer-brand collaborations, and smart dispensing technologies, such as HolyGrail's digital watermarking initiative. As the number of independent zero-waste stores and refill sections in mainstream supermarkets increases, the concept goes from niche alternative to a viable component of the circular economy, proving that sustainable shopping can be both environmentally responsible and commercially successful (Ellen MacArthur Foundation, 2020).

However, before such systems are put into place, a systematic analysis of its impact should be carried out to verify whether it is genuinely sustainable or simply moving the problem.

Fonte: Freepik

Bans, consumers, and brands drive the shift

Single-use plastics make up a significant proportion of global waste: Globally, only about 9% of plastic is recycled, while the rest is incinerated, landfilled, or leaks into the environment as pollution.. As microplastics, they are a danger to the environment, wildlife, and human health. Moreover, their production relies on fossil fuels, generating 3.8% of global greenhouse-gas emissions. Over 100 countries have banned or restricted these plastics, driven by policies like the the SUPD and EPR requirements. Supported by movements like #BreakFreeFromPlastic, consumer demand for sustainable packaging is rising, with 72% saying they favour environmentally friendly brands. Unilever, Coca-Cola, and other major corporations are reducing the amount of virgin plastic they use, while other initiatives, such as TerraCycle's Loop, seek to provide options for reuse (Accorsi et al., 2022).

Sustainable reuse options include Loop's containers and RePack's mailers, Notpla's seaweed-based packaging, Ecovative's mycelium-based solutions, and Algramo's vending machines. Edible packaging, digital labels, and mono-material designs can further reduce waste. However, challenges remain, including high costs for biodegradable materials, inconvenience for consumers, and greenwashing. The build-out of composting and recycling infrastructure must also keep pace with the growth of compostable and multi-use alternatives; more compostable packaging necessitates an equal growth in the capacity to compost it. Today, a considerable portion of waste sent to landfills is organic; increasing the volume of compostable packaging without an adequate system could worsen the problem.

Rwanda's plastic-bag ban has made it one of the cleanest countries, while South Korea cut plastic waste by 33% through strict recycling policies. McDonald's, IKEA, and other consumer-facing firms are adopting paper straws and reusable containers. Other major brands are scaling refillable packaging, and Amazon promotes minimal designs. This progress has been driven by policy, innovation, and consumer activism. Future efforts to achieve a waste-free economy include the UN Global Plastics Treaty (Global Plastic Laws Database), chemical recycling and algae-based plastics, and cultural shifts toward zero-waste lifestyles. Progress towards this goal will likely rest on reusable systems, advanced materials, and circular business models. As the circular-economy principle states: 'There is no "away".' Ending single-use packaging is a crucial step toward this vision.

The reuse revolution

Over one million plastic bottles are sold every minute globally—but less than 10% of them are recycled. The plastic bottles themselves contribute to ocean pollution, and microplastic contamination, while their production causes greenhouse-gas emissions. Beyond that, the bisphenol A that is used to make the plastic can leach into the water the bottles contain, posing health risks. Bottled water is also up to 2,000 times more expensive than tap water (WWF Basket, 2022).

Reusable bottles are a sustainable alternative to single-use drinkware that combines durability, style, and reduced environmental impacts. Stanley, founded in 1913 and known for rugged products, collaborated with Starbucks in 2023 on limited-edition Quencher H2.0 FlowState Tumblers. By combining function (stainless-steel, double-wall vacuum insulation that can keep drinks hot or cold for hours) and form (vibrant colours, ergonomic designs with handles and straw lids), they have the potential to replace hundreds of single-use bottles throughout their lifetime. Popular reusable drinkware is also produced by Hydro Flask, S'well, and Klean Kanteen (Design Guide, Danish Plastics Federation, 2023).

The Stanley Cup tumbler became a status symbol after it was promoted by influencers on TikTok and Instagram, while the release of limited-edition versions created a sense of urgency and drove up resale values. The tumbler encourages consumers to choose reusable drinkware and has transformed Stanley from an outdoor brand to a lifestyle icon that appeals to young urban consumers (Ellen MacArthur Foundation, 2020).

Stanley Quencher H2.0 Flowstate Tumbler—Starbucks Red Holiday Tumbler (Stanley)

Its success aligns with a growing global popularity of sustainable products, despite often costing more; some 66% of consumers say they are willing to pay more for environmentally friendly products (European Commission, Directorate-General for Environment, 2019). Major brands, including Starbucks, Nestlé, and Coca-Cola, are investing in reusable packaging to meet sustainability goals, with Starbucks aiming for a 50% reduction in waste by 2030 by phasing in reusable cups. Other brands are turning to innovation to promote sustainability: LARQ has developed a self-cleaning bottle, and S'well offers personalisation as a way to encourage reuse.

Governments are supporting these trends by implementing bans and taxes on single-use plastics, such as the SUPD, and California's Plastic Waste Reduction Act. The future looks likely to favour reusable bottles and tumblers over single-use options, paving the way for brands to introduce recycling programmes and for emerging markets to adopt reusable products as the infrastructure required to process it improves. One point of attention is the amount of reusable packaging we accumulate. According to one estimate, there are more mugs than human beings on the planet (LCA on Reuse of Packaging in the Nordics, 2024).

New materials and recycling

The shift toward sustainable materials is driving innovation in biogenic, plant-based, and biotech solutions—all of which are crucial for a circular economy. Biogenic materials derived from natural sources like seaweed, mycelium, and algae offer renewable and biodegradable alternatives to conventional plastics. Seaweed, for instance, requires no freshwater or farmland to grow and is used by Notpla, Loliware and other firms to make edible packaging and films. Similarly, mycelium are engineered by Ecovative into durable, compostable packaging and textiles, while the algae-based bioplastics produced by Algix turn carbon-dioxide absorbing organisms into foams and plastics (Versino et al., 2023).

Second-generation plant-based materials avoid concerns about using crops for other purposes than food by using agricultural waste or non-edible biomass. Paptic and Stora Enso transform wood pulp and crop residues into fibre-based packaging, while Hemp Plastic and Agraloop convert hemp and crop waste into bioplastics and textiles. Bagasse is already used for disposable food containers by brands like Eco-Products and Vegware (Design Guide, Danish Plastics Federation, 2023).

Meanwhile, biotech firms are pushing the boundaries for bioengineered materials. Danimer Scientific and RWDC are using fermentation to produce biomass-based polylactic acid (PLA) and polyhydroxyalkanoates, a type of biodegradable plastic that is made by microbes. Bolt Threads and Spiber are employing synthetic biology to produce spider-silk proteins. Modern Meadow is using the same approach to make bacterial cellulose, while MycoWorks is turning mycelium into a material that resembles leather (Pushparaj et al., 2022).

Seaweed straw (Loliware); mycelium packaging (Ecovative Design); 3D algae filament (ALGIX)

To close the loop, compostable packaging, along with chemical recycling, such as Carbios's process for using enzymes to break down PLA, ensure these materials are broken down into their constituent parts at the end of their lives. Even more groundbreaking are carbon-negative materials, including like LanzaTech's carbon-dioxide converted ethanol or algae-based products that remove more carbon than they emit (Ellen MacArthur Foundation, 2016).

Together, these innovations reduce reliance on fossil fuels, cut waste, and even reverse emissions, underscoring that sustainability and cutting-edge science go hand-in-hand.

For this approach to have the biggest impact, packaging plants should be established close to the producer or waste generator in order to help keep costs and carbon pollution down. One of the challenges when rolling out innovations is the scale of production, especially products such as mycelium packaging.

A trade off that comes with reusable containers is that they are heavier than single-use packaging, and will increase the overall volume of waste when they are finally discarded, underscoring the need to assess the overall impact of a new initiative (LCA on Reuse of Packaging in the Nordics, 2024).

Automation and AI close the loop

The circular packaging economy aims to minimise waste and maximise the reuse, recycling, and recovery of materials. Automated and robotic return systems, along with AI-assisted sorting technologies, are playing a significant role in advancing this goal. Below are examples of innovative return systems that support the circular packaging economy (Ellen MacArthur Foundation, 2020).

Automated return and sorting systems

- Reverse vending machines: kiosks that use optical sensors and barcodes to accept used bottles and cans, and to pay out refunds. They are a cornerstone of deposit-and-return schemes in Norway, Germany, and parts of the US (Tomra) (Notes from Poland, 2022).
- Smart return system: end-to-end platforms for reusable packaging, from drop-off / mail-in, tracking, cleaning, and refilling (Looped) (Making the Switch, Reloop Platform).
- Smart waste bins: employing AI to sort recyclable and non-recyclable items at the point of disposal (CleanRobotics) (Innovate UK, Smart Sustainable Plastic Packaging Challenge).

AI and robotics in recycling facilities

- AI-guided robotic sensors to sort plastics, metals, and paper (AMP Robotics, ZenRobotics).
- Recycling robots to handle materials like glass and plastics and improve sorting efficiency (FANUC).
- AI analytics and near-infrared sensors to identify materials and to accurately sort materials (Greyparrot, Pellenc ST) (Recycling of Post-Consumer Plastic Packaging Waste in the EU, 2021).
- Applying technology developed for the mining industry to detect the composition of discarded packaging (MineSense).

Smart packaging and tracking

- Reusable e-commerce packaging that is fitted with RFID tracking tags. Both also offer incentives to consumers (RePack, Lizee).
- Smart bins and apps for tracking returns and rewarding customers (RePack DRS, Return and Earn).
- Using blockchain technology to provide rewards for returning plastics and ensure transparent recycling trails (PlasticBank, Circularise) (HolyGrail Project, Digital Watermarks Initiative).

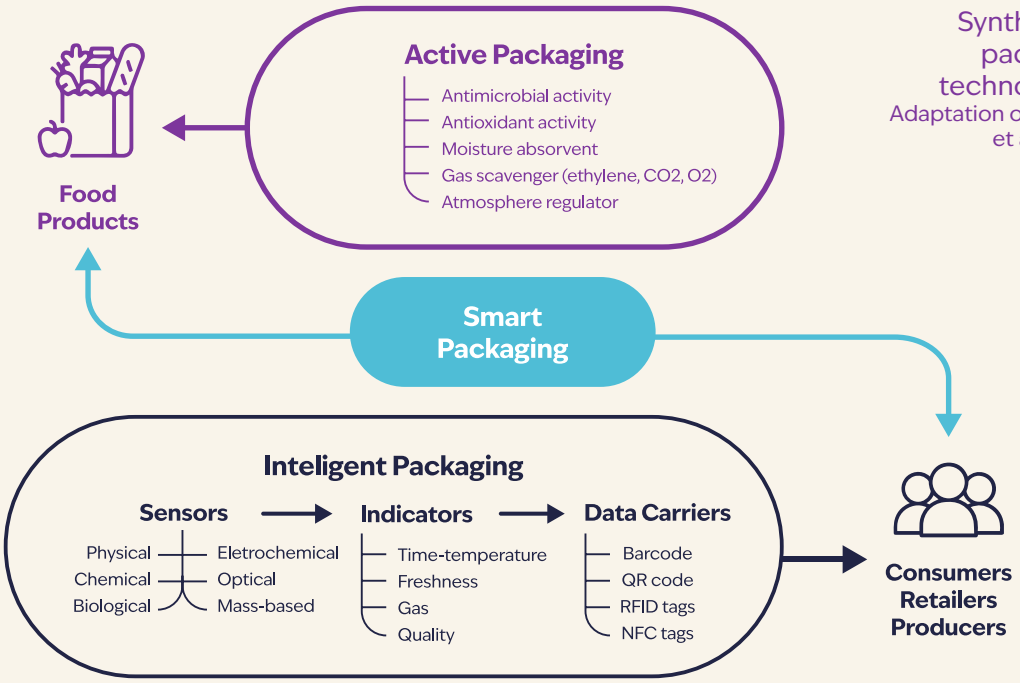
These technologies remove recycling's biggest hurdles—sorting accuracy, consumer participation, and traceability—to make a true circular economy possible. By merging automation, AI, and incentivised returns, they are turning packaging waste into a resource loop.

Overall, the main emerging packaging technologies and materials are associated with food preservation, including protective barriers against fungi, bacteria, and external environmental influences. Additionally, there is a focus on product traceability to reduce waste throughout the value chain and enhance user experience. In this context, Versino et al. (2023) place new types of packaging in one of three groups: active packaging, intelligent packaging, and smart packaging.

Active packaging comprises systems composed of antimicrobials, antioxidants, nanomaterials, and various types of gas and moisture absorbers. These components, in addition to improving the properties of packaging films, extend the shelf life of food. Active materials are designed to ensure the quality of food for longer periods by modifying the composition or characteristics of the contents or its surrounding environment (Rodrigues et al., 2021; Versino et al., 2023).

Intelligent packaging aims to detect changes within the food packaging and provide information about the state of the the contents. While limited to detection and communication, intelligent packaging can enhance safety, protection, and convenience by providing consumers with real-time information about the freshness and ripeness of the product, as well as the integrity of the packaging and whether the contents have been contaminated in some way (Ahari et al., 2022; Versino et al., 2023).

Smart packaging emerges from the combination of active and intelligent packaging, although sometimes the term is applied to both. However, food-packaging systems that only maintain or monitor freshness may not be able to meet all practical needs (Versino et al., 2023). Figure presents a synthesis of the three technologies.



Synthesis of packaging technologies. Adaptation of Versino et al. (2023)

Other techniques that use new technologies for packaging, are being explored, including a method that employs machine learning and a multispectral sensor to predict and estimate the quality parameters and shelf life of fresh dates packaged in a natural atmosphere. (Mohammed et al. 2023).

Regarding the use of new materials, Siddiqui et al. (2022) emphasise the importance of nanotechnology in additives and food packaging, enhancing the safety, shelf life, and quality of food. Nanopackaging utilises materials such as silver nanoparticles and zinc oxide, as antibacterials and freshness indicators. Nanosensors in the packaging monitor the condition of the food, altering the color of the packaging in case of deterioration and ensuring the product's integrity (Siddiqui et al., 2022; Silvestre et al., 2011).

Various types of biopolymers are also being studied, as Sid et al. (2021) detail in a literature review on the subject. A final noteworthy article is an overview by Zhang et al. (2022) of moulded cellulose production and its potential to reduce the environmental impact of packaging.

CASE STUDIES

Focus on applied solutions

Automated return and sorting systems

The use of recycled plastics in product lines is a growing trend among retailers and brands aiming to reduce their environmental footprint and support the circular economy. Two notable examples are Coop Switzerland a Swiss retailer, and Żabka, a Polish convenience store chain, both of which have launched product lines incorporating recycled plastics.

Coop Switzerland introduced product lines that use 100% recycled polyethylene terephthalate (rPET) for packaging and products. Examples include: the Coop Naturaline line of organic cotton clothing; Coop Oecoplan, a range of household cleaning products; and house-label bottled water, soft drinks and other beverages. Coop Switzerland uses labelling and marketing campaigns to inform Swiss consumers about the benefits of recycled plastics. It also encourages its customers to return used plastic bottles to in-store collection points. Returned bottles are recycled into new products. These initiatives have significantly reduced the amount of virgin plastic Coop Switzerland uses in its packaging. Its success with rPET has inspired other retailers to adopt similar practices.

The Żabka Eco product line features items made from or packaged in recycled plastics. Examples include: reusable bags made from 100% recycled materials and offered as an alternative to single-use plastic bags; salad bowls, sandwich containers, and cutlery made from rPET; beverage bottles made from recycled plastic. Żabka works with suppliers to develop sustainable packaging solutions and plastic packaging for recycling can be returned to its stores and is. Żabka also uses in-store signage and digital platforms to inform its customers about the benefits of recycled plastics.

Coop's Oecoplan line of cleaning products are packaged in recycled plastic (Coop Switzerland); Żabka sells reusable bags that are themselves made of recycled plastic (Żabka)

The initiatives by Coop Switzerland and Żabka highlight the potential for retailers to drive the transition to a circular economy. As more companies adopt recycled plastics, economies of scale will reduce costs and improve availability. The examples set by leading retailers such as Coop Switzerland and Żabka can influence suppliers and competitors to adopt sustainable practices, just as retailers can work with governments to improve recycling infrastructure and create supportive regulations.

If a raw material is depleted, producers will find a way to make do. One of the challenges is to raise awareness among companies and individuals about the immediate need to change from the linear model to the circular model.

Digital watermarks improve recycling accuracy

The Holy Grail 2.0 initiative, led by the European Brands Association and supported by the Alliance to End Plastic Waste, is a pilot project testing digital watermarks to improve the sorting of packaging waste. These watermarks are imperceptible codes about the size of a postage stamp embedded on packaging and containing details about the material. When scanned by high-resolution cameras in recycling facilities, they facilitate precise sorting, leading to higher-quality recycled materials and a more efficient recycling process.

Beyond waste management, digital watermarks and QR codes can support the supporting the EU's Circular Economy Action Plan by providing consumers with recycling instructions, product details, or promotional offers. Major brands like P&G, Nestlé, and PepsiCo have already participated in pilot tests, and the Digital Watermarks Initiative is now scaling up the technology, making it possible that it could be integrated into EU packaging regulations to enhance recycling systems industry-wide.

Fonte: Unsplash

PHASE III b

Industrial Test Validation
Results of Pellenc ST/Digimarc
Prototype Detection Sorting Unit

Results of food/noon-food PP and LDPE flexible separation

		December 2023 only flexibles average throughput 800kg/h	February 2024 Flexibles + rigids average throughput 2000kg/h
PP flexibles	Digimarc detection efficiency	>99%* *(for one packaging type, not possible to verify for the other)	Not tested**
	Sorting efficiency	85,7%	
	Purity	76,7%	
PE flexibles	Digimarc detection efficiency	96,8%	89,9%
	Sorting efficiency	93,8%	75,1%
	Purity	70,6%	88,1%

** Due to multiple bailing and unbailing operations, some samples were heavily fragmented, and this led to poor detection and sorting results. The results were therefore not considered.

Reprocessing trials completed in June 2024

The tests focused on sorting flexible packaging from four HG2.0 Brand owners to create specific types of output fractions from a mixed waste stream

- Food-grade PP flex
- Hygiene-grade LDPE flex

Overall sorting results are remarkable considering the operating conditions were harsher than expected due to:

- Combination of higher and variable throughput
- Presence of both flex and rigids in the waste stream during sorting
- More baling than usual

Advanced sorting using Digimarc's digital watermark technology and an add-on module developed by machine vendor Pellenc ST. Tests were performed on a mix of post-consumer waste, digitally watermarked polypropylene films, and low-density PE films produced by Essity, Kraft Heinz, PepsiCo, and Procter & Gamble

Comparison of digital watermarking with GS1 Digital Links and RFID tags

Feature	Holy Grail 2.0 (Digimarc Watermarks)	GS1 Digital Link QR Codes	RFID/NFC Tags
Visibility	Invisible (watermarks) or visible (QR)	Visible (QR codes)	Visible (NFC) / Hidden (RFID)
Data capacity	Medium (watermarks) / High (QR)	High (URL-linked data)	Very High
Scan range	Requires high-res cameras (watermarks)	Standard smartphone (QR)	Near-contact (NFC) / Long-range (RFID)
Cost	Low (no extra material)	Low (print-based)	High (chip-based)
Use case	Recycling sorting + consumer info	Supply chain + marketing	Premium tracking (luxury, pharma)
Adoption	Growing in EU (AIM-led)	Global (GS1 standard)	Niche (expensive)

Innovations make disposable cups recyclable

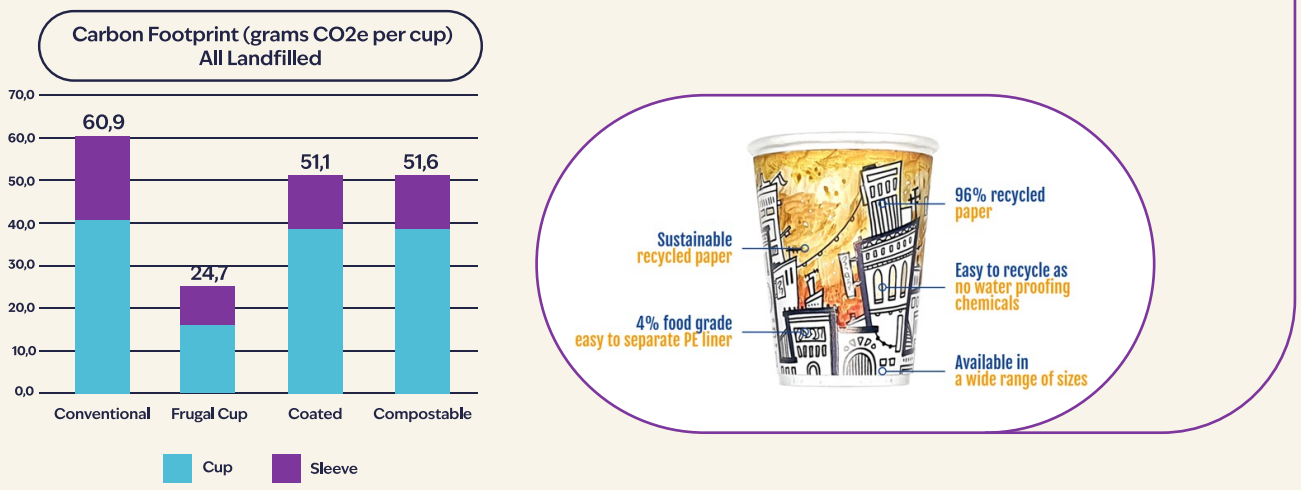
The shift toward single-use recyclable paper coffee cups is a critical step in addressing the environmental impact of disposable coffee cups, which are a significant source of waste globally. Globally, an estimated 250 billion disposable cups are used yearly, most ending up in landfills due to the difficulty of separating plastic linings from paper. This contributes to deforestation, plastic pollution, and greenhouse gas emissions.

The polyethylene (PE) lining that is used to make traditional paper coffee cups waterproof makes recycling them difficult. However, innovations in materials and recycling technologies are enabling the development of truly recyclable paper cups (Report on Excessive and Problematic Packaging, Plastik Pact Poland, 2022).

The European paper industry is a leader in sustainable practices: according to Two Sides, a non-profit organisation, over 90% of the wood used in European paper production comes from certified forests or controlled sources, ensuring replanting and biodiversity protection. The industry also minimises waste by finding uses for recycled fibers and by-products like sawmill residues. Strict EU regulations and certification schemes, such as FSC and PEFC, guarantee that forests grow faster than they are harvested. These regulations have contributed to a 50% increase in the amount of European land covered by forests since 1950. Paper production in Europe is a circular model, with a 72% recycling rate, demonstrating its commitment to environmental responsibility.

Innovations are emerging to tackle this issue. Frugalpac's Frugal Cup uses a lightweight, easily separable lining, allowing recycling in standard paper facilities. Made from 96% recycled paperboard, it has been adopted by the UK chain Costa Coffee and others. Similarly, Detpak's RecycleMe cup features a detachable lining certified for standard recycling, and is used by 7-Eleven and The Coffee Club in Australia, with clear labelling to encourage proper disposal.

Starbucks is testing PLA linings and improving recycling infrastructure in cities like Seattle and London and is one of several major firms that have set a goal of using 100% recyclable or compostable cups by 2025. Their efforts highlight a growing industry push toward sustainable packaging solutions.



A comparison of the carbon footprint of Frugal Cup and other types of coffee cups, and its composition

Other firms are seeking to develop materials that make it possible not use any type of plastic barrier at all. One of them, Suzano, markets Bluecup Bio as a plastic-free coated paper for cups and packaging that come into contact with food and beverages. Klabin, meanwhile, offers Klacup Bio, a more differentiated product that is the result of numerous investments that Klabin has made into developing barriers that are not made of PE. Klabin guarantees the Klacup Bio can hold hot or cold food and beverages.

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Bluecup Bio
(Suzano)

Klacup Bio
(Klabin)

Innovation and regulation are driving progress

Food and beverage-makers lead the circular shift in packaging

The push toward sustainable packaging is accelerating across industries and is fuelled by environmental concerns, regulations, and consumer demand. Breakthroughs in materials science, smart technology, and circular business models are redefining packaging's future, proving that sustainability can both enhance performance reduce waste.

Food producers looking to shift their focus from recycling waste to eliminating it entirely have any number of—sometimes radical—innovations at their disposal.

- RFID-enabled reusable cup system that incorporates automated deposits and washing that cuts single-use waste by 95% (Cupernican).
- Seaweed-based, edible packaging (Notpla).
- Compostable cups that make disposal obsolete (Loliware).
- Smart labels, capable of detecting freshness / spoilage and temperature (FreshTag, TempTime).
- Reusable films (TIPA, EcoCortec).
- Materials innovations:
    - Methane-based bioplastics (Mango Materials).
    - Wood-based bioplastics (Paptic).
    - Paper bottles: (produced by Paboco and used by Coca-Cola and Absolut).

Food and beverage-makers lead the circular shift in packaging

As the examples below show, circular packaging is already viable and being used to reduce waste and resource use, while at the same time enhancing product performance. As technology and infrastructure improve, these innovations will shift from niche to mainstream, proving that a waste-free future is within reach.

- Beverages: infinitely recyclable aluminium bottles (Ball Corp) and plant-based PE furanote caps offer plastic-free durability (Carlsberg).
- E-commerce and fashion: reusable mailers (Returnity) and digital garment IDs (EON) enable circular-business models.

- Electronics: mycelium-based protective packaging (Ecovative) 100% recycled materials (Apple), and's water-soluble alternative to polystyrene (Green Cell Foam) set new standards.

- Healthcare: recyclable inhalers (GSK), compostable blister packs (Syntegon), and smart medication bottles (AdhereTech) merge sustainability with functionality.

- Automotive: reusable crates (IFCO) and biodegradable foam (Sealed Air) prove even industrial packaging can go green.

Food packaging predominates in the articles selected for this systematic literature review:

- Use of active oxygen in beverage packaging: Anthierens et al. (2011).

- Using organic waste from wine production for biopolymer development: Etxabide et al. (2022).

- Using RFID labels for beverage stock control and monitoring: Rossi et al. (2023).

- Literature review on packaging for dairy products: Karaman et al. (2015).

- Application of new technologies to extend the shelf life of packaged meat (Figure): Ahmed et al. (2018), McMillin (2017), Soro et al. (2021).

- Cereal and confectionery packaging: Bauer et al. (2022).

- Intelligent cheese packaging: Kontogianni et al. (2023).

- Methods for extending the shelf life of produce: Alzuabi et al. (2023), Gomes et al. (2023).

Most food packaging innovations incorporate nanotechnology (Pushparaj et al., 2022; Ur Rahim et al., 2021), biopolymers (Chaudhary et al., 2022; Ortega et al., 2022), or agribusiness waste (Fernandez et al., 2021). Lastly, Chelliah et al. (2021) address tracking technologies being used in the healthcare industry in general, with a focus on packaging for pharmaceuticals.

Examples of meat packaging

Kicking the plastic habit: Denmark shows a way

Before the EU began imposing restrictions on plastic-bags, the average European used ~200 lightweight plastic bags per year. In 2022, 29.8 billion lightweight plastic carrier bags were sold in the EU, or 66.6 bags per person.

Denmark stands out for its pioneering efforts that have combined taxation, bans, and behavioural incentives. In 1993, it implemented a surcharge on plastic bags with straps that has led to a 40% reduction in the number of bags sold to consumers. In 2021, it went further and mandated a minimum price of €0.54 for all plastic bags that were thicker than 30 microns. The same law made it illegal to give away plastic bags that were between 15 and 30 microns. Retailers may still give away bags thinner than 15 microns, provided they do not have straps, since these bags are typically used for produce and, as such, help to prevent food waste.

These bans align with Denmark's goal of incinerating less plastic and transitioning to a circular economy. The result has been a reduction in the average number of single-use bags sold to less than 4 per person per year (vs ~300 / year in the US) and a shift to heavier-duty bags made of materials such as cotton or rPET. Cloth tote bags became a cultural norm, driven by cost avoidance and social accountability. Similarly, in 2016, the Netto supermarket chain experimented with a refund scheme for bags and pledged to donate any unreturned bag fees to environmental causes.

Plastic-bag policies in selected EU countries

Country	Policy	Reduction Achieved	Key Measure
Denmark	Ban on most free lightweight bags + pricing	80% (2014–2016)	Mandatory €0.54 fee for bags thicker than 30 microns
Ireland	€0.22 levy since 2002	80% (2014–2016)	World's first plastic-bag tax
France	Full ban (lightweight + produce bags)	~70% (2016–2020)	Banned all single-use bags thinner than 50 microns
Italy	Bioplastic bag requirement (2011)	55% (2011–2013)	Compostable alternatives only

Advances in collection, recycling, and reuse systems show that solutions exist

Technological advancements are revolutionising how waste is collected, processed, and reintegrated into supply chains—key to achieving a zero-waste future. From AI-powered sorting to circular models, these innovations prove scalable solutions exist.

Smart collection systems optimise waste recovery

— IoT sensors in bins optimise pickup routes, cutting costs and emissions (Enevo).

- Solar-powered compacting bins reduce collection frequency by 80% (Bigbelly).
- Reverse vending machines boost recycling rates for bottles and cans (Tomra).
- AI-enabled bins with app tracking streamline reusable container returns (RePack).

Recycling-technology breakthroughs

- AI-guided robots sort waste 99% accurately (AMP Robotic, ZenRobotics).
- Enzymatic recycling breaks down plastics infinitely without quality loss (Carbios).
- Upcycling of PET waste into food-grade plastic, closing the loop (Loop Industries).

Reuse models gaining traction

- Vending machines that dispense household products into reusable containers via RFID tracking (Algramo)
- In-store refill stations that dramatically reduce single-use packaging in personal care (The Body Shop)
- Lease models for clothing and lighting keep products in use longer (MUD Jeans / Philips)

Reuse models gaining traction

BOFA, the municipal waste company serving the island of Bornholm, is pioneering Denmark's circular economy. The island already recycles 70% of its waste (compared with the EU average of 48%), and the next step is 100% recycling / reuse by 2032. To facilitate this goal, BOFA has implemented an integrated system based on three principles:

- Smart facilities: recycling stations and a waste-to-energy plant that converts non-recyclables into heat and power
- Organic innovation: biogas from food waste fuels households in the Greater Copenhagen area, while a nappy composting pilot project achieved complete breakdown in 10 days (compared with the 10-12 months it takes to compost garden waste)
- Circular initiatives: reuse shops, repair cafés, and a landfilling target of less than 3% og all waste (compared with the EU average of 23%) that is met through a strict 1997 ban on landfilling recyclables

These systems demonstrate that with the right mix of policy, technology, and community engagement circularity is achievable today. Their experiences serve as a roadmap for turning waste into resources.

Berry Global develops the world's first mechanical process to recycle polypropylene (PP) into food-grade packaging.

World's first mechanical recycling plant for food-grade PP

Berry Global's Leamington Spa facility represents a paradigm shift in PP recycling. The world's first commercial-scale mechanical process for converting post-consumer PP waste into 100% food-grade recycled material, the proprietary system employs a multi-stage purification protocol: post-consumer feedstock (yogurt pots and takeaway containers) undergoes high-velocity washing to remove labels and residues; advanced flotation separation; and Berry Global's patented decontamination process. This process results in PP that contains less than 1% foreign matter, and meets the US Food and Drug Administration's standards volatile organics and microbial contaminants in food packaging (21 CFR 177.1520 compliance).

The mechanical approach marks a technical breakthrough: previous food-grade rPP required energy-intensive chemical depolymerisation. By preserving the integrity of the polymer chain through controlled thermal processing, the facility produces rPP pellets with virgin-equivalent melt flow indices (MFI 12-25 g/10min) and organoleptic neutrality, enabling direct substitution in injection-moulded and thermoformed food packaging. Life cycle analysis shows a 48-52% reduction in carbon footprint versus virgin PP production.

Current applications include yogurt pots (Danone), ready-meal trays, and cosmetic containers, though approval by the European Food Safety Authority for sale in the EU awaits 2024-25 migration-test results. Key challenges remain in optimising collection streams for contamination thresholds of less than 500ppm and reducing the 10-20% cost premium through scaled throughput. This technological milestone demonstrates the feasibility of closed-loop mechanical recycling for rigid food-contact applications at commercial scale.

A GLOBAL SHIFT

Regulation, corporate action, and consumer behaviour drive the change

This chapter explores a global movement away from disposable packaging to circular-packaging models. Driven by environmental concerns, regulation, and consumer demand, the movement involves phasing out single-use plastics and implementing refill systems, as well as phasing in sustainable materials such as seaweed and mycelium. Successful examples have already been seen at the national level in Brazil, Canada, Chile, France, India, Kenya, the US, as well as in the EU, just as firms the likes of Unilever, Nestlé, and Coca-Cola are moving the private sector forward. Key to further progress towards systemic change will be extended producer responsibility laws, product redesign, and behavioural shifts among consumers. The rise of zero-waste shops and refill stores further demonstrates the growing consumer preference for minimal-packaging solutions.

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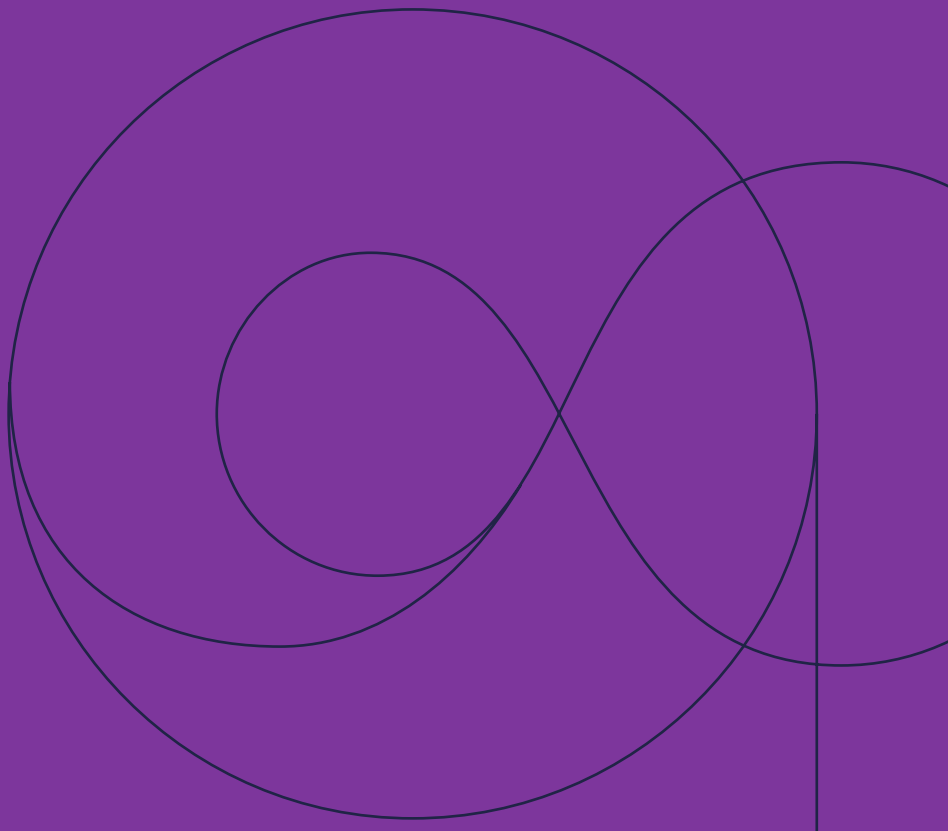
CHAPTER 4

User behaviour and shaping *sustainable cultures of consumption*



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Sustainable consumption is increasingly recognised as a vital component in addressing global environmental challenges (Sargin & Dursun, 2025). Recent studies highlight the role of user-generated content on social media in promoting sustainable consumption behaviour (Yuqiao, Abbasi, Liu, & Ahmad, 2024). Consumer behaviour in sustainable consumption encompasses various stages, including the selection, use, and disposal of products (Sargin & Dursun, 2025). Motivations such as personal self-concept, ethical obligation, and anticipated reciprocity significantly influence consumers' decisions to engage in sustainable practices (Yuqiao, Abbasi, Liu, & Ahmad, 2024). Hence, understanding user behaviour is crucial for shaping sustainable cultures of consumption, as it helps identify the motivations and barriers consumers face in adopting environmentally friendly practices (Sargin & Dursun, 2025; Yuqiao, Abbasi, Liu, & Ahmad, 2024).

As consumers become more conscious of the environmental consequences of their choices they are increasingly opting for environmentally friendly alternatives, including minimal, reusable, and biodegradable packaging (Dillon, 2024; Esko, 2025). Educational campaigns and societal pressure are driving this change, encouraging consumers to make more sustainable decisions (Dillon, 2024; Yuqiao, Abbasi, Liu, & Ahmad, 2024). Additionally, many consumers are willing to pay a premium for products that are packaged in an environmentally responsible way (Lindh, Olsson, & Williams, 2015; Popovic, Bossink, Van Der Sijde, & Fong, 2020; Packaging Gateway, 2024). One study showed that 86% of Swedes are willing to do so (Lindh, Olsson, & Williams, 2015), while another study found that 73% of consumers in 11 countries, including the UK, the US, France, Germany, and Turkey, were willing to do so (Popovic, Bossink, Van Der Sijde, & Fong, 2020). This growing demand prompts businesses to innovate and adopt greener practices, creating a feedback loop that further promotes sustainable food packaging (Dillon, 2024).

This chapter explores how consumer behaviour towards sustainable consumption practices is evolving, with a focus on trends and behaviours in Europe and the South Baltic Sea region.

CONSUMER ATTITUDES

Consumer demand is reshaping Europe's packaging choices

European consumers are increasingly looking for sustainable-packaging options when making purchasing decisions. The trend is driven by increasing environmental awareness and the desire to mitigate the impacts of packaging waste. A significant majority of consumers are now prioritising environmentally friendly packaging options, reflecting concerns over plastic pollution, resource depletion, and climate change (Packaging Gateway, 2024; Popovic, Bossink, Van Der Sijde, & Fong, 2020). Continent-wide, 72% of European consumers say they prefer products with environmentally friendly packaging. The rate is highest in Italy, where 81% of consumers say they prefer to buy products packaged in sustainable materials. (Davies, 2025).

One of the most prominent trends is the rising demand for biodegradable packaging made from plant-based plastics, cellulose, and starch blends. These materials decompose naturally, helping to reduce environmental harm without sacrificing functionality (Dillon, 2024). According to Fact.MR, the demand for biodegradable packaging materials in Europe increased by a factor of 1.3 between 2017 and 2021, and is projected to increase by a factor of 1.7 between 2022 and 2032 (Fact.MR, n.d.). It should be pointed out that the efficiency of biodegradable products is not always properly tested, meaning that claims about their effectiveness have yet to be verified.

Consumers also view compostable packaging favourably. In the UK, 85% of consumers believe that food packaging should be compostable (The European , 2025). In addition to degrading naturally, compostable materials contribute positively to soil health, aligning with consumers' growing interest in circular-economy practices. The combined annual growth rate for the compostable packaging market in Europe is forecast to be 6.1% between 2025 and 2030 (Horizon, 2025). This raises two questions: whether the region has sufficient capacity to compost on this scale, and whether the carbon-dioxide emitted during the transport of imported compostable packaging outweighs its environmental benefits.

Another important development is the popularity of minimalist packaging, which eliminates excess material and promotes efficiency (Dillon, 2024; Esko, 2025). Consumers are drawn to minimalist designs by their clean aesthetics and environmental benefits. Reducing material use leads to less waste, lower production costs, and fewer carbon-dioxide emissions during transport—factors that increasingly influence purchase decisions (Ding, Meng, & Sun, 2024). Reducing the amount of printed area has, in and of itself, limited benefits, but it contributes to a systematic reduction of the environmental impact.

At the same time, reusable packaging is gaining traction. About 77% of European consumers have a positive view of reusable packaging solutions (Packaging Reporter, 2023). However, there are still challenges: 78% of consumers have reservations about hygiene, and only 30% fully understand how reusable-packaging systems operate (Packaging Reporter, 2023). Education and clear labelling will be essential for broader acceptance. Despite these concerns, the European market for reusable packaging is forecast to grow 6.5% (combined annual growth rate) between 2025 and 2030 (Horizon Grand View Research, 2025). Though reusable packaging tends to be a good solution, its lifecycle impact needs further evaluation. Municipal legislation for reusable packaging should also be mapped.

Lastly, recyclable packaging remains a top priority. Europe-wide, 51% of consumers say they prefer recyclable packaging, citing ease of disposal and environmental impact as deciding factors when faced with a choice. Furthermore, 75% of consumers consider recycling a legitimate form of reuse, reinforcing the importance of designing packaging that uses easy-to-recycle materials (Packaging Reporter, 2023). For recycling to be effective, the value chain must be consolidated in the region of operation.

Across all trends, one expectation is clear: consumers demand transparent and verifiable sustainability claims. Labels must clearly communicate how packaging can be disposed of or reused responsibly (Dillon, 2024). In this situation, the packaging designer takes on the key role of developing the visual cues that inform and nudge the consumer at the time of purchase.

The EU plays a significant role in influencing how Europeans view sustainable packaging

The Single-Use Plastics Directive (SUPD) targets the plastic items most commonly found on European beaches, among them: cotton-bud sticks, cutlery, plates, straws, and beverage containers (European Commission, 2025). The directive aims to reduce plastic waste by banning certain products made of single-use plastic and promoting sustainable alternatives (European Commission, 2025). Additionally, it sets ambitious targets for recycling, such as incorporating 25% recycled content in PET beverage bottles by 2025 (European Commission, 2025). These measures are driving an awareness of plastic pollution and encouraging consumers to seek out products with environmentally friendly packaging.

The Circular Economy Action Plan promotes the design, production, and recycling of plastic products in a way that minimises their environmental impact (European Commission, 2025). It encourages businesses to innovate and adopt sustainable packaging solutions, which in turn influences consumers to prefer products that can be part of a circular economy (European Commission, 2025).

Public campaigns like the European Week for Waste Reduction play a crucial role in raising awareness about waste prevention and sustainable consumption. The European Week for Waste Reduction mobilises citizens, schools, businesses, and NGOs to participate in activities that highlight the importance of reducing, reusing, and recycling waste (European Week For Waste Reduction, 2023). Such campaigns foster a culture of sustainability and encourage consumers to make environmentally conscious choices.

Consumer demand for sustainable packaging is on the rise, according to the findings of a number of recent reports. Brands are increasingly adopting environmentally friendly packaging, both to meet this demand and to comply with European Union regulations (Dillon, 2024; Esko, 2025). This shift is evident in the growing market for biodegradable, compostable, and recyclable packaging (Esko, 2025).

Overall, the combination of EU directives and public campaigns is driving a significant shift in consumer trends towards sustainable packaging in Europe, reflecting a broader commitment to environmental sustainability.

Fonte: Freepik

The South Baltic region is moving forward, if at an uneven pace

National approaches to sustainable packaging are shaped by a diverse landscape of sustainability practices and consumer preferences that, in turn, form popular attitudes toward environmental protection, inform regulatory frameworks and dictate economic considerations. The section below explores how these factors are at play in in Denmark, Lithuania, Poland, and Sweden.

Denmark: environmentally aware, economically sensitive

Consumer attitudes towards sustainable packaging in Denmark are shaped by increasing environmental awareness, regulatory frameworks, and economic considerations. Research conducted by Plastic Change indicates that awareness about recyclable take-away food packaging rose to 17% in 2023, from 9% in 2021. Additionally, 92% of consumers said they would recycle more types of food packaging, if the systems for doing so were in place (Plastic Change, 2023). This growing awareness is reflected in the high return rates reported by Dansk Retursystem, which achieved a 93% return rate for single-use bottles and cans in 2021. Some 94% of these were used to make new bottles and cans in a closed loop system (FACHPACK, 2024).

Despite this strong inclination towards sustainability, economic factors play a crucial role in consumer decisions. A Boston Consulting Group (BCG) report reveals that while Danish consumers care about sustainability, they are generally not willing to pay more for sustainable options. Only about 25% of Danes would be willing to pay a premium for sustainable packaging if it come with clear recycling information (Malby, Laerkholm, Lorentzen, & Stamp, 2024). However, Plastic Change's work suggests the attitude is more mixed: it found that 51% of consumers are willing to pay more for sustainable packaging (Plastic Change, 2023).

Material preferences also reflect these trends. The volume of fibre-based packaging, such as cardboard and paper, increased by 19,000 tonnes in 2021, driven by the rise in online shopping. Glass packaging increased by 5,000 tonnes, while plastic packaging decreased by 7,000 tonnes, suggesting a shift towards recyclable materials for packaging (FACHPACK, 2024).

These factors reflect the social and financial conditions of the population. In developing countries, for example, the price of the product and the level of education directly reflect this paradigm shift.

Lithuania: growing recognition, increasing engagement

In Lithuania, consumer trends towards sustainable packaging are increasingly influenced by environmental awareness and regulatory frameworks. A significant portion of Lithuanian consumers actively engage in sustainable practices, such as waste sorting, sharing and

reusing items, repairing and restoring items, and opting for recyclable packaging (Bartkienė, Bikauskaitė, Mincytė, & Šakelaitė, 2023). This shift is driven by a growing recognition of the environmental impact of packaging waste and the benefits of a circular economy.

A 2021 survey by AUGA Group revealed that 88% of urban Lithuanians understand the concept of sustainability, and 71% are prepared to change their consumption habits if they can assured that products meet sustainability criteria (AUGA, 2021). These attitudes are reflected in shopping preferences: 53% of Lithuanians say they choose more sustainable food and beverage options, including those with environmentally friendly packaging, even if they cost more. Additionally, 32% actively seek products with reduced or no plastic packaging (Made in Vilnius, 2023).

Creating the infrastructure that enables sustainable practices, such as Lithuania's deposit-and-return system, has significantly improved recycling rates. The initial return rate when the system was implemented in 2016 was 34%. By 2018, it was over 90%. (Open Access Government, 2018).

Surveys also suggest that consumers increasingly prefer sustainable materials. Tetra Pak that 75% of Lithuanians consider cardboard the most environmentally friendly form of packaging, while 82% believe that consumers will pay more attention to packaging in the next five years (Chinga, 2018).

Poland: willing but waiting

A 2021 study indicated that 48% of German and Polish consumers are willing to pay extra for environmentally friendly packaging (Industry Intel Inc., 2022). Furthermore, a 2024 Mondi survey revealed that 74% of Europeans consider sustainable packaging important when shopping online, with 58% expecting parcels to be delivered in recyclable or compostable packaging within the next five years (Mondi, 2024).

According to the latest edition of the Responsible E-commerce report, 64% of Poles consider sustainability issues important when shopping online. This growing awareness is reflected by their preference for environmentally friendly packaging, with 63% saying they pay attention to it, an year-on-year increase of 8 percentage points. Additionally, 40% of consumers say they are willing to pay extra for sustainable packaging. The trend towards refillable packaging is also notable, with 42% of consumers saying they use them occasionally and 8% saying they choose them whenever available (Oktaba, 2024).

On 1 October, Poland will introduce a deposit-and-return system for single-use plastic bottles up to 3 litres, reusable glass bottles up to 1.5 litres, and metal cans up to 1 litre. Currently, less than half of beverage containers are recycled, but the hope is that the return rate will increase to 90% after the system is rolled out, potentially leading to the recovery of over 12 billion beverage containers annually. This initiative is part of Poland's broader efforts to enhance resource efficiency and reduce litter (Sapota, 2023).

Sweden: incentivised engagement

In Sweden, a significant preference for biodegradable and compostable packaging has emerged, with companies like GAIA BioMaterials leading the way in developing alternatives

to traditional plastics (Gaia Biomaterial, 2025). According to Amcor's 2025 research on European attitudes towards packaging sustainability, 72% of consumers in a group of countries that includes Sweden report that they understand the paper-based packaging claims and use them to inform their purchasing decisions (Amcor, 2025).

The deposit-and-return system for plastic bottles and metal cans is a cornerstone of Sweden's recycling efforts. In 2023, the system achieved an impressive 88.5% return rate, saving 180,000 tonnes of carbon-dioxide emissions (Recycling Magazine, 2025). The system's success is attributed to high levels of consumer engagement and increased deposit amounts, which further incentivise recycling (Recycling Magazine, 2025).

Recycling practices in Sweden are robust, and 99% of its household waste is recycled. This is driven, in part, by extensive waste-to-energy processes and mandatory separation of food waste, and will contribute to Sweden's efforts to eliminate waste (Bakshi, 2016). The Swedish Return System exemplifies the reuse and refillable packaging trend, with over 50% of fresh produce delivered in reusable crates, significantly reducing packaging waste (Ellen Macarthur Foundation, 2021). Furthermore, 86% of Swedes say they are willing to pay a premium for sustainable packaging (Lindh, Olsson, & Williams, 2015), reflecting a broader shift towards environmentally responsible consumption.

EMERGING CONSUMER PREFERENCES AND BEHAVIOURS

Cost, convenience, health and digitalisation influence how people engage with packaging

Consumer behaviour—including aspects such as food choices, digitisation, and sustainability—provide an understanding of how consumers' preferences and habits are evolving in today's dynamic markets, and how they impact sustainable packaging.

Discount and competitive pricing significantly influence consumer behaviour by creating a sense of urgency and perceived value, leading to increased impulse purchases. Discounts can alter consumer perceptions, and this may make products seem more attractive and affordable. Competitive pricing, on the other hand, drives consumers to compare options and seek the best value, often resulting in brand switching (Accounting Insights, 2025; Bazzoni, o.a., 2022).

These pricing strategies impact sustainable packaging by pushing companies to balance cost and environmental responsibility. Sustainable packaging materials are often more expensive, but the demand for environmentally friendly options is rising, and firms must navigate the trade-off between maintaining competitive pricing and investing in sustainable practices. Effective strategies include optimising packaging design and bulk purchasing of sustainable materials as a way to defray costs. Ultimately, aligning pricing strategies with sustainability goals can enhance brand reputation and consumer loyalty (Davis D. , 2025;

Santos, 2023). Conversely, if we consider the systemic cost of products, promoting waste reduction throughout the value chain could reduce the cost of sustainable initiatives.

The rise of fast food and convenience retail in Europe has resulted in a shift in consumer expectations towards food options that are easily accessible and quickly obtained. Meeting these expectations often results in more packaging waste, making it a less sustainable option. A survey by PA Consulting found that while 80% of quick-service restaurant customers said they recognised the need to reduce single-use plastics, 76% do not actively choose products with minimal or recyclable packaging. The reason given for this discrepancy was the challenge of incorporating sustainable practices into daily life (QSR Media UK, 2025).

In response, European retailers are adopting strategic approaches to packaging. For example, one major food retailer, with the support of Capgemini Invent, has launched over 100 pilot projects to optimise packaging in pursuit of its goal of having all of its private-label products packaged in fully recyclable plastic by 2025 (Capgemini, 2025).

These efforts have not eliminated the gap between consumer intentions and their actions. Fostering more sustainable purchasing habits will require both industry innovation and a higher level of consumer engagement (QSR Media UK, 2025). Both of these can be influenced by the design of packaging, product projects that involve consumer interaction, and new business models.

Healthy eating and responsible consumption are increasingly shaping consumer behaviour in Europe, influencing lifestyle choices as well as packaging preferences. Initiatives like Denmark's Whole Grain Partnership, which has successfully increased wholegrain intake, demonstrate how collaborative efforts between governments, NGOs, and the food industry can promote healthier diets and reduce environmental impact (Capgemini, 2025). However, a recent pan-European study indicates that consumers are veering away from healthy and sustainable food choices: only 36% believe their diet is sustainable, and less than half believe it it is healthy (eitFood, 2024).

Nevertheless, sustainability remains a significant factor in purchasing decisions. A report by the Freedonia Group noted that, as consumers become more environmentally conscious, the preference for sustainable packaging materials increases. Biodegradable, compostable, and recyclable packaging options are gaining traction, aligning with the values of health-conscious consumers who prioritise personal as well as planetary well-being (Davis B., 2024).

These findings suggest a strong link between healthy eating and a preference for sustainable packaging that reflects a holistic approach to personal health and environmental responsibility among consumers.

One factor that requires attention is the larger relative quantity of packaging needed for reduced portion sizes of products containing high levels of sugar, fat, and sodium, due to changes in consumption habits and to higher levels of health-consciousness.

Digitalisation and self-service technologies are transforming consumer behaviour in Europe, which has an influence on sustainable packaging choices. Fully 70% of consumers now consider the sustainability of packaging when making a purchase (Flexcon, 2024).

Self-service systems empower consumers to make environmentally conscious choices. For instance, Relevo offers a deposit-free, reusable-packaging solution that allows customers to scan and return containers themselves, significantly reducing the amount of single-use plastic waste (Relevo, 2023).

Another example is Algramo's dispensing system that allows customers to dispense its products into reusable containers, minimising packaging waste (Nicholos & Martins, 2021).

These innovations align with the growing consumer demand for sustainability and demonstrate how digitisation facilitates environmentally friendly practices. It remains to be seen, however, whether they can become widespread.

CULTURES OF CIRCULARITY AND BEHAVIOURAL CHANGE

Sustainable consumption cannot be an occasional choice

Three concepts—circular cultures; reward and deposit-and-return systems; and motivation, nudging, and education—are essential for integrating sustainable practices into everyday life that can promote a more environmentally friendly and resource-efficient economy.

Circular cultures are an integral part of the circular economy and emphasise the importance of designing systems that minimise waste and maximise resource efficiency. These cultures promote sustainable consumption by encouraging practices such as reuse, recycling, and regeneration of materials. Circular cultures view sustainable packaging as a key to reduced environmental impact, since it keeps packaging materials in use for as long as possible through methods like composting and recycling (Circule, 2025).

An example of circular cultures in practice is IKEA's buy-back scheme that refurbishes and resells used furniture, thus extending the life of its products. Similarly, Adidas has demonstrated its commitment to reducing waste and promoting circularity with initiatives to create shoes that use marine plastic pollution. Burger King's approach, meanwhile, has been to introduce reusable packaging options as part of its effort to reduce the amount of single-use plastic it uses (World Economic Forum, 2020). All three examples illustrate how circular cultures can drive sustainable consumption by integrating circularity into everyday practices, ultimately fostering a more resilient and environmentally friendly economy.

Rewards and deposit-and-return systems are effective tools for promoting sustainable consumption and sustainable packaging. These systems give consumers an incentive to return used packaging by offering a monetary reward or refund. Deposit-and-return systems work by requiring consumers to pay a small deposit on beverage containers. The deposit is refunded when the container is returned to a designated collection point (Green nudges in Nordic cities, 2024). Such schemes contribute to a circular economy by encouraging recycling and reducing waste.

Two of the most efficient deposit-and-return systems are found in the South Baltic Sea region. The Danish system, operated by Dansk Retursystem, collects a deposit on plastic, aluminium, and glass beverage containers that amounts to €0.13, €0.20 or €0.40, depending on the type of container. The system achieves a return rate of over 90%, reducing waste and promoting recycling (FACHPACK, 2024). Lithuania's deposit-and-return system, introduced in 2016, collects a deposit of €0.10 on plastic, metal, and glass beverage containers. The system has also achieved a return rate of over 90% (Open Access Government, 2018).

Beyond promoting recycling, these systems foster a culture of sustainability by encouraging consumers to participate actively in efforts to reduce waste. Promoting educational games or games that encourage the return of packaging can be a good alternative to encourage consumers.

Motivation, nudging, and education are all crucial for encouraging sustainable consumption, particularly concerning packaging. Motivational strategies tap into our intrinsic values, encouraging choices that align with environmental stewardship. Nudging subtly alters the decision-making environment in a manner that influences the decisions of individuals or groups, without restricting freedom of choice. Education enhances awareness and understanding, and empowers consumers to make informed decisions.

Complementary nudging strategies, such as prompts and informative signage in coffee shops, have significantly increased the use of reusable cups. A 2024 Nordic Council of Ministers report on green nudges in Nordic cities evaluated behavioural interventions aimed at increasing the use of reusable coffee cups in Sweden and Denmark (Green nudges in Nordic cities, 2024). The study tested various nudging techniques—including verbal prompts, visual cues, social-norm messaging, and lottery incentives—used by 21 coffee shops and canteens (Green nudges in Nordic cities, 2024). Among the key finding was that verbal prompts were the most effective form of nudging, particularly when implemented dynamically and with consistent staff engagement.

One example highlighted in the report was Original Coffee in Copenhagen's practice of prompting customers to choose reusable cups. The effect was to increase their share, expressed as a percentage of all cups served, from nearly nil to 14.46% (Green nudges in Nordic cities, 2024). However, when the prompting ceased, usage declined, highlighting the importance of sustained staff involvement. Social-norm interventions, such as displaying the number of people choosing reusable cups, also influenced behaviour, especially in workplace canteens or other settings where patrons shared an affiliation. These results suggest that combining dynamic verbal prompts with social-norm messaging is more effective in promoting sustainable consumption behaviours than visual cues alone (Green nudges in Nordic cities, 2024).

A social-norm intervention in the form of a sign in the canteen at an ISS coffee shop at Nordea's Copenhagen headquarters seeking to steer employees towards reusable coffee cups (Nordic Co-operation, 2024)

Sustainability and profit can go hand-in-hand

Packaging return schemes in Europe present multifaceted monetisation opportunities, from revenue from the sale recycled materials to enhanced customer loyalty and regulatory benefits. Leveraging these opportunities makes it possible for firms to earn money while also helping the environment.

High-quality recyclables, such as food-grade plastics and aluminium, collected via deposit-and-return systems can be sold to manufacturers, creating a steady revenue stream. In Norway, 84% the national deposit-and-return system's operating costs are covered by revenue from unredeemed deposits (49% of costs) and material sales (35% of costs) (Tomra, 2022). Similarly, in Denmark, 93% of beverage containers are returned, generating substantial revenue from the sale of high-quality recyclables. This has made it possible to eliminate extended producer-responsibility fees (Strinati, 2023).

Deposit-and-return systems can enhance brand loyalty and customer engagement by offering rewards or discounts for returned packaging. A study found that 53% of consumers are more likely to purchase from brands offering pre-filled returnable packaging, with the figure rising to 84% among those who have previously purchased items in reusable packaging (Packaging Europe, 2023). Lidl and other retailers have capitalised on this by using their recycling efforts as a way to strengthening their brand images (Tomra, 2021).

Compliance with packaging regulations not only helps avoid fines but also positions companies to receive subsidies and incentives. Under the EU Packaging and Packaging Waste Regulation, firms using sustainable materials may benefit from a reduced extended producer-responsibility fee, which is adjusted based on environmental impact. This has the effect of rewarding those choosing environmentally friendly packaging solutions (Grief, 2025).

Partnerships and collaboration among waste-management companies, recycling firms, and technology providers can enhance the efficiency and profitability of return schemes. In Finland, RePack and other firms collaborate with retailers to offer reusable-packaging options. The result has been increased sales and customer engagement (European Cluster Collaboration Platform, 2025).

Fonte: Unsplash

Innovation matters, but consumer acceptance matters most

Whether a sustainable-packaging idea is ultimately a success hinges on consumer acceptance and usability. Effective marketing is crucial for advancing sustainable practices and fostering long-term environmental impact and commercial impact.

A sustainable cap meets consumer resistance

Efforts to introduce sustainable packaging sometimes run into consumer resistance. Case in point is the introduction of a recyclable twist-off cap on dairy products produced by Thise for Coop Denmark. The cap was a more environmentally friendly solution and met with EU guidelines, but many consumers—especially among the elderly—found it difficult to use, prompting a return to the original design. Thise also adopted a flip-top milk carton closure to improve freshness and reduce spillage. The outcome was similar: consumers reacted negatively to the new mechanism, describing it as inconvenient and difficult to use, and Coop subsequently reverted to the previous carton design for some products (The Local, 2023)

These cases highlight the importance of balancing the potential environmental gains of an innovation with consumers' willingness to adopt them. While sustainability remains a priority, acceptance is critical if a packaging innovation is to make an impact. For packaging design to be adopted, it must take into account the interaction of the packaging with the product, the packaging process, its relationship with the consumer, and its disposal.

A win for reusable drinkware

Stanley has become a leading producer of reusable drinkware, thanks to the success of its Quencher tumbler. Stanley originally marketed the Quencher for outdoor use, but a 2019 pivot that promoted it as an everyday item, significantly boosted sales (Peng, 2024). This shift was part of a broader strategy of offering durable, reusable alternatives to single-use drinkware. The Quencher went viral on TikTok and other social-media platforms, which gives an indication of the depth of consumer interest in sustainable products (Peng, 2024). Stanley's commitment to quality and innovation in reusable packaging is credited with revitalising its brand, and to a significant reduction in plastic waste (Lamour, 2024). Its efforts demonstrate the potential of combining environmental responsibility with effective marketing (Lamour, 2024).

The economy of standardisation

Aldi's Go UnPackaged initiative, launched in October 2023 at its store in Solihull, in the UK, is a pilot programme aimed at reducing single-use plastic by offering in-store dispensing stations for dry goods and household products (Refill Coalition, 2024). Customers bring their own containers to fill, significantly cutting down on plastic waste. Early results show strong consumer support, with refills reaching up to 50% of sales alongside versions pre-packaged in single-use containers (Eco-Plastics In Packaging, 2025). Pending the outcome of the Solihull trial, Aldi is prepared to expand the concept to more of its outlets (Refill Coalition, 2024).

The Refill Coalition, comprising Aldi UK, Ocado Retail, and CHEP, was established in 2020 by GoUnPackaged (Refill Coalition, 2024). Its key accomplishment was the establishment of a standardised reusable bulk vessel for refills. The vessel was first used in-store at the Solihull Aldi, and online by Ocado in August 2024 (Refill Coalition, 2024). The trials have shown high levels of satisfaction, with 96% of customers saying they are likely to buy again (Eco-Plastics In Packaging, 2025). The coalition hopes that spreading the concept throughout the UK will help it achieve its goal of reducing plastic waste and promoting a circular economy (Eco-Plastics In Packaging, 2025).

A new bottle for an old idea

Abel & Cole, in partnership with Berry Global, launched the UK's first refillable plastic milk-bottle scheme in October 2023 as part of its Club Zero programme. The scheme uses lightweight, 1-litre polypropylene bottles that can be professionally cleaned and reused up to 16 times before being removed for recycling. At just 50g, the bottles have a much lower level of emissions related to their transport, compared with other forms of container. Life-cycle assessments show their carbon footprint is halved after only four uses, and that they outperform glass bottles after 15 uses (Abel&Cole, 2023).

The initiative's target is a 75% return rate. The current rate of 64% amounts to 450,000 single-use bottles that are not being thrown away every year—equivalent to 23 tonnes of plastic (Berry, 2024). The program has received industry recognition and continues to set a benchmark for sustainable packaging in the UK.

Sustainability through education

BOFA, the waste-management authority on the Danish island of Bornholm, has developed an extensive educational programme to introduce schoolchildren to circular-economy principles and recycling awareness. The initiative includes interactive workshops, classroom materials, and hands-on activities designed to teach pupils about waste reduction, resource efficiency, and sustainable practices (Christensen, 2023).

A central component of this program is the Skraldedariet, an innovative facility intended as a laboratory and workshop where children and adults can take part in creative experiments with waste and up-cycling. The goal is to foster a deeper understanding of circular-economy concepts through practical experience. BOFA hopes that introducing children to sustainability at a young age will help Bornholm achieve its ambitious vision of becoming a zero-waste society by 2032 (Co.creative, 2024).

Focusing on education has helped to raise environmental awareness among young people on Bornholm and positioned the island as a model for integrating sustainability into community education.

Businesses should look to deliver environmental and economic benefits

Challenges: mixed messages

Sweden and Denmark have made significant strides in recycling; in 2021, Denmark had already reached its 2025 target of a 65% recycling rate. Challenges persist, however—particularly when it comes to single-use plastics. Denmark has seen a decline in the use of reusable packaging. This is particularly noticeable for beverages, which has seen an increase in the amount of disposable packaging used (FACHPACK, 2024). The situation in Sweden is similar: 55% of Swedes are willing to pay more for sustainable products, but 50% find price a significant obstacle to shopping sustainably, according to a 2024 report by Voyado. Additionally, 53% of consumers struggle to make sustainable choices due to unclear product information. This suggests that convenience and cost considerations often take precedence over sustainability (Kruth, 2024).

Poland's packaging industry faces a number of significant challenges in its pursuit of sustainability. One of the most significant is cost increases due to inflation and rising wages. Faced with higher production costs, firms are less likely to invest in sustainable materials and technologies (Poland Insight, 2024). Lithuania's recycling rate is 63.8%. While that aligns with the EU average, factors such as insufficient labelling and a lack of consumer awareness result in low recycling rates of takeaway-food packaging and other items (Daugėlaitė & Kruopienė, 2024).

Opportunities: motivation, regulation, innovation

In Denmark, the focus is on creating a circular economy for plastics. So far so good: it has already surpassed its 2025 recycling targets. This makes it easier for firms to develop new forms of recycled and biodegradable packaging (FACHPACK, 2024).

Lithuania is a below-average performer on the EU Eco-Innovation Scoreboard, but it is hopes that initiatives like its first accelerator programme for sustainable start-ups will see it make strides up in the rankings. Firms can capitalise on growing consumer demand for environmentally friendly products and the government's support for green technologies (F6S community, 2025; Impact Accelator, 2021).

Poland's packaging industry is adapting to strict EU regulations aimed at reducing plastic waste. The market is ripe for firms offering innovative, environmentally friendly packaging solutions, such as recycled polyethylene terephthalate and biodegradable materials. A growing economy and increased consumer awareness further enhance these opportunities (Ensun, 2025; Poland Insight, 2024).

In Sweden, the introduction of sustainable packaging is driven by technological innovations and a strong commitment to environmental sustainability. Companies like PlasticFri and PulPac lead the way with alternatives to traditional plastics. The Swedish market offers

fertile ground for firms that develop sustainable packaging, supported by a robust regulatory framework and consumer preference for environmentally friendly products (GlobalData, 2024; Kendall, 2021).

Recommendations: packaging with benefits

to adopt sustainable packaging solutions that align with environmental goals and have economic benefits. As members of the EU, these countries are committed to its ambitious sustainability targets, including the reduction of plastic waste and carbon footprints. By prioritising sustainable packaging, businesses can help meet these objectives while unlocking significant financial advantages.

For Sweden and Denmark, leaders in sustainability, businesses should focus on using recyclable, biodegradable, or reusable materials. These solutions reduce environmental impact, making them appealing to environmentally conscious consumers, enhancing brand loyalty and driving demand. Investing in efficient packaging systems can also lead to cost savings by reducing material usage and waste-management expenses.

In Poland and Lithuania, where the transition to sustainable packaging is still evolving, businesses should consider adopting packaging made from recycled materials and innovative alternatives, like compostable or edible packaging. This shift can boost market competitiveness by appealing to a growing consumer base that values sustainability. Additionally, reducing packaging waste can lower disposal costs and potentially provide access to green subsidies and incentives.

T THE INTERSECTION OF PROFIT AND PURPOSE

Success depends on consumer acceptance, innovation, and collaboration, alongside overcoming

The evolving landscape of sustainable packaging in Europe reflects a growing recognition of the need for both environmental responsibility and consumer engagement. Emerging consumer preferences—driven by health consciousness, convenience, and digitisation—are reshaping packaging strategies, with a notable shift towards environmentally friendly alternatives. Despite cost pressures, consumer resistance, and other challenges, businesses are finding innovative ways to align sustainability with profitability, such as through deposit-and-return systems and packaging-reuse schemes. The monetisation opportunities within these systems, including revenue from the sale of recycled materials and brand loyalty, present significant benefits for companies that invest in sustainability.

The case studies highlighted demonstrate that consumer acceptance, usability, and effective marketing are pivotal to the success of these initiatives. The successful examples, such as Stanley's reusable drinkware and Abel & Cole's refillable milk bottles, show how practical and scalable sustainable packaging can be profitable business

ventures, that at the same time benefit the environment. However, challenges persist, particularly in the areas of consumer education, regulatory compliance, and economic pressures. Overcoming these obstacles will require firms to innovate, collaborate, and leverage technological advancements and design. Prioritising sustainable packaging is a way for companies to meet regulatory requirements and contribute to a circular economy while also enhancing their brand reputation and consumer loyalty.

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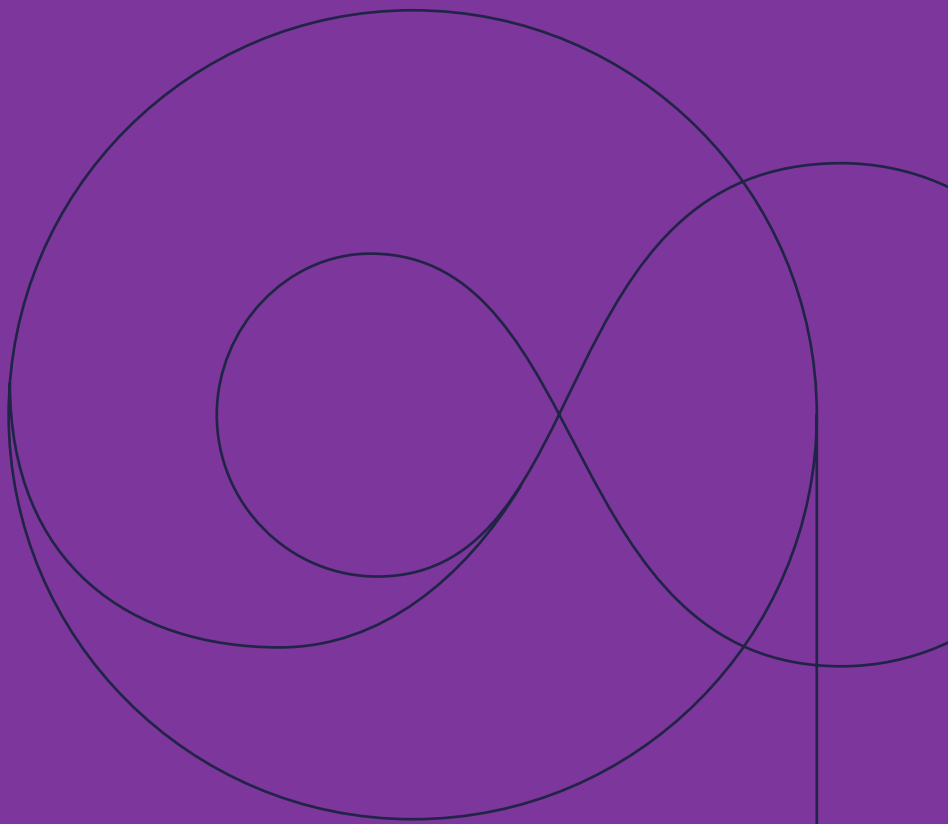
CHAPTER 5

Rethinking ***business models*** for ***circular food packaging***



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To drive significant change, food retailers are increasingly exploring business models that enable circular packaging systems. However, several key challenges hinder progress: the low cost of virgin plastics, the relatively high cost of recycling, and insufficient infrastructure and technology. These factors make it difficult for producers to adopt circular packaging without raising consumer prices.

This chapter seeks to address these challenges by answering three questions:

- What types of business models can support circular packaging?
- How can take-back schemes and consumer incentives, such as packaging and bottle deposits, contribute to economically viable solutions?
- How might commercial innovations, including food and beverage subscription services, create market opportunities for circular packaging?

WHAT IS CIRCULAR FOOD PACKAGING?

Hint: it is both a necessity and an opportunity

Circular business models represent a significant shift away from traditional linear practices, which have proven environmentally unsustainable. In the South Baltic Sea region, food retailers, producers, and other stakeholders are increasingly investigating models that support circular packaging. These solutions aim to tackle the dual challenge of inexpensive virgin plastics and the comparatively higher cost of recycling (Angelis, 2022; Polityka Insight, 2019). A lack of infrastructure and technology further complicates the adoption of circular materials, while also preventing the cost for consumers from falling. Transitioning to circular models is essential for reducing environmental impacts, conserving raw materials, and achieving long-term resource efficiency (Angelis, 2022; Klein, Nier, & Tamásy, 2022).

Globally, the recycling rate for plastic packaging remains low: approximately 14% is collected for recycling, but only 2% makes its way into new packaging in a closed loop (Feghiu & Haaren, 2025). This highlights the significant challenges in achieving higher recycling rates for food-packaging materials. In Europe, recycling rates for packaging waste vary by material. As of 2022, the overall European Union recycling rate for packaging waste was approximately 65.4% (Eurostat, 2022). The recycling rate for plastic packaging was around 42% (Scheuchzer, 2024). Other materials have higher recycling rates, with glass packaging reaching 80.2% and steel packaging 80.5% (Scheuchzer, 2024).

Understanding circular packaging

Circular packaging is designed to be reused, recycled, or composted, with the aim of minimising waste and environmental impact. This approach has several key benefits. Firstly, it reduces the carbon footprint of a product by decreasing the need for virgin materials and reducing the greenhouse-gas emissions related to production and disposal (Rooks, 2022).

Secondly, it conserves resources by promoting the use of recycled and renewable materials, thereby reducing the strain on natural resources (EPA, 2024). Additionally, circular packaging can lead to long-term economic advantages by fostering innovation in packaging design and creating new market opportunities for sustainable products (Lacerta, 2024). Overall, circular packaging is vital if food retailers are to become more sustainable.

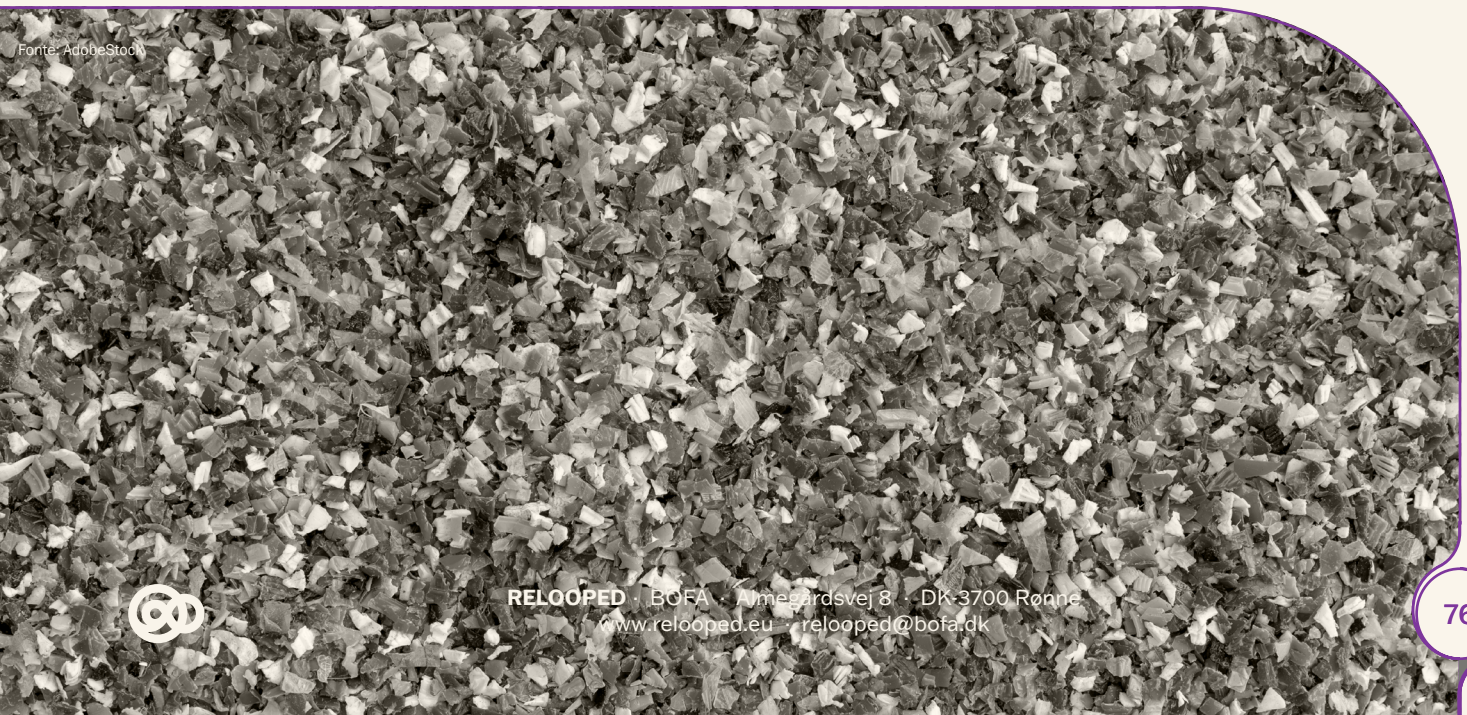
Customer needs and available options

In the Baltic countries, there is a significant and growing demand for sustainable food packaging. Multiple reports have found that more than half of consumers consider the environmental impact of their purchasing decisions. According to Pro Carton's 2025 European Consumer Packaging Perceptions Study, 84% trust their waste-management systems for recycling fibre-based packaging (Pro Carton, n.d.). Additionally, a survey by Eviosys found that 63% of European consumers recognise metal packaging as a more sustainable alternative to plastic packaging (Martin, 2024).

This trend is reinforced by a systematic literature review published in the Italian Journal of Marketing highlighting that consumer awareness, knowledge, and attitudes toward sustainable packaging are key drivers of this demand (Branca, Resciniti , & Babin , 2024). Businesses in the South Baltic Sea region can capitalise on this momentum by integrating circular packaging, in the form of reusable-packaging systems or take-back schemes, into their product offerings. These initiatives meet evolving consumer expectations while at the same time strengthening brand reputation and fostering customer loyalty (PR Newswire, 2023).

Legislation

In the South Baltic Sea region, legislation such as the EU Packaging and Packaging Waste Directive (94/62/EC) and the recently adopted Packaging and Packaging Waste Regulation (2025/40) set strict requirements for packaging design, waste management, and recycling. The goal of these directives to reduce packaging waste by increasing the use of recycled materials and by requiring that, by 2030, all packaging be recyclable. Complying with these regulations helps businesses meet legal requirements, while also supporting the transition to a circular economy and enhancing sustainability efforts (Circular Plastic Alliance, 2024; European Union, 2018; Herbert Smith Freehills, 2024).


Fonte: AdobeStock

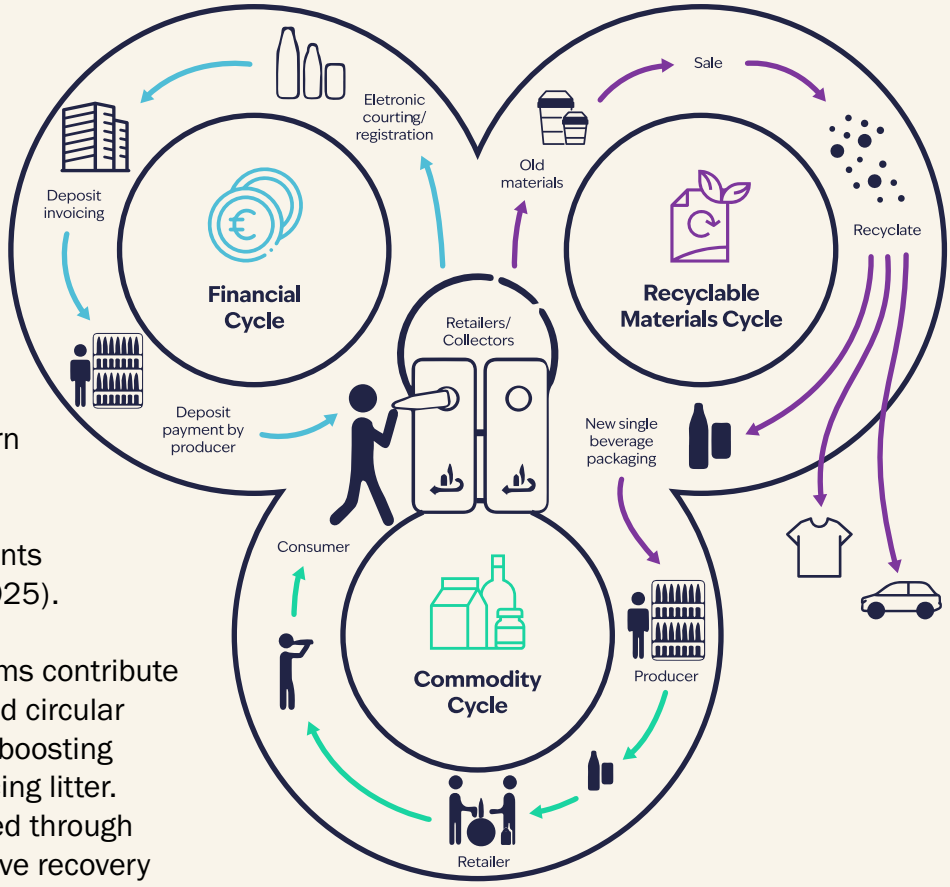
Reuse and collaboration strategies drive sustainable and viable packaging systems

The **product-as-a-service (PaaS)** approach to plastic packaging is a business model in which companies retain ownership of packaging materials and offer them to customers through subscription or usage-based fees. This approach supports the circular economy by ensuring that plastic packaging is returned, cleaned, and reused, rather than disposed of after a single use (KPMG, 2025; Long, Ceschin, Mansour, & Harrison, 2020).

In this model, companies provide maintenance, repair, upgrades and other services that enhance the customer experience and extend the life of packaging. This reduces plastic consumption while also fostering stronger customer relationships and creating recurring revenue streams (Long, Ceschin, Mansour, & Harrison, 2020).

An example of packaging as a service is RePack, which supplies durable, reusable packaging to e-commerce retailers. Orders are shipped with prepaid labels that customers can use to return the empty packaging (RePack, 2017).

Deposit-and-return systems use financial incentives to encourage consumers to return packaging materials—most typically bottles and cans—for reuse or recycling. When consumers purchase a product, they pay an additional fee that is refunded when they return the empty packaging to designated collection points (Tomra, 2025; Tomra, 2025).



(DPG PFANDSYSTEM GMBH, 2025; Sensoneo, 2025)

Deposit-and-return systems contribute to a more sustainable and circular economy by significantly boosting recycling rates and reducing litter. They are often established through legislation and can achieve recovery rates of 90% or higher (Schwizgebel & Roling, 2025;

Collaborative consumption in the plastic packaging industry involves businesses partnering to create a shared packaging infrastructure. This model promotes sustainability by pooling resources and expertise to develop, maintain, and utilise reusable-packaging systems. Companies work together to design packaging that can be returned, cleaned, and reused, reducing waste and the environmental impact of single-use plastics (Mohan, 2024; Americorp, 2025).

Collaboration of this sort allows manufacturers, distributors, and retailers to contribute to a circular economy. Such partnerships spread the costs and share the benefits of sustainable-packaging systems, making it easier for businesses to adopt and scale reusable-packaging systems, while also reducing the up-front costs of innovation and measures to improve efficiency (Mohan, 2024; Americorp, 2025). Nestlé, Unilever, Procter & Gamble and other manufacturers have partnered with Loop to offer products in durable, reusable packaging. Consumers pay a deposit, use the product, and return the empty packaging. Loop is responsible for cleaning and refilling the packaging (LOOP, 2025; LOOP, 2025; Salazar, 2019).

Extended producer responsibility (EPR) is a policy approach in which producers are held accountable for packaging during its entire lifecycle, from design to disposal. This model aims to internalise the environmental costs associated with packaging waste by encouraging producers to design products that are easier to recycle and generate less waste (Plastics Engineering, 2025; The Consumer Goods Forum, 2025).

In EPR schemes, companies that place packaging on the market are responsible for funding its collection, sorting, and recycling. This helps to increase recycling rates of packaging waste while also reducing its environmental impact (Ellen MacArthur Foundation., 2022; The Consumer Goods Forum, 2025). Procter & Gamble in France has integrated extended producer responsibility into its business model. (Rosengren, 2018; P&G, 2025; P&G, 2025).

SUPPORT STRATEGIES

Circular packaging succeeds when it turns sustainability into a competitive

Product-life extension refers to plastic-packaging designs that reduce waste and minimise environmental impact by ensuring that items can be reused (Circular Economy, 2017; Glasdon, 2025).

This strategy aligns with the principles of circular economy by promoting the repair, reuse, and recycling of packaging materials. Reusing high-quality, long-lasting packaging, instead of continuously producing new packaging can reduce the overall amount of virgin raw materials companies need, allowing them to meet their own sustainability goals, as well as the EU's strict environmental regulations and targets (Circular Economy, 2017; Glasdon, 2025). Schoeller Allibert is doing this by providing tailored operational services that include

maintenance and repair of reusable packaging, along with traceability, cleanliness, and recyclability support (Schoeller Allibert, 2025).

Design for recycling refers to enhancing recyclability by creating packaging that can be efficiently sorted and turned into new products (Eco Design of Plastics Packaging, 2025; Packaging Europe, 2025).

Key principles include:

- **Material selection**—using a single material that is widely recyclable, such as polypropylene (PP) or polyethylene (PE) (Association of Plastic Recyclers, 2025; Packaging Europe, 2025).

- **Design considerations**—ensuring packaging is free from contaminants and complex structures that hinder recycling (Eco Design of Plastics Packaging, 2025; Packaging Europe, 2025).

- **Industry collaboration**—working with recyclers and other stakeholders to optimise packaging for the recycling process (Eco Design of Plastics Packaging, 2025; Packaging Europe, 2025).

This strategy supports the circular economy through reduced waste and high rates of reuse, aligning with European sustainability goals (Packaging Europe, 2025).

Subscription services in the food-and-beverage industry offer a recurring, sustainable model that promotes the use of reusable and returnable packaging. These services deliver food and beverages to customers on a regular basis, such as weekly or monthly, using packaging that is designed to be returned, cleaned, and reused (Bolsita Verde, 2025; Fortune Business Insights, 2025; The Conscious Farm Kitchen, 2025).

This model aligns with the principles of the circular economy by reducing waste and minimising the environmental impact of packaging. Companies offering subscription services often provide incentives for customers to return packaging, ensuring a continuous cycle of reuse (Bolsita Verde, 2025; Green Living, 2025). This approach supports sustainability while also enhancing customer loyalty and providing a steady revenue stream.

Going from business model to business

Loop by TerraCycle is a pioneering initiative that showcases the successful deployment of reusable packaging. Introduced in 2019 at the World Economic Forum, Loop aims to redefine the circular economy by offering products in durable, reusable packaging that is collected, cleaned, and reused (Packaging Europe, 2019; Terracycle, 2025).

TerraCycle relies on brand partnerships to place its reusable Loop packaging in consumers' hands (Terracycle, 2025)

Loop collaborates with Carrefour, Haagen-Dazs, Burger King, and other major brands to provide a wide range of products in reusable containers. Using high-quality materials reduces waste while at the same time enhancing the consumer's experience (Terracycle, 2025). The initiative has gained traction throughout Europe, demonstrating the viability and benefits of reusable-packaging systems (Packaging Europe, 2019; Terracycle, 2025).

RePack is a European initiative that provides a model for reusable delivery packaging as a means to significantly reduce single-use-plastic consumption. RePack offers a sustainable-packaging system to online retailers that makes it convenient for consumers to return packaging for cleaning and reuse (CORDIS - EU, 2022; RePack, 2024; Totaro, 2018).

RePack offers a model for reusable delivery packaging that significantly reduces single-use plastic consumption

The packaging is made from recycled PP (rPP) and designed to be used 20 times (Totaro, 2018). Prizes and discounts serve as incentives for customers to return the packaging, promoting a circular economy. RePack worked with Filippa K and MUD Jeans and other European firms to develop the system (Totaro, 2018).

Vytal is a European company that offers innovative solutions for reusable packaging with the goal of reducing consumption of single-use plastic and promoting sustainability. Vytal seeks to make it easy for businesses and consumers to adopt sustainable practices by providing a complete reusable-packaging system that encompasses storage, logistics, cleaning, and reporting (Vytal, n.d.; Vytal, n.d.).

Vytal seeks to keep reusable packaging simple

Vytal works with major brands, cities, and other stakeholders to implement reusable-packaging solutions in a variety of settings, including festivals, events, and canteens (Vytal, n.d.; Vytal, n.d.). Its advanced technology ensures a high return rate, which attests to the effectiveness of its end-to-end process (Vytal, n.d.; Vytal, n.d.). Vytal seeks to provide a simple, seamless interaction by integrating with point-of-sale systems and offering an app (Vytal, n.d.; Vytal, n.d.).

Gram is a unique, package-free grocery store located in Malmö, Sweden, that promotes sustainability by offering high-quality food and household products without packaging. Customers purchase items by weight or volume, which is both economical and environmentally friendly (Gram, n.d.).

Gram supports consumer's efforts to eliminate secondary packaging

Gram works with local producers and organic farms to provide over 300 unpackaged food and non-food items. It also sells reusable containers (Gram, n.d.). The store aims to reduce waste and encourages a zero-waste lifestyle by allowing customers to fill their own containers (Gram, n.d.).

This model serves to eliminate secondary product packaging. The product arrives at the retailer in primary packaging, and the consumer takes it home in reusable storage containers.

Relevo is a German company that provides reusable-packaging systems to the food and beverage industry. Founded in Munich in 2020, Relevo aims to reduce the need for disposable packaging and to promote environmental protection by offering a digital and sustainable system that makes it easy for restaurants to use high-quality reusable packaging for takeaway and delivery (Relevo, 2023; Relevo, 2023).

Customers borrow Relevo containers by scanning a QR code and return them to any partner location after use (Relevo, 2023). The deposit-free system is designed to seamlessly integrate into existing operations. (Relive, 2023). Relevo works with over 2,500 European business to provide a sustainable alternative to single-use packaging (Relevo, 2023).

Relevo's containers feature a QR code that consumers scan

RECUP is Germany's largest reusable-packaging system for the food-service industry. Its sustainable alternatives to single-use packaging include the RECUP (reusable cup) for take-away drinks and the REBOWL (reusable bowl) for take-away meals (ReCup, 2025; ReCup, 2025).

Customers can borrow containers by paying a modest deposit (€1 for a cup and €5 for a bowl) that is refunded when the containers are returned to any of RECUP's 20,000 partner locations across Germany (ReCup, 2025). After being cleaned, the containers enter into circulation again (ReCup, 2025).

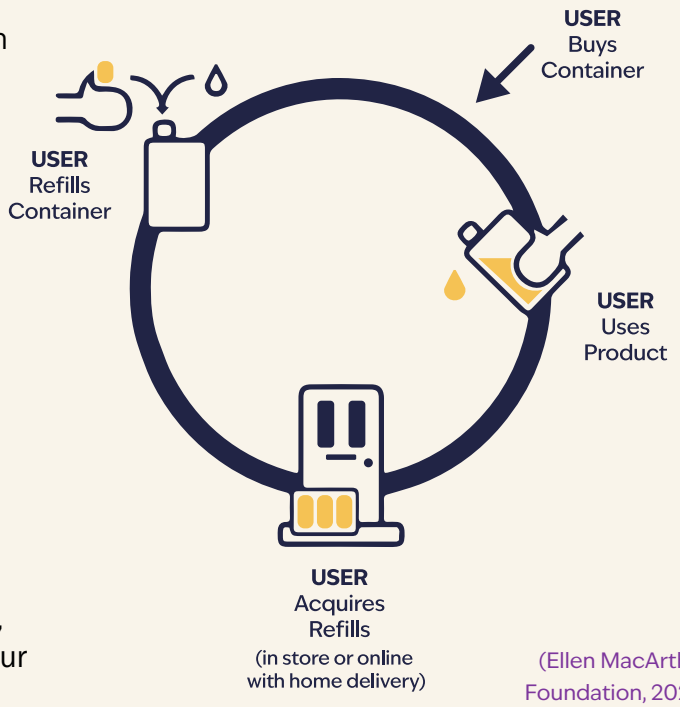
RECUP relies on a modest deposit to ensure its products remain in circulation

The cases above provide valuable insights into how reusable-packaging systems can effectively reduce waste and promote sustainability. Individually, their successes show the need to understand the value chain first to validate the idea behind the respective system and then to be able to roll it out successfully. Taken collectively, the cases reveal traits that appear to be required for a circular packaging system: provide durable products; incorporate technology; collaborate with involved firms; offer incentives for return.

Let the system fit the context

There are a number of practical approaches to facilitating the adoption of circular packaging. The Ellen MacArthur Foundation outlines four key business models for reusable packaging. (Ellen MacArthur Foundation, 2023).

Refill-at-home: Consumers use their own reusable containers and refilling them at home with products purchased in-store or or that they subscribe to. Users are responsible for cleaning and maintaining the packaging. A growing trend is the sale of concentrated or solid versions of liquid products, which reduce shipping weight and environmental impact. Subscription-based automatic refills are also common and are a way to generate repeat business. To ensure environmental benefits, refill packaging should be minimal, recyclable, compostable, or reusable (Ellen MacArthur Foundation, 2023).

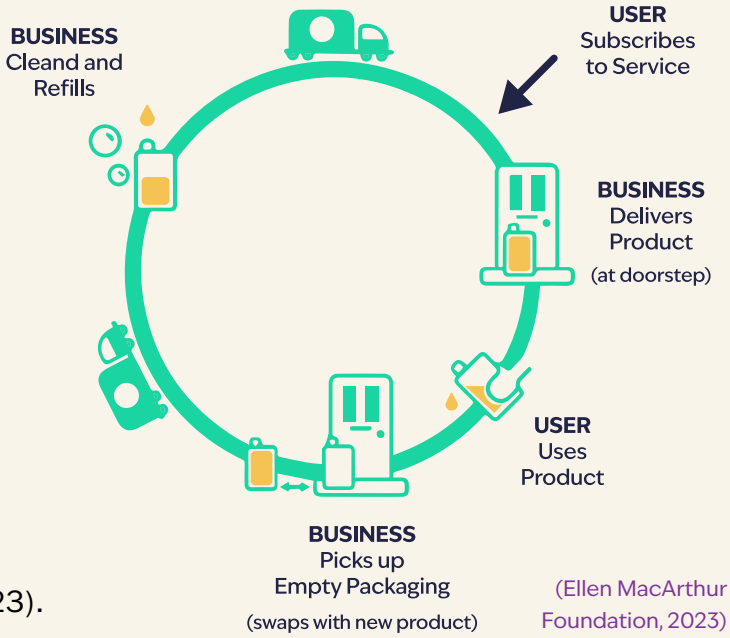


(Ellen MacArthur Foundation, 2023)

Refill-on-the-go: Consumers refill their reusable containers outside their homes, typically using dispensing systems in retail environments. As with refill-at-home approaches, users are responsible for maintaining and cleaning their own containers (Ellen MacArthur Foundation, 2023). Examples include dispenser units that allow customers to select and purchase specific quantities of products. Users can refill their containers away from home using a dispenser in stores, office complexes, or a public venues, or at a mobile unit. Refill-on-the-go models are most typically used to dispense grains, pasta, legumes, and other types of dry foods, as well as beverages (Ellen MacArthur Foundation, 2023).

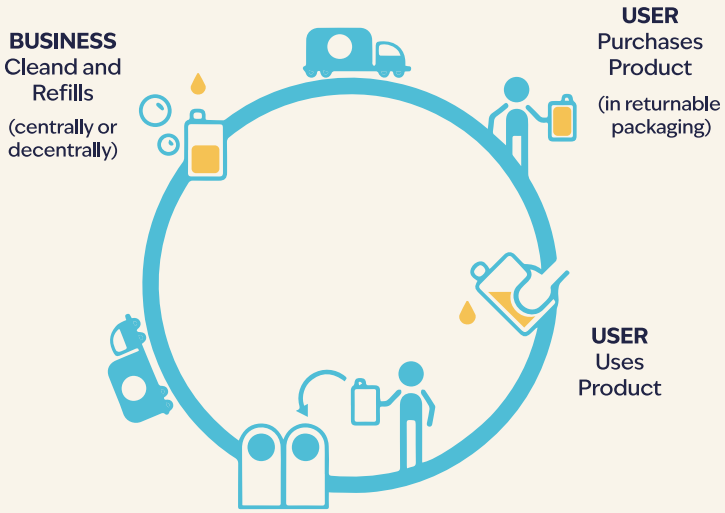
(Ellen MacArthur Foundation, 2023)

Return-from-home: Businesses collect reusable packaging directly from customers, typically as part of a subscription service. The company retains responsibility for cleaning, maintaining, and reusing the packaging. Empty containers are usually picked up during the next scheduled delivery, making the packaging a valuable, reusable asset. This encourages investment in high-quality, user-friendly packaging. This model is most effective in urban areas, where shared logistics and cleaning services can reduce operating costs (Ellen MacArthur Foundation, 2023).



(Ellen MacArthur Foundation, 2023)

Return-on-the-go: Consumers receive products in reusable packaging and return the packaging at designated drop-off points, such as stores, return machines, or postboxes. The packaging is then collected, cleaned, and reused. Smart technologies can enhance this model by tracking packaging and managing deposits or rewards, helping build customer loyalty. In many cases, third-party providers manage the reuse system, easing the burden on brands or retailers; this approach is especially common for drinks and takeaway food. Standardised packaging across brands or categories can reduce system costs and improve efficiency throughout the supply chain (Ellen MacArthur Foundation, 2023).



(Ellen MacArthur Foundation, 2023)

All four of the strategies above provide examples of the practical steps needed to implement circular packaging effectively, as well as the success factors (Ellen MacArthur Foundation, 2023).

Unilever provides an example of a firm that is following the strategies at a large scale. It is trialling all four reuse-and-refill models and has formulated written guidelines for each. It emphasises that no single model is best suited for all situations and is testing and scaling multiple approaches tailored to different geographies and consumer behaviours (Unilever, 2025).

Another example of LivingPackets, a system that employs a ‘return-from-home’ model that facilitates convenient returns and contributes to sustainability in e-commerce logistics (LivingPackets, n.d.).

BARRIERS, CHALLENGES, AND OPPORTUNITIES

Cost, regulation, and consumer resistance must be overcome if circular packaging is to succeed

Economic viability

Addressing cost structures and aligning business models with existing resources and capabilities is necessary, given that recycled plastics often cost more than virgin plastics. Additionally, the initial investment required for setting up return systems, advanced recycling technologies, and infrastructure can be substantial (Plastics Technology, 2025).

Regulatory and policy barriers

Inconsistent regulations across regions can create challenges for businesses trying to implement circular practices. Similarly, varying standards for recycling and waste-management can complicate the development of uniform packaging (Stanislaus, 2018).

Consumer behaviour

Changing consumer habits and expectations of convenience can be difficult. Many consumers are accustomed to single-use packaging and may resist reusable or returnable packaging (Stanislaus, 2018).

Greenwashing

Making claims about the about the sustainability of products to make them appear more environmentally friendly than they are—known as greenwashing—is a significant barrier to implementing reusable packaging. Firms have a variety of tactics for overstating the merits of their products, including labelling them with undefined terms such as ‘environmentally friendly’ or ‘biodegradable’, often without substantial evidence to support even these vague claims. This misleads consumers and undermines genuine sustainability efforts (Cruz Foam, 2025; Good Start Packaging, 2025).

Innovation

Developing packaging that is easy to recycle and using materials that can be efficiently processed can enhance the recyclability of packaging. This includes selecting mono-materials like PP and PE, and ensuring that packaging is free from contaminants (Plastics

Technology, 2025). Innovation should encompass more than appearance and structural design; the reusable-packaging systems must also be looked at with new eyes, just as it is important to understand the interactions between the stages of the packaging lifecycle and the internal stages in each of them.

Consumer education and engagement

Educating consumers about the benefits of circular-economy practices and encouraging participation through incentives can drive behavioural change. Effective communication strategies can highlight the environmental and economic advantages of reusable and recyclable packaging (Plastics Technology, 2025).

Collaboration

Partnerships among businesses, governments, and NGOs can drive the development of shared infrastructure and logistics for recycling and return systems. Collaborative consumption models that serve to pool resources and expertise can benefit development of efficient and scalable solutions (Plastics Technology, 2025).

HOW TO TRANSITION TO REUSABLE PACKAGING

Circular design, collaboration across the value chain, consumer engagement, strong infrastructure, and clear metrics are necessary

In order for a framework to facilitate a transition towards a more circular approach to food-packaging, it must address food safety, contamination, material recovery, and consumer behaviour (Ellen MacArthur Foundation , 2021; European Commission, n.d.; ISO, 2022).

Framework for Circular Economy in Food Packaging

Design for Circularity
Material Innovation & Design

Collaborate
Supply Chain Collaboration

Awareness
Consumer Engagement & Behaviour Change

Enable
Infrastructure & Logistics

Evaluate
Metrics Compliance

Design with circularity in mind

- Goal: Design packaging to be reused, recycled, or composted.

- Actions:

    - Use mono-materials or bio-based alternatives
    - Eliminate unnecessary packaging layers
    - Design for easy separation of components (such as labels and films)
    - Example: Replace multi-layer plastic with recyclable paper-based solutions.

(Ellen MacArthur Foundation , 2021; European Commission, n.d.; ISO, 2022).

Collaboration among all links in the value chain

- Goal: Align stakeholders from farm to fork

- ·Actions

    - Develop packaging solutions with suppliers and retailers
    - Standardise packaging to improve collection and sorting
    - Share packaging-performance and recovery-rate data

(Ellen MacArthur Foundation , 2021; European Commission, n.d.; ISO, 2022).

Influence consumer engagement and behaviour

- Goal: Encourage responsible use and disposal

- Actions:

    - Prefer clear terms (‘recyclable’ or ‘compostable’) to vague (‘environmentally friendly’)
    - Incentivise return schemes (such as deposit-and-return systems)
    - Inform consumers about proper disposal and reuse

(Ellen MacArthur Foundation , 2021; European Commission, n.d.; ISO, 2022).

Enable infrastructure and logistics

- Goal: Enable effective collection, sorting, and processing

- Actions:

    - Invest in local composting and recycling infrastructure
    - Partner with municipal authorities and waste-management companies
    - Use QR codes or other forms of technology to monitor packaging flows

(Ellen MacArthur Foundation , 2021; European Commission, n.d.; ISO, 2022).

Evaluate metrics and compliance for continual development

- Goal: Measure impact and adapt strategies

- Actions:

    - Use life-cycle assessment, circularity indicators, or similar tools
    - Align with the EU's Packaging and Packaging Waste Regulation and other relevant legislation
    - Set targets for recycled content, recovery rates, and emissions

(Ellen MacArthur Foundation , 2021; European Commission, n.d.; ISO, 2022).

A CHALLENGING, BUT NECESSARY, PATH

Circular packaging is unavoidable, but its success depends on models that balance environmental responsibility with economic viability

Adopting circular business models for food packaging is both a strategic necessity and, increasingly, an opportunity for firms to reduce their environmental impact, meet consumer expectations, and align with regulations. Reusable-packaging, PaaS models, and extended producer responsibility all offer ways in which firms can make a meaningful contribution to the transition to a sustainable and resource-efficient economy.

But, while the environmental and reputational benefits of circular models are clear, their long-term success hinges on their economic viability. Transitioning to circular systems often requires significant upfront investment in infrastructure, logistics, and consumer engagement. Moreover, the higher cost of recycled materials compared with virgin plastics and the difficult of changing consumer behaviour present challenges that cannot be overlooked.

It is also important to understand all aspects of packaging: what it is, what it does, what it is made of, how it is made, how it is classified, how it is perceived by consumers, what the stages in its lifecycle are, who is involved at those stages, and what systems are used to process it. This understanding can come by observing: the relationship between packaging and product development, the relationship with the product and the user, production and logistics processes, display at the point of sale or distribution, and disposal practices.

Packaging is an element of a complex system that includes controllable and non-controllable variables; taking an external view can reveal important insights for the development of products and systems that can reduce its environmental impact.

Circular business models that are truly sustainable must both reduce waste and generate tangible economic gains. This requires designing models that are scalable, cost-effective, and integrated into a firm's core operations—not treated as peripheral sustainability efforts. Companies must take a pragmatic approach to circularity: balancing environmental goals with financial realities and ensuring that innovation results in measurable returns.

Ultimately, there is no one single circular-packaging system that can be applied in all situations. Finding the right one requires tailored strategies, cross-sector collaboration, and continuous adaptation. By combining environmental responsibility with sound business logic, firms can lead the transition toward circularity—for the benefit of the planet and their bottom lines.

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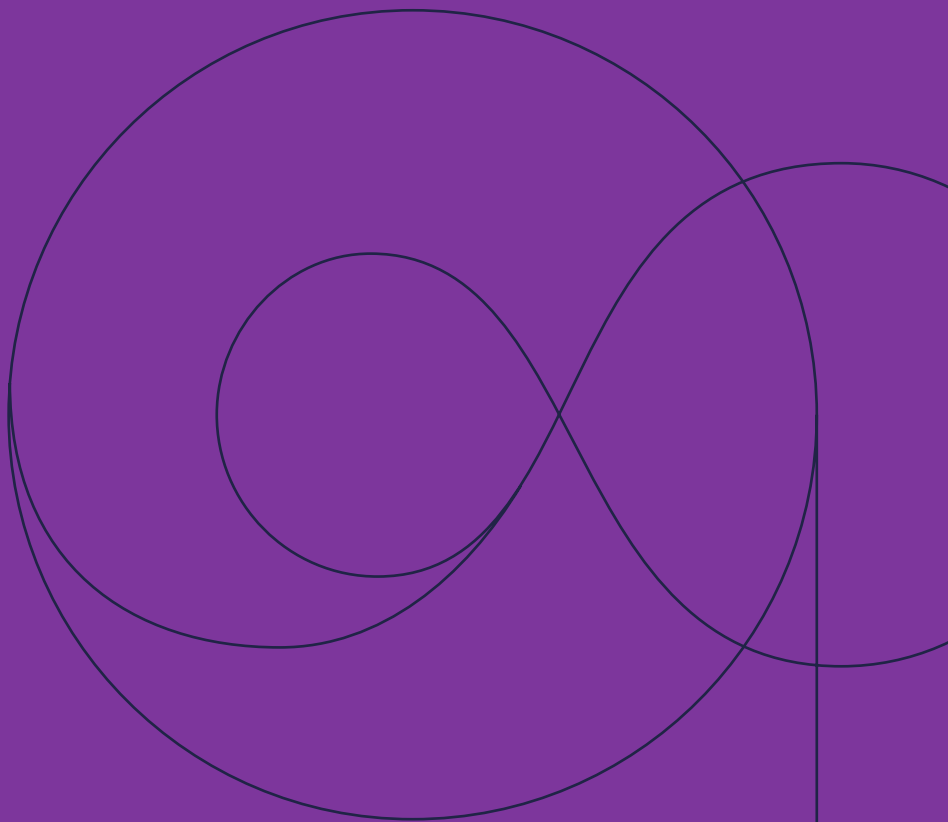
CHAPTER 6

Innovation pathways and *circular game changers*



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As the **Retail Relooped** project moves from conceptual exploration to practical application, identifying viable innovation pathways and potential circular game changers has become a critical next step. Building on the business models discussed in chapter 5, this chapter shifts focus from current market practices to forward-looking strategies that can enable systemic change in the retail-packaging landscape.

The transition to circular retail-food systems demands solutions that go beyond incremental improvements. While existing business models such as deposit-and-return systems and product-as-a-service provide important foundations, the complexity of the packaging-waste challenge requires broader, more integrated approaches. These must not only address technological and logistical barriers but also align with shifting consumer preferences, evolving regulatory landscapes, and emerging market opportunities. Systemic design can greatly assist in the development of new types of packaging by looking at packaging from the very beginning of product development.

This chapter identifies and analyses key **innovation pathways**, strategic directions that can support the design and implementation of circular retail-packaging systems. It also highlights potential **game changers**, disruptive innovations or systemic shifts capable of overcoming entrenched barriers and unlocking new forms of value creation. These insights are intended to inspire and inform project stakeholders, **living lab** participants, and the wider circular-economy community.

By mapping out these opportunities, the chapter contributes to the Retail Relooped project's overarching ambition: to co-design circular shopping experiences that not only minimise environmental impact but also offer compelling value propositions for consumers, retailers, and producers alike.

COMPLEMENTARY CONCEPTS

Circular packaging advances slowly, then all at once

To effectively advance circular packaging systems for food retailers, it is essential to distinguish between two complementary concepts: **innovation pathways** and **circular game changers.**

I**nnovation pathways** are strategic trajectories that guide the development and scaling of new solutions over time. They represent a combination of emerging technologies, evolving business practices, and shifting consumer behaviours that, together, can support the transition from traditional linear models to circular systems. Innovation pathways are often incremental and iterative, reflecting the realities of technical constraints, market readiness, and evolving regulatory environments.

Examples of innovation pathways relevant for food retailers include:

— **Reusable-cup initiatives:** Żabka Poland's Green Cup programme uses discounts and

loyalty rewards as an incentive for customers to use personal or store-provided reusable coffee cups (Żabka Group, 2023).

- **Packaging-reduction strategies:** Coop Danmark's decision to package its best-selling types of a milk in carton without a screw cap eliminates unnecessary plastic at scale without compromising product quality or convenience (The Local, 2023).

- **Deposit-and-return systems:** a citywide scheme piloted in Aarhus, Denmark, achieved high return rates through smart collection infrastructure and app-based refunds.

- **Smart-technology integration:** using radio frequency identification tagging and digital tracking to simplify reuse logistics and enhance consumer convenience.

By following such pathways, businesses and stakeholders can align innovation efforts with broader consumer trends, regulatory developments, and environmental goals.

Circular game changers are disruptive forces capable of transforming the system itself (in contrast to the gradual pace of innovation pathways). They either remove entrenched barriers or create entirely new market opportunities, accelerating the shift to circular models.

Key examples of circular game changers include:

- **Legislative innovation:** the 2024 European Union Packaging and Packaging Waste Regulation (PPWR) sets binding reuse targets and mandates acceptance of customer-provided reusable containers in all member states by 2030 (European Council, 2024).

- **National reuse mandates:** Germany's 2023 reuse law requires food-service businesses to offer reusable alternatives for all takeaway food and beverages, reshaping consumer expectations and retailer practices (German Federal Government, 2023).

- **Retailer coalitions:** all firms within an industry collaborate to create shared reuse infrastructure—for example, a coalition of major supermarkets in Belgium has piloted a unified reusable-packaging system for produce.

- **Rehavioural incentives:** strategies that leverage loyalty rewards, deposits, and digital engagement to normalise reusable packaging systems among the general public.

These game changers do not merely improve existing systems, they reshape market conditions, consumer behaviour, and business practices, opening up new ways to design sustainable and scalable circular solutions.

Purpose of the framework

By clearly defining innovation pathways and game changers, this chapter provides a conceptual and applied framework to inform the identification and development of circular packaging strategies within the Retail Relooped project. This dual approach ensures that both steady progress and disruptive opportunities are considered when designing systems that are resilient, scalable, and aligned with real-world market dynamics.

Retailers hold the key

The transition to circular retail packaging requires a blend of best practices and emerging strategies that can be adapted and scaled across diverse markets. This section highlights key innovation pathways with the potential for systemic impact in food retail, emphasising their relevance to the Retail Relooped project and its partners.

Relevo's containers feature a QR code that consumers scan

Retailer-led reuse and incentive models

Retailers are uniquely positioned to influence consumer behaviour through reuse schemes supported by incentives or loyalty rewards. Żabka Poland's Green Cup programme is an example of this approach. Customers who purchase one of the retailer's durable, reusable coffee cups receive a discount on the price of a cup coffee when using it. Żabka serves over 24 million hot drinks annually. Through this initiative, it has successfully promoted reusable packaging while significantly reducing single-use waste.

Other European retailers have introduced loyalty points and discounts for customers who bring their own containers, supporting gradual behavioural change and preparing consumers for new regulations that promote or require reusable packaging (Morrisons, 2018).

Packaging reduction through product and design innovation

Reducing packaging at the source is a core innovation strategy. Coop Danmark's elimination of plastic screw caps from the cartons of its most-sold types of milk reflects how simple design changes can immediately cut single-use-plastic consumption without compromising product quality or consumer convenience.

Other retailers are adopting 'natural' branding techniques, including laser-marking produce, as well as standardising reusable crates and transit packaging to minimise waste throughout the supply chain (Eosta/ICA, 2018). These types of initiatives made it possible for Ocado to cut the amount of packaging it used for its private-label products by 141 tonnes between 2021 and 2023, demonstrating how incremental design tweaks can add up to significant waste reduction over time (Ocado Retail, 2023).

Digitalised deposit-and-return and reuse logistics

Smart technologies are enhancing the efficiency and appeal of deposit-and-return and reuse systems. The Aarhus pilot collected takeaway cups in automated return stations and paid refunds using an app, achieving an 87% return rate and preventing the use of tens of thousands of single-use cups that would have wound up as waste (UNRIC, 2025).

Similar digital deposit-and-return systems are being tested by retailers like Ocado. Its pilot allows customers to scan unique QR codes on empty containers and receive immediate refunds. These smart engagement tools lower barriers to participation and provide valuable data for system optimisation (Packaging Scotland, 2023).

Collaborative infrastructure and shared systems

Collaboration among retailers is driving standardised reuse systems. In Belgium, six major supermarket chains have formed a coalition to pilot a shared reusable-container system for produce, creating economies of scale and simplifying consumer participation. This collaborative model lowers operational barriers and reduces the complexity of managing reuse systems.

Consumer engagement and behaviour-driven design

Retailers are leveraging behaviour-driven design, gamification, and personalised experiences to motivate consumers towards sustainable practices. Coop Danmark's long-standing incentives to promote reusable bags, along with on-going informational campaigns, are examples of how consistent, small-scale rewards can normalise reuse habits (Co-operative News, 2018).

Broader public campaigns, such as 'bring your box' initiatives at deli counters, also encourage consumers to adopt reusable packaging in daily shopping routines.

Policy-aligned innovation and adaptive strategies

Proactively aligning with emerging policy frameworks ensures long-term viability. The PPWR mandates binding reuse and waste-reduction targets, including requirements for retailers to accept customer-provided reusable containers for takeaway food and beverages (EU PPWR, 2025).

Early adopters of these standards gain compliance advantages, while at the same time positioning themselves as industry leaders in sustainability innovation.

CIRCULAR GAME CHANGERS

Some developments shift packaging from incremental improvements to systemic transformation

While innovation pathways represent incremental progress towards circular retail packaging, true systemic change requires identifying and deploying circular game changers, disruptive forces capable of transforming industry norms, consumer behaviour, and regulatory frameworks. This section highlights key game changers shaping the future of circular packaging that are relevant to the Retail Relooped project.

Legislative mandates

Ambitious policy frameworks are among the most powerful game changers in accelerating the adoption of circular practices. The PPWR sets binding reuse and waste-reduction targets for the entire EU, requiring that, by 2030, significant portions of transport and grouped packaging must be reusable or refillable. Businesses, meanwhile, will be required to accept customer-provided reusable containers for takeaway food and beverages. National initiatives complement these efforts: a 2023 Germany law mandates, for example, reusable packaging options for takeaway food and beverages, reshaping market expectations and consumer habits.

These regulations not only encourage change, they compel businesses to innovate or risk non-compliance, transforming circular packaging from a niche concern into an industry-wide priority.

City-wide reuse systems

Several European cities are pioneering comprehensive reuse infrastructures that replace single-use packaging with shared, standardised solutions. The Aarhus deposit-and-return system for takeaway cups serves as an example. Launched in 2024, the programme allows consumers to use a single reusable cup at multiple vendors throughout the city and then return it at automated collection points. In its first year, the system achieved an 87% return rate, demonstrating that citywide collaboration can normalise reuse practices and maintain the level of convenience consumers have come to expect (De Lorenzo, D., 2025).

Such initiatives provide an example of how localised systemic change can serve as a model for broader regional or national adoption.

Cross-industry collaboration and shared infrastructure

Collaboration among retailers, producers, and service providers has emerged as a critical enabler of circular packaging. In Belgium, a coalition of six major supermarkets has launched a pilot programme for shared reusable produce containers, creating a unified system that simplifies logistics and reduces operational barriers (Reusable Packaging Coalition, 2024). Similarly, platforms like Loop, which partners with multiple brands and retailers, have demonstrated the viability of reusable packaging pools that circulate across industries.

These collaborations achieve economies of scale and standardisation that individual businesses cannot easily attain on their own.

Economic incentives and legal instruments

Financial and legal mechanisms are increasingly being used to accelerate the transition to circular packaging. In 2022, the city of Tübingen, Germany, introduced a tax on single-use food containers and cutlery. Despite legal challenges, the tax was found legal by the German Constitutional Court in 2023 (Krantz, P., 2025). The tax discourages disposable packaging, while at the same time incentivising businesses to adopt reusable alternatives. Expanded deposit-and-return schemes and differentiated producer fees that reward reusable or fully recyclable packaging further reinforce this shift.

Such mechanisms create external pressures and incentives that simultaneously drive consumer behaviour and corporate decision-making towards sustainability.

Corporate leadership and voluntary commitments

Forward-thinking retailers are setting ambitious goals that influence industry standards. Coop Danmark has committed itself to eliminating unnecessary packaging and ensuring all private-label packaging is recyclable or reusable by the mid-2020s. Initiatives like Ekoplaza's 'plastic-free' supermarket aisle challenge suppliers and competitors alike to rethink packaging design and reduce environmental impact (Taylor, M. 2018).

These bold corporate actions often pre-empt regulatory requirements and demonstrate that market leadership and sustainability can go hand-in-hand.

FROM CONCEPT TO REAL WORLD

Ideas must survive first contact with consumers

The innovation pathways and circular game changers identified in this chapter provide more than just a roadmap for systemic change, they serve as a practical foundation for designing and testing real-world solutions, living labs. These collaborative spaces where innovations can be prototyped, evaluated, and refined with active stakeholder involvement are critical for translating strategic ideas into scalable practices. In these spaces, the collaboration of a packaging specialist is recommended to promote a systemic view of the packaging and product-life cycle that meets the requirements of projects and the people and companies involved.

Example of return system for coffee cups created as part of the Żabka living lab (IMP PAN)

Turning systemic thinking into practical prototyping

The transition from conceptual innovation to market-ready solutions requires iterative testing under real-world conditions. While many innovations show promise in controlled environments or pilot studies, they fail to hold up when faced with the multiple layers of complexities that retail operations provide, be it supply-chain logistics, variabile consumer behaviour, staff-training needs, or compliance with evolving regulations.

Living labs serve as bridging mechanisms between theory and practice. They allow stakeholders to:

- **Test feasibility** by assessing whether innovations can function effectively within existing retail infrastructure.
- **Measure consumer acceptance** by observing how demographic groups respond to new systems like reuse schemes or bulk sales.
- **Identify operational challenges** by revealing practical barriers such as staff workload, hygiene management, and logistics co-ordination.
- **Gather data for scaling** by collect insights that inform broader rollout strategies, both for individual retailers and industry-wide applications.

By engaging consumers, retailers, designers, and policymakers in a shared design process, living labs ensure that circular solutions are not only technically viable but also desirable, practical, and scalable.

CASE STUDY

Coop Danmark: bridging theory and practice

The Coop Danmark design sprint conducted in January 2025 offers a clear example of how the project's innovation pathways are being explored in practice. The sprint focused on reducing packaging waste through bulk sales ('sell-by-weight' sections) and reusable containers, culminating in the development of a shop-in-shop concept featuring sm dispensers and gravity bins for a range of dry goods and liquids.

Key aspects of the concept align with the innovation pathways identified in this chapter:

- **Behaviour-driven design:** making sustainable choices intuitive and appealing.
- **Digital technology:** supporting smart dispensing and tracking of container reuse.
- **Policy readiness:** anticipating regulations that favour reusable packaging and refill systems.

Example of gravity dispensers showcased at the 2025 Folkemøde (BOFA)

— **Collaborative logistics:** initially outsourcing dispenser maintenance, with the potential to transition to in-house solutions.

A planned living lab at a Coop Danmark outlet in Rønne will serve as a real-world trial for these. The lab will be used to find the optimal method and equipment for dispensing products, as well as to evaluate consumer acceptance, operational feasibility, and regulatory compliance. The pilot will provide critical feedback for future scaling and refinement of the concepts.

Informing future living labs

Although the living labs for the Retail Relooped project have already been selected, the principles and approaches outlined here offer a transferable framework. Whether piloting smart reuse logistics, digital deposit systems, or collaborative infrastructure, future living labs can draw on the insights gained from this strategic analysis and the practical experiences of the Coop Danmark case.

The adaptability of the living lab methodology also allows for iterative improvement. Successful concepts can be refined and expanded, while challenges identified can lead to new innovation pathways or the identification of new game changers.

Learning from broader European experiments

The Retail Relooped living labs are part of a broader European trend in which cities and retailers use real-world testing to accelerate circular innovation. For example, the citywide reusable-cup system in Aarhus combines retailer co-operation, consumer incentives, and an app to achieve reuse rates in excess of 85%. Similar initiatives in Germany and Belgium are trialling shared reuse infrastructure and deposit-and-return systems, often supported by public-private partnerships and aligned with emerging EU policy mandates.

These cases demonstrate that living labs are not isolated experiments but rather critical components of systemic change strategies. They offer flexible, adaptive environments in which stakeholders can respond to evolving technologies, shifting consumer expectations, and new regulatory pressures.

LAYING THE GROUNDWORK

Living labs turn circular packaging ideas into scalable, consumer-ready, and policy-compliant solutions

By grounding innovation in practical, consumer-facing trials, the Retail Relooped living labs will play a central role in advancing the project's mission of creating scalable, user-friendly, and policy-compliant circular packaging for retailers. They will also contribute valuable data and insights that can inform the project's future activities, as well as the broader transition to a circular economy in Europe.

The shift to circular retail packaging is not a single innovation or policy change; it is a complex, multi-layered process requiring sustained collaboration between businesses, consumers, policymakers, and designers. This chapter has outlined a set of innovation pathways (incremental, scalable strategies) and identified circular game changers capable of driving systemic shifts. The key insights from this chapter include:

- Retailers play a pivotal role in shaping consumer behaviour, developing reuse and incentive models, and testing packaging reduction strategies.
- Technology integration from digital deposit-and-return systems to smart logistics can enhance operational efficiency and consumer engagement.
- Collaboration and shared infrastructure reduce the cost and complexity of scaling circular solutions.
- Policy alignment ensures that innovations are resilient and positioned for long-term viability under evolving regulations.
- Behaviour-driven design and consumer incentives are essential if sustainable practices are to be adopted by the general public.

The Retail Relooped project's living labs, including the upcoming pilot in Rønne, represent practical applications of these strategies. By testing concepts such as bulk sales with reusable containers, smart dispensers, and behaviour-driven engagement, the living labs will generate valuable insights into consumer acceptance, operational feasibility, and policy compliance.

Stakeholders—including retailers, logistics providers, policymakers, and consumers—are encouraged to:

- Adopt the identified innovation pathways where feasible, integrating circular principles into product design, packaging logistics, and customer engagement.
- Experiment through pilot programmes and living labs, recognising that iterative testing is key to refining and scaling successful solutions.
- Advocate for supportive policy environments that incentivise reuse, reduce barriers to adoption, and promote shared infrastructure initiatives.

The insights gathered through these efforts will advance the Retail Relooped project's objectives while at the same time contributing to the broader transition towards a circular economy in Europe.

The following chapter presents a roadmap for engaging stakeholders through various user-interaction formats, including surveys, qualitative discussions, and generative design sessions. These methodologies further refine the concepts explored in this chapter, ensuring that circular packaging is developed collaboratively and reflects the needs and expectations of diverse user groups.

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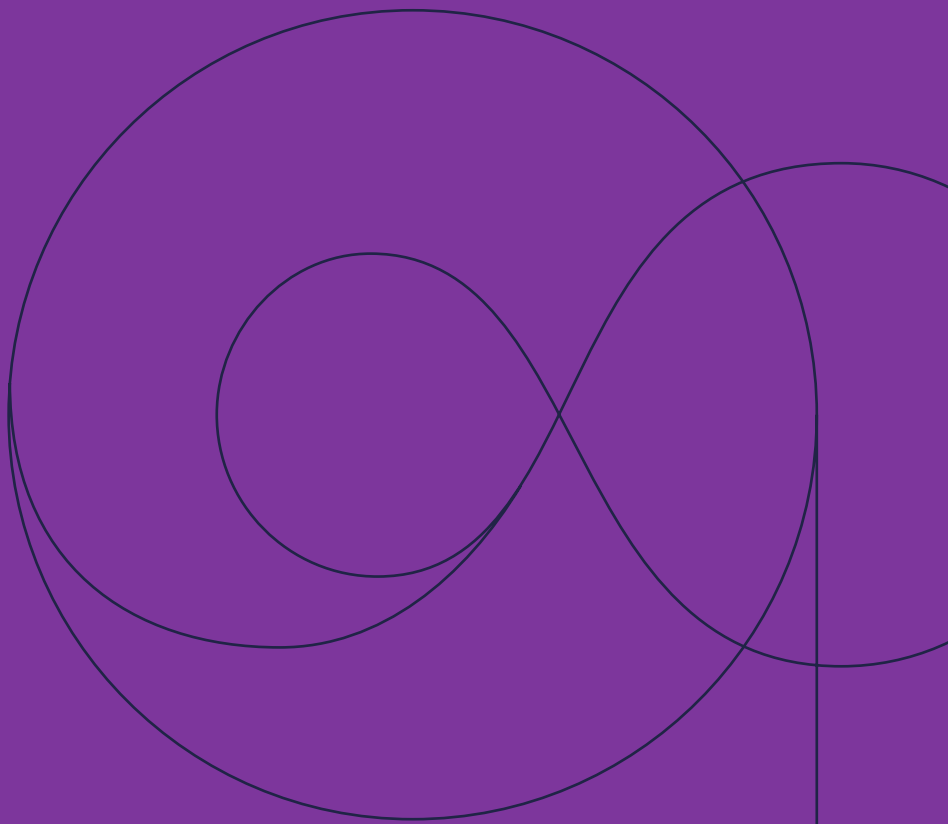
CHAPTER 7

Strategic co-design methodologies and applied ***living-lab models*** in circular-retail innovation



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RELOOPED's innovation process is grounded in strategic design, co-design, and living lab approaches. It integrates academic frameworks with applied tools to enable replication, iteration, and upscaling in circular-economy contexts. Below, we define some of the conceptual foundations of the project, look at it in terms of real-world applications, before finally presenting RELOOPED as an embedded case.

DESIGNING FOR SYSTEMIC CHANGE

Logistics, user behaviour, and stakeholder interests must all be considered

Designing sustainable packaging systems for food retailers requires more than technical fixes; it involves shifting systems of production, consumption, and disposal. Ambitions for circular economies can only succeed if operational logistics, user behaviour, and stakeholder interests are aligned. To address this complexity, RELOOPED applies a strategic-design approach that integrates long-term, systematic thinking with user-centred innovation practices.

Strategic design draws from interdisciplinary traditions that situate design beyond product development, focusing instead on systems, policies, and multi-actor processes (Manzini, 2015; Jégou & Manzini, 2008). Below, we discuss co-design and living labs, as well as the other tools RELOOPED adopted to facilitate this change.

During RELOOPED, we applied the following methodological concepts, grounding each in relevant theoretical frameworks:

- **Strategic design:** a multidisciplinary approach focused on addressing complex societal challenges through systems thinking, long-term visioning, and stakeholder alignment; strategic design shifts design from artefact-making to strategic problem framing and policy-oriented interventions (Manzini, 2015; Jégou & Manzini, 2008).

- **Co-design:** a participatory design methodology in which users and stakeholders are engaged as equal partners throughout the innovation process; co-design promotes democratic knowledge production, inclusion, and shared ownership of solutions (Sanders & Stappers, 2008).

- **Human-centred design:** a design philosophy and process that grounds innovation in deep understanding of user behaviour, needs, and lived experiences; human-centred design ensures that solutions are desirable, feasible, and viable (IDEO.org, 2015).

- **Living labs:** open, user-centred innovation environments set in real-life contexts, where users, researchers, and companies co-create and test new solutions iteratively (ENoLL, 2020; Juujärvi & Pesso, 2013).

— **key performance indicators (KPIs):** a structured set of behavioural, operational, environmental, and economic metrics used to evaluate innovation performance, adaptability, and impact in living-lab settings (Interreg Europe, 2023)

These methodological pillars underpin RELOOPED's roadmap for circular transition, linking research, stakeholder engagement, design innovations, and measurable outcomes.

By integrating these frameworks, RELOOPED provides a roadmap for transition-oriented innovation in circular retail systems.

STRATEGIC-DESIGN FRAMEWORKS

Linking users, services, and governance

Strategic design is an interdisciplinary approach that applies design methods to complex, systemic challenges. Unlike conventional design, which often focuses on artefacts or services, the strategic-design process considers policy, institutions, and infrastructure to shape long-term societal transitions (Manzini, 2015). It is particularly suited for contexts marked by uncertainty, multiple stakeholders, and competing value systems—such as the shift to circular packaging systems for retail food.

Strategic design involves not only envisioning new futures but also orchestrating the pathways toward them. This includes framing problems, co-developing solutions, prototyping innovations, and facilitating their real-world testing. In doing so, strategic design helps integrate innovation with governance and user experience (Jégou & Manzini, 2008).

Strategic design is the overarching logic applied throughout RELOOPED's project lifecycle.

During **Work Package 2 (WP2)**, it structured the research phase, enabling mapping of system dynamics and problem framings through study tours, stakeholder insights, and value-chain exploration.

During **Work Package 3 (WP3**), it guided ideation and concept development, especially through design-sprint methodologies, and it continues to guide the design and adjustment of real-world pilots through on-going testing cycles and collaboration with stakeholders in living labs.

The RELOOPED approach draws on several interlinked traditions:

— **Human-centred design** focuses on deep engagement with users to ensure solutions are desirable, feasible, and viable (IDEO.org, 2015).

— **Design thinking**, especially the double-diamond model developed by the UK Design Council, structures design into four phases: discover, define, develop, and deliver (Design Council, 2019).

— **Service design** complements the methods above by focusing on end-to-end user experiences and the integration of backend operations. Rather than developing entirely new packaging designs, the emphasis of service design is on how existing or adapted packaging formats function as touchpoints within the overall service journey. This approach ensures that innovations—such as reusable containers or deposit-and-return models—are aligned with consumer behaviour and logistical realities, making them viable for implementation and scaling (Stickdorn & Schneider, 2011; Polaine et al., 2013; Stickdorn et al., 2018).

These frameworks help position RELOOPED as a strategic attempt to intervene in existing systems through iterative, participatory design practice.

METHODOLOGIES FOR CO-DEISGN

Stakeholders as equal partners in design

Co-design refers to collaborative design approaches that actively involve users and stakeholders in the innovation process, from problem definition to solution development. Rooted in participatory design traditions, co-design methods recognise that users are experts when it comes to their own experiences and that they are critical contributors to systemic change (Sanders & Stappers, 2008). In the standard model, a design is placed in the hands of consumers; the co-design model involves stakeholders in the process. During RELOOPED, this philosophy has been operationalised through design sprints, stakeholder involvement, and prototyping sessions that embed users and practitioners in the development and refinement of circular-packaging concepts.

In the context of circular transitions in food retail, co-design offers an inclusive framework to navigate diverse stakeholder priorities, balancing regulatory compliance, operational feasibility, and customer behaviour. It fosters shared ownership of innovations while enabling real-time adjustments through iterative feedback loops.

RELOOPED applies co-design as both a philosophy and a structured method. Key techniques include:

— **Generative workshops:** multi-stakeholder sessions using journey mapping, collage making, scenario play and other creative facilitation tools to explore alternative futures.

— **Visual tools:** idea matrices, stakeholder maps, and prioritisation boards to enable cross-disciplinary sense-making.

— **Rapid prototyping:** sketches, mock-ups, and low-fidelity pilots to surface early insights and test desirability before implementation.

These techniques were primarily applied during RELOOPED's design sprints, which served as structured environments for activating co-design. The sprints enabled teams to frame

challenge areas, explore alternative ideas, and collaboratively select promising concepts for development.

Following the sprint, selected concepts were brought into living-lab environments for real-world testing. Here, the prototypes were iteratively refined in collaboration with stakeholders based on performance data and user feedback. This on-going design process ensured that co-design remains a guiding principle not just during ideation, but throughout implementation.

TESTING CIRCULAR SOLUTIONS

Living labs use real-world contexts to put concepts through their paces

Living labs provide real-world environments where innovations are co-created, tested, and iterated together with users and stakeholders. Unlike laboratory settings or demonstration pilots, living labs are situated within actual use contexts such as shops, homes, or cities, and rely on sustained stakeholder collaboration and active user involvement (ENoLL, 2020).

According to Juujärvi & Pesso (2013), living labs enable experimental design that addresses both technological functionality and social acceptance by embedding prototypes in communities. These environments are characterised by multi-actor collaboration, iterative development cycles, and user feedback as a critical learning mechanism.

During RELOOPED, living labs have served as the operational field for testing selected circular-packaging innovations in co-operation with retail chains, local authorities, universities, and individuals. The labs support a real-life validation of co-designed concepts while allowing iterative refinement across behavioural, logistical, and infrastructural dimensions.

The RELOOPED living-lab model incorporates the following features into its structure:

- **Real-world context:** activities are embedded within functioning retail environments (Coop Danmark and Żabka Polska) and at institutional testbeds (the fab lab at Lithuania's Klaipeda University and IMP PAN in Poland).
- **iterative prototyping:** innovations are treated as evolving prototypes that are tested, refined, and scaled based on stakeholder input and KPI feedback.
- **Multi-stakeholder engagement:** retailers, packaging experts, logistics providers, design researchers, and consumers are engaged at different stages of the lab cycle.
- **Evaluation logic:** living-lab pilots are embedded with performance indicators (see below), enabling data-informed scaling or reconfiguration.

RELOOPED's living labs align with the principles outlined by the European Network of Living Labs (ENoLL), including openness, transparency, co-creation, and value-driven experimentation. The approach also draws from the Living Lab Harmonization Cube (Schuurman et al., 2016), which aligns lab governance, infrastructure, and stakeholder participation, and from the Interreg ACSELL Living Lab Implementation Guide (Interreg Europe, 2023), which recommends modular phasing and local stakeholder buy-in.

These sources provide the conceptual and practical scaffolding for RELOOPED's iterative, field-based validation of circular-packaging concepts.

EVALUATING IMPACT

To learn from living labs, we must be able to measure their outcomes

Effective monitoring and evaluation (M&E) frameworks are essential for the tracking the progress of living labs and ensuring that their results can be learned from. In real-world testing environments, where innovations unfold in dynamic settings, evaluation must accommodate behavioural, operational, and environmental complexity. RELOOPED's evaluation approach builds on the Wasteman project's reuse-assessment model (Jensen et al., 2019), Interreg ACSELL guidance (2023), and key metrics for circular-packaging systems (Betts et al., 2022).

The goal of RELOOPED's M&E framework is to guide iterative learning, provide evidence of system effectiveness, and inform decisions about adaptation or scaling. The framework integrates qualitative and quantitative indicators and is tailored to track the success of pilots in Denmark, Poland, and Lithuania.

Core KPI categories for RELOOPED living labs

1. **User behaviour and acceptance**

- KPIs: participation rates, satisfaction, willingness to reuse, reported barriers.
- rationale: changing user behaviour is fundamental to circular packaging adoption.

2. **Return rates and reuse performance**

- KPIs: packaging return rates, loss rates, average reuse cycles per item.
- rationale: high return and reuse rates signal system viability and user co-operation.

3. **Operational feasibility and logistics**

- KPIs: handling time, cleaning turnaround, digital-tracking integration, delivery-loop completion.
- rationale: solutions must be compatible with of real-world supply chains.

4. **Waste-stream impact (morphology)**

- KPIs: reduction of single-use waste, volume of diverted material, change in residual-waste composition.
- rationale: the pilots aim to visibly alter local waste flows.

5. **Economic viability**

- KPIs: cost per use, net savings, system-level cost-benefit.
- rationale: circular systems must be cost-effective for retailers and consumers.

6. **Energy and infrastructure load**

- KPIs: energy use per reuse cycle, reverse-logistics emissions, cleaning resource demand.
- rationale: environmental gains depend on infrastructure efficiency.

Each KPI category is mapped to living-lab phases and can be adjusted locally. The indicators were inspired by on-going co-operation with project partners and reflect the design logic of the various living-lab configurations. Rather than being fixed in advance, they were proposed as a flexible framework that partners can adapt to suit their own pilots. This approach supports locally relevant monitoring while maintaining strategic consistency. In line with Interreg's living-lab guidance, indicators are shaped iteratively and used in mixed-method evaluations, pairing, for instance, sales or sensor data with qualitative feedback such as interviews or ethnographic observation.

RELOOPED AS AN EMBEDDED CASE STUDY

How design frameworks become real-world circular innovation

The RELOOPED project offers a real-world demonstration of how strategic design, co-design, and living-lab methodologies can be integrated to accelerate circular innovation in food retail. Grounded in theory and implemented in three European Union countries, RELOOPED operationalises design frameworks to address complex system barriers to reuse, collection, recycling, and reduction.

WP2: from context mapping to design activation

During WP2, RELOOPED applied strategic and human-centred design approaches at Coop Danmark and Żabaka Polska outlets in order to explore the system dynamics of circular packaging. Study tours to corporate headquarters and retail environments provided foundational insights aligned with the discover and define phases of the double-diamond model. While these visits did not immediately generate prototype ideas, they helped identify key system barriers and contextual challenges through direct engagement with retail

environments and staff. The insights were later brought together and structured using mapping exercises, stakeholder interviews, and supply-chain diagnostics.

The project framed problems from policy and operational angles, while also providing the perspective of retail managers, logistics co-ordinators, and consumers. This phase established a shared understanding that grounded the subsequent design work.

WP3: design sprints and prototyping

Based on the insights from WP2, RELOOPED launched distributed co-design activities, including design sprints that incorporated stakeholder workshops. These applied methods from the convivial toolbox and double-diamond model to structure idea generation and early prototyping. Rather than follow a conventional five-day design-sprint model, RELOOPED adapted a modular format that spread design phases across partner sessions.

Participants brought with them experience in logistics, packaging, behavioural science, and retail operations. The process generated a range of ideas for reusable and refillable packaging, as well as for collection and sorting—some of which advanced to living-lab piloting. Tools included idea matrices, customer-journey sketches, priority-setting grids, and role-based scenarios. This stage exemplifies co-design in action: solutions were co-developed by actors from different points on the value chain, ensuring ownership and contextual relevance.

Applied living labs: Denmark, Poland, and Lithuania

Field testing of the the co-developed concepts is being carried out as living-lab experiments.

- In **Denmark**, Coop is in the process of implementing reuse and refill pilots in a large-scale retail environment.

- In **Poland**, Żabka's living lab includes two stages: the first focuses on collecting and sorting single-use coffee cups and lids, while the second tests a low-tech return system for reusable coffee cups integrated into Żabka's retail infrastructure.

- In **Lithuania**, Klaipeda University hosts a fab lab in support of decentralised prototyping and user testing in a university canteen setting.

- Also in **Poland**, IMP PAN leads a bio-experiment looking into using insects as an alternative treatment stream for packaging degradation.

These living labs reflect the project's commitment to context-responsive innovation. Each site is guided by the shared KPI framework, while retaining local flexibility in design, operations, and measurement.

Stewarding complexity is key

As a whole, RELOOPED illustrates how living-lab approaches can align with strategic policy goals and be applied in operational settings. By aligning research, prototyping, and piloting under a unified strategic-design framework, the project moves beyond demonstration to broader systems-oriented testing. The project's modular process—combining insight gathering, design sprints, field trials, and impact monitoring—can serve as a replicable model for others tackling circular packaging or broader sustainability transitions. Delivering on this model requires not just the right tools, but the right competencies and an adaptable framework.

A hybrid profile

To steward the type of systemic and iterative transition advanced by RELOOPED, the individual tasked with managing strategic circular innovation projects must embody a hybrid professional identity. This person must be able to manage timelines and resources, while at the same time act as a systems steward, a design facilitator, and a public-facing innovation broker.

Drawing on frameworks from the OECD (2017) and public change-management insights from the WASTEMAN project, the following desirable characteristics for this type of role have been identified:

- **Strategic-systems literacy:** possesses a deep understanding of systems thinking, including the ability to work with complexity, feedback loops, and long-range impact scenarios.
- **Design-led facilitation:** proficient in participatory design methods (including design sprints and double diamond); capable of facilitating stakeholder co-creation and guiding iterative prototyping cycles.
- **Adaptive leadership:** able to navigate in uncertain situations, politically acute, and capable of recalibrating on the fly based on real-world feedback.
- **Transversal co-ordination skills:** can operate across institutional silos, mediate between public and private interests, and connect public-facing activities, such as user engagement, with back-office operations, such as regulatory compliance and logistics.
- **Evidence and learning orientation:** familiar with mixed-methods evaluation (KPIs, qualitative indicators) and committed to iterative learning (as opposed to static planning).

This profile resonates with OECD's call for 'champions committed to change' who can steward systems transformation in unpredictable and politicised environments (OECD, 2017).

Modular and adaptive implementation architecture

The RELOOPED framework itself is designed to be modular and adaptable, allowing it to be replicated regardless of geography or industry. Structurally, it spans five interlinked stages:

1. **Explore:** desktop research, stakeholder mapping, and ethnographic insights.
2. **Co-design**: participatory sprints and solution sketching.
3. **Test:** prototype deployment in living-lab environments.
4. **Evaluate:** continual monitoring via KPIs and feedback loops.
5. **Scale:** transfer and expansion of viable models.

Each module is scaffolded by a phased learning logic, incorporating OECD-inspired tactics such as framing, connecting, prototyping, and stewarding (Interreg South Baltic Programme, 2022). This dynamic architecture allows local actors to engage with the process, regardless of institutional maturity, while ensuring systemic integrity.

In short, both the project manager and the framework design must be oriented toward stewarding complexity, not seeking certainty. Circular innovation at scale, be it managing projects or facilitating transitions, requires this shift.

A ROADMAP FOR CIRCULAR RETAIL AT SCALE

Modularity makes the RELOOPED framework adaptable anywhere

Anchored in academic theory and applied design practice, the RELOOPED project's roadmap offers a replicable model for stakeholder-led, real-world experimentation.

Through a structured sequence (context mapping, design sprints and real-world testing in living labs, and continuous monitoring), RELOOPED bridges the gap between ambition and implementation. Strategic design enables alignment of systemic change with user experience, while co-design ensures inclusive and creative problem solving. Living labs and embedded KPIs make iterative learning and adaptive scaling possible.

The RELOOPED framework establishes a method that is not tied to a specific geographic area or industry. Its modular structure, spanning research, co-design, piloting, and evaluation, allows it to be applied regardless of packaging system, retail setting, or policy environment. Elements such as stakeholder co-creation, KPI monitoring, and phased experimentation are broadly applicable, while specific living-lab designs or tools can be tailored to local infrastructure, behaviours, or regulatory contexts.

Projects aiming to replicate RELOOPED's approach can follow a path that includes the modules below:

— **Explore:** desktop research, system mapping and study visits.

— **Co-design:** design sprints with stakeholder involvement.

— **Test**: prototype pilots in living labs.

— **Evaluate**: monitor using KPIs and adapt based on results.

— **Scale**: refine and scale circular solutions.

While RELOOPED does not develop entirely new packaging formats or materials, packaging design plays a key role in the system-level transitions explored. Packaging is treated as a critical touchpoint in user journeys and logistical systems, shaped through co-design, evaluated in living labs, and adapted based on operational realities. This complements technical approaches, such as packaging metadesign, which focus more directly on material innovation and format development. Future projects may benefit from integrating both perspectives—strategic system design and technical packaging development—to unlock their full circular potential.

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