Demand-led Innovation Scoping Study:

Future innovations in the packaging industry

Collating industry insights on where innovation is needed to drive more low carbon outcomes in the packaging sector.

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Executive summary

As part of its 'Transforming Foundation Industries' challenge, Innovate UK has commissioned Oakdene Hollins to assess the potential for demand-led innovation in the packaging sector. This study is looking to showcase the products that fall into the category of 'demand-led innovation' and to provide an estimate of the transformative impacts these products could have on the market. To accomplish this, Oakdene Hollins conducted a workshop and a series of interviews with representatives from trade associations, prominent brand owners and retailers in the UK, including Co-op, Waitrose, and Nestlé. The main goals of these interactions were to identify the major challenges faced by these organisations and to identify innovative solutions that could tackle these challenges.

The challenges outlined by the stakeholders were categorised into three distinct areas:

1. **Accurately identifying low-impact resources and production processes**

The industry has made efforts to choose alternative materials that have a reduced carbon impact, through including recycled content, and offering biobased or compostable options. However, there is currently insufficient reliable data to support the widespread adoption of these choices on a large scale. The lack of consistent information as well as varying approaches to life cycle assessments (LCAs) creates uncertainty, making it challenging to compare results and understand the most favourable route for a sustainable future for packaging. This underscores the importance of establishing industry-wide standards to develop material profiles for different packaging options.

Key innovations or support mechanisms include:

- A verified data database
- AI prediction for novel materials.
- Technological advancements like hydrogen-powered or electric arc furnaces mitigate the impact of carbon-intensive processes.
- Consumer intervention schemes like carbon credits incentivise better purchasing habits.

2. **Mainstreaming reusable and refillable packaging**

In contrast to single-use packaging, reuse and refill options are designed to be cleaned and reused multiple times, slowing the loop and temporarily reducing manufacturing. Extending the use of this packaging can reduce the carbon impact of material over its full lifetime but many such schemes require high maintenance, consumer behavioural shifts, and an integrated reverse logistic system (in the case of pre-fill options). Interviewees also

highlighted that these schemes are not a silver bullet, and more studies need to be done on understanding where best to apply reuse and refill schemes.

To promote the widespread adoption of reuse and refill schemes, research efforts should be prioritized. This includes collaborative trials among competitors to establish labelling, return infrastructure, and suitable products for reuse. Furthermore, researching consumer incentives is essential. Integrating return infrastructure with existing recycling systems is a viable approach, which require digital tagging on reusable packaging to facilitate proper sorting.

3. Expanding kerbside recycling schemes to include flexible films

Legislation and labelling, such as the on-pack recycling label, have significantly helped increase packaging recycling rates in the UK from 25%, when the Packaging Waste Regulation (1997) was introduced, to 44% in 2017 (1). However, there are still challenges around sorting infrastructure for expanding kerbside collection to include flexible film packaging and “nudging” consumers to correctly use kerbside recycling bins. This will likely require activities including harmonisation across supermarkets to only use packaging that can be recycled, local authorities to ensure recyclable packaging is being collected at kerbside, material is being correctly sorted, and encouraging consumers to correctly dispose of their waste. Enabling better recycling rates requires better sorting technologies to separate flexible films and rewards-based systems to encourage more consumers to recycle.

When assessing the potential impact of these innovations on carbon reduction targets, certain key areas stand out; these include the adoption of existing technologies like alternative furnaces and digital tagging, as well as avenues for further research on reuse schemes and the development of industry guidelines.

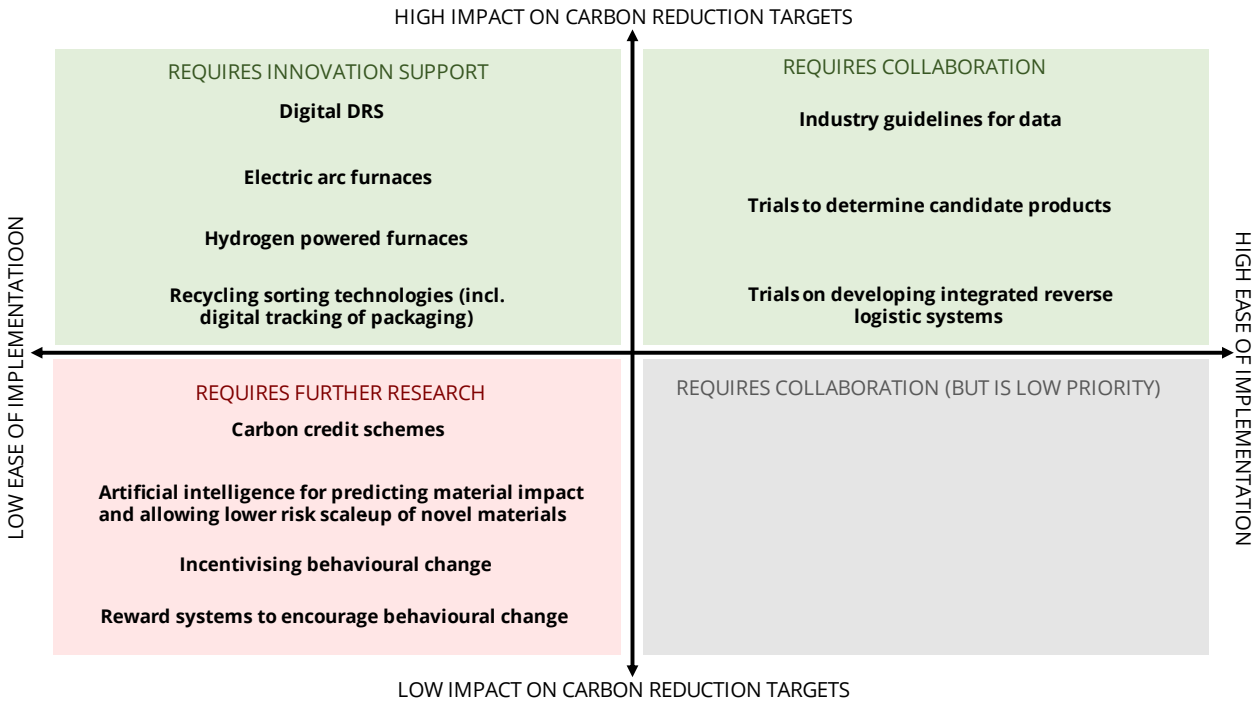

Figure 1: Potential impact of different innovations discussed

The packaging industry continues to evolve and innovate to develop more effective and sustainable packaging solutions. However, to decarbonise the industry at scale, and at speed, will likely require a strong focus on cross-supply chain and cross-competitor collaboration.

1. The case for supporting innovation in packaging

In 2019, the United Kingdom became the first global economy to legislate a target of reaching net-zero emissions by 2050 (2). This will require the transformation of every sector in our economy, including the UK Foundation Industries (FI), which include cement, glass, ceramics, paper, metals, and bulk chemicals. These industries are the largest industrial greenhouse gas emitters, generating 10% of the UK's CO_2 emissions every year and play a critical role in supplying material for the UK packaging industry (3). To align with 'The Futures of Packaging 2050' report (4), this work will focus on primary and secondary packaging[1] for fast moving consumer goods (FMCG)[2] and use food packaging as a case study.

Packaging plays a vital role in the FMCG space, with the majority being used in the food sector, as shown in Figure 2 (5). The primary use of packaging in the food sector is to preserve and protect perishable products. Effective packaging extends the product shelf life and reduces food waste; a 2017 study found that for every kilogram of food produced, the correct packaging creates an extra 3 gCO_{2eq} but reduces food waste by 350 gCO_{2eq}. (6). As packaging plays a significant role in reducing food waste by protecting and preserving products, it must not be overlooked by industry and government.

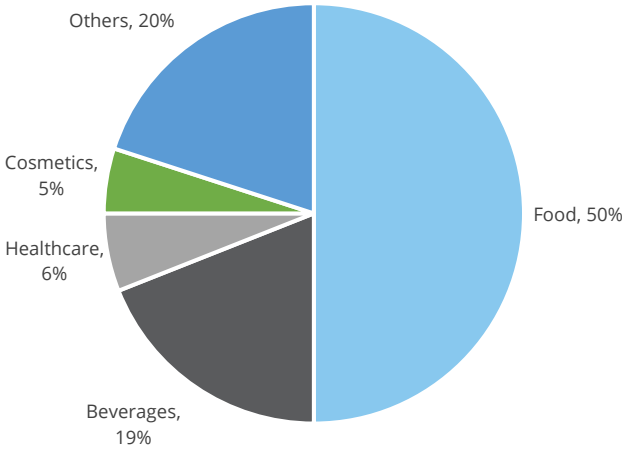

Figure 2: Breakdown of the consumer packaging industry by end-use

Some brand owners and retailers anticipate that the carbon footprint of packaging will play a significant role in decision making as -the industry is looking for options to reduce carbon impacts and need the data to support it. However, whilst carbon impact does inform more sustainable purchasing habits, it is not the only metric consider. Additional negative environmental effects include resource depletion, impact on biodiversity, soil depletion, waste generation, habitat damage, and water contamination/use. Promoting

[1] Primary packaging comes into direct contact with a product while secondary packaging protects or bundles products together.

[2] FMCG are goods bought and used by consumers rather than businesses or manufacturers.

sustainability requires organisations to use a holistic approach and take into account all these factors.

With the support of Innovate UK, Oakdene Hollins aimed at analysing the innovative solutions being pursued by the packaging industry to enhance sustainability. This takes into consideration not only the exploration of necessary innovations for industry compliance with policies, but also the evaluation of the industry's existing best practices and the identification of ways in which the industry can bolster their ambitious sustainability objectives.

2. Demand-led innovation

Driven by the **needs** and **wants** across the supply chain

As depicted in the above image and laid out in the Cambridge Institute for Sustainability Leadership's (CISL) report (7), demand-led innovation is defined as:

> *"Innovation that is incentivised by a gap in the market for a product or a service that consumers or buyers want to have access to and for which they would be willing to pay."*

Demand-led innovation therefore could assist in the decarbonisation of the packaging supply chain through establishing a market demand for low carbon packaging options and technologies. This also allows for more certainty when considering the demand for these low carbon products, therefore reducing the risk of investment into research and development of novel and pre-commercial scale innovations which could provide solutions to the market demand.

3. Our methodology

To identify potential opportunities to decarbonise the current packaging supply chain, this work aims to define key challenges faced by the industry, and then identifying R&D work that could address the industry needs, (i.e., demand-led innovation). This is different to traditional innovation, which is often driven by the desire to create something new or better, as well building on technological advancements, which may not always directly align with specific customer needs. The focus tends to be on creating something novel, and then developing a business case for the product with the expectation that a suitable application will be identified. This results in a linear approach to innovation, as shown below:

Driven by technological advancements and a desire to **create something new and better**

In this study, demand-related insights were gathered from stakeholder interviews and an industry workshop, which brought together trade association representatives, brand owners, and retailers to identify challenges and explore potential solutions. Prominent UK retailers including Waitrose and The Cooperative Group (Co-op), along with brand owner Nestlé, were among the participants.

The insights presented in this report highlight the industry's perspectives on the key challenges they face. This approach was applied throughout the supply chain, with industry stakeholders identifying three crucial demands in the sector:

1. Accurately identifying low-impact resources and production.
2. Mainstreaming reusable and refillable packaging.
3. Expanding kerbside recycling schemes to include flexible films.

4. Building ambition above legislation

4.1. Fiscal drivers

Since 1994, there has been a legislative focus on promoting more sustainable outcomes for packaging with regulations aimed at businesses, such as the Packaging Waste Regulations (8), which has three broad objectives:

- Reduce the amount of packaging produced in the first place.
- Reduce how much packaging waste goes to landfill.
- Increase the amount of packaging waste that is recycled.

Packaging recycling rates in the UK have increased dramatically since the introduction of this regulation, rising from 25% to 44% in 2017 (1). To encourage more recycling, the UK government launched a 'Plastic Packaging Tax' in April 2022 (9). Under this legislation, plastic packaging manufacturers become liable to a tax should their products not contain at least 30% recycled content. The aim of this policy is to encourage a higher demand for recycled content within the industry, and in turn, stimulate the need for a better and more efficient recycling infrastructure. The government estimates that almost 200,000 tonnes of carbon savings (10) could be made through the establishment of this policy, based on a 40% increase in recycled plastic in 2022 – 2023. Initial reports indicate that the scheme has surpassed expectations, as His Majesty's Revenue and Customs (HMRC) collected approximately £263 million within the first 10 months. HMRC have now expressed their intention to reform the tax to incentivise investments in chemical recycling.

The 2018 Resources and Waste Strategy for England outlined the ambition to implement Extended Producer Responsibility (EPR) for several products, including packaging. The packaging EPR (pEPR) requires producers to cover the cost of collection and disposal of household packaging (11). This incentivises a switch to recyclable and reusable packaging, and where possible, a reduction in the amount of packaging placed on the market. There is also potential for including closed-loop recycling targets, as well as targets for reusable packaging with plans to review legal obligations for producers from 2025 onwards. As of now, the European Union has implemented regulations stipulating that all packaging must be reusable or economically recyclable by the year 2030 (12).

EPR schemes charge using modulated fees, in accordance with set criteria (such as recyclability of packaging material or recycled content), often allocating a portion of these fees to funding innovation within the industry. This has not been explicitly stated in the pEPR plans and furthermore, stakeholders have highlighted the lack of direction for how local authorities need to spend the funding they receive through pEPR fees. It is estimated that the pEPR will generate £1.7 billion per year (13) – a substantial sum which

could contribute to the creation of an innovative, "world class" recycling system (as described by a key stakeholder). Whilst the EPR system is designed to cover the cost incurred by local authorities of end-of-life treatment, there is potential for excess funding to be allocated to innovation, research, and development opportunities. This funding could align with Innovate UK-funded projects towards improving sustainable practice in the packaging industry and leverage the industry's existing voluntary action.

4.2. Voluntary initiatives

Fiscal drivers tend to prioritise recycling rather than focusing on waste prevention (and reuse), the main priority of the waste hierarchy (a framework which priorities waste management strategies, as shown in Figure 3) (14).

Figure 3: The waste hierarchy

Initiatives such as the Waste and Resource Action Programme's (WRAP) Plastic Pact and the Worldwide Fund for Nature's (WWF) Basket Metrics for Packaging aim to help companies focus on goals that align with this hierarchy.

WRAP's UK Plastic Pact (UKPP) (15) brings together plastic industry stakeholders and government to reduce plastic waste and promote circularity (in the packaging industry), through four key goals:

- Eliminate problematic and unnecessary single-use packaging.
- Ensure all packaging is reusable, recyclable, or compostable by 2025.
- Increase the percentage of recycled content in new packaging.
- Improve collection and recycling of plastic packaging.

Most UK retailers are currently members of this agreement, including Tesco, Sainsbury, Morrisons, Waitrose, Aldi, Lidl, Asda, Co-op, Boots, and M&S.

The WWF's Basket Metrics for Packaging (16) on the other hand, takes a more material agnostic approach and provides companies with a consistent way of measuring environmental impact, and encourages companies to track the percentage progress on a material basis. The aim of the WWF is to achieve the following outcomes by 2030:

- 100% recyclable packaging.
- 40% reduction in material use.
- All material contains the maximum recycled content possible and is sustainably sourced.

This has been endorsed by numerous well-known international brands, including Coca-Cola, Nestlé, and Danone.

Many organisations that take part in these programmes do so with the intention of going above and beyond legislation, towards their own often more ambitious, net zero agendas, reducing their environmental impact and contributing to a more sustainable future.

4.3. Building alliances to align with net zero

Often, there exists a misalignment between the packaging industry's sustainability objectives and company-wide net zero targets. Packaging goals typically focus on resource efficiency, such as reducing material usage and promoting recyclability or reusability, as shown by Unilever's pioneering packaging innovations illustrated in Figure 4 (17). Conversely, Unilever's (and other companies') net zero strategies often target energy conservation, combatting deforestation, and ensuring water security, as shown in Figure 5 (18).

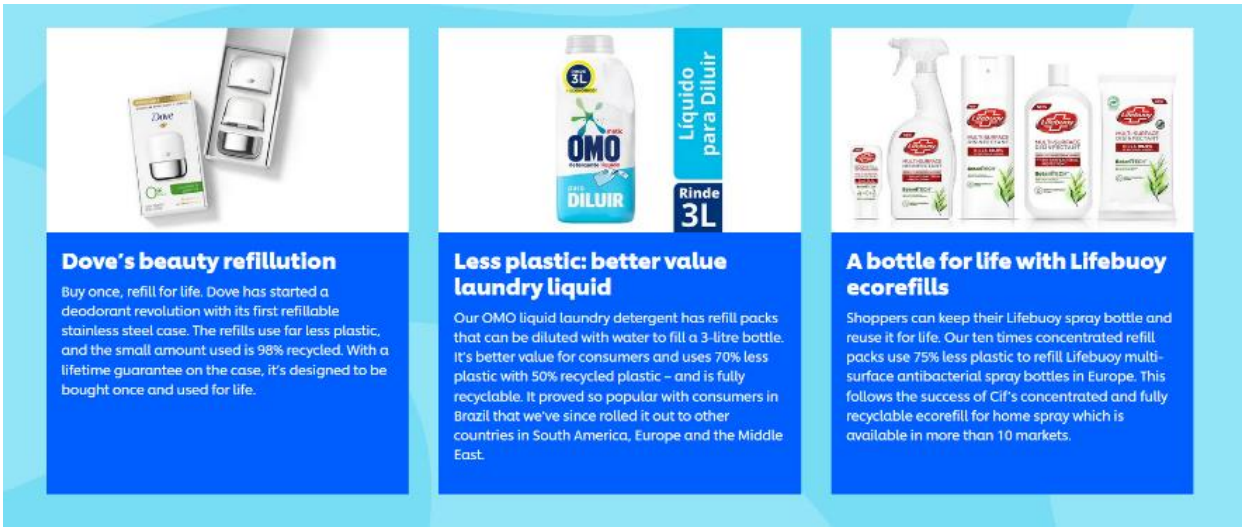

Figure 4: Examples of Unilever's innovative packaging solutions

The disparity between these goals, as evident from the two figures, has generated apprehension among stakeholders in our study regarding the industry's direction and where the emphasis should go.

The objective of this study is, therefore, to uncover synergies between packaging innovations and decarbonization targets, determining the necessary actions to prepare for the future and identify priorities that align with the pursuit of net zero objectives.

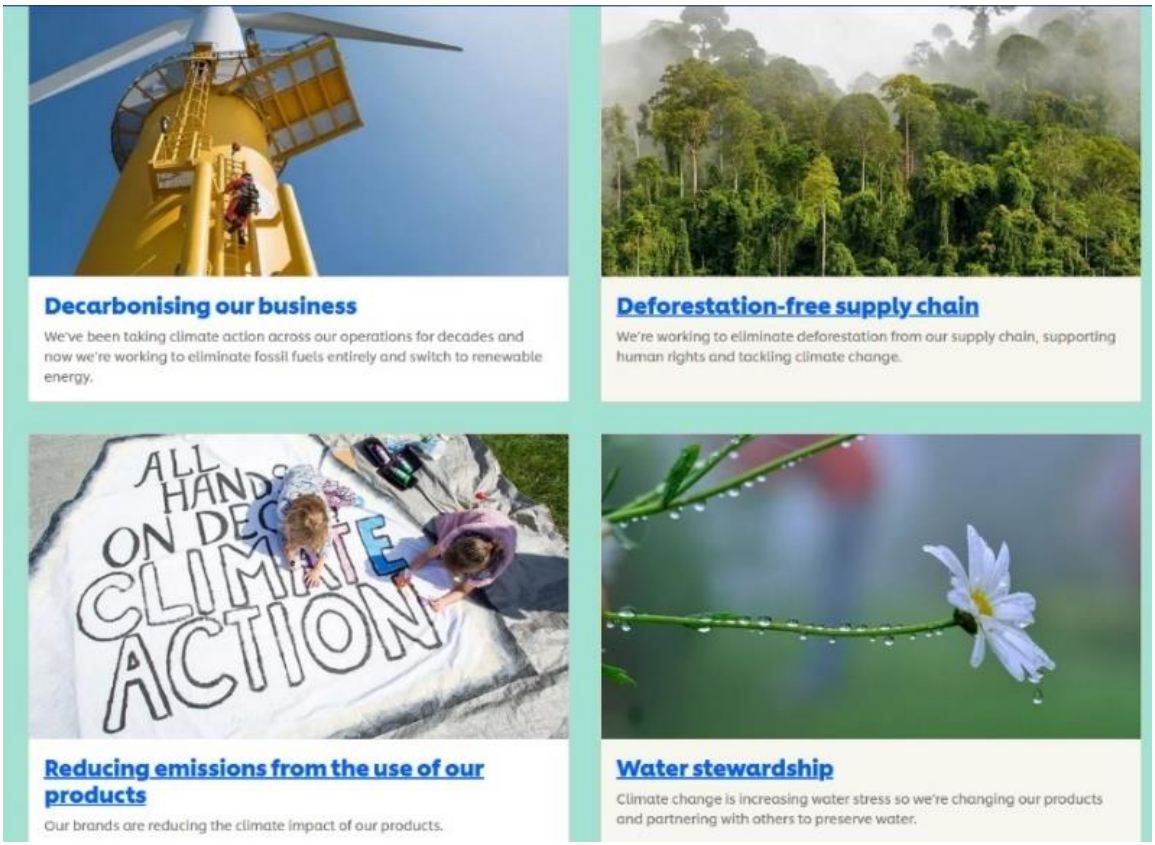

Figure 5: Unilever's objectives towards reaching net zero

5. Fulfilling packaging's purpose

Packaging is designed to safeguard and preserve goods. Its key functions can be divided into four major categories:

- **Preservation**: In the food and drink industry, packaging plays a crucial role in extending the life of the product. It acts as a barrier against environmental elements including moisture, light, and oxygen which cause deterioration over time, preserving the quality and freshness of goods.
- **Protection** from damage: During handling, storage, and transportation, packaging shields goods from deterioration, contamination, and damage. It lessens the possibility of product loss or waste and aids in ensuring that goods reach their destination in good condition.
- **Convenience**: Packaging makes products easier to use and transport by including handles spouts, and other characteristics to aid handling.
- **Information**: Packaging provides opportunity to include details on ingredients, nutritional value, and usage guidelines.

The sector is well-known for its continuous innovation and dynamic nature, exemplified by the annual packaging awards held in the UK (19), which recognise innovations in design and material. Every packaging innovation must preserve the ability of the product to effectively serve its intended purpose. However, despite notable progress in the packaging industry, challenges around finding scalable low carbon solutions persist.

5.1. Accurately identifying low-impact resources and production methods

The production of packaging often contributes significantly to its overall carbon footprint; for instance, the manufacturing stage of virgin LDPE plastic packaging can account for 52% of its carbon footprint (20). While this may vary depending on factors such as the material used and where it comes from, reducing carbon emissions associated with the early stages of the packaging life cycle has been identified as a top priority for the industry. To address this challenge, the industry can explore innovative approaches such as material substitution with lower carbon alternatives, decarbonization of manufacturing processes, and an overall reduction in packaging usage.

5.1.1. Alternative materials

Industry and government place great emphasis on reducing the use of virgin materials in packaging, with a specific focus on plastics. Different solutions exist to address this, including circular business models, innovative materials, and collaborative efforts within the supply chain. However, stakeholders acknowledge that a certain level of virgin resources will still be necessary unless there is a significant decrease in product demand.

Although technological advancements in material recovery and production may reduce this reliance in the future, the industry is actively exploring alternative material options to meet existing demands. These choices focus on:

- Finding alternatives to virgin fossil fuel-derived materials.
- Reducing the energy intensity of materials manufacture and production.
- Ensuring material can be recycled (via the biological or technical branches of the circular economy) (21) at the end of its life.

Replacing high impact fossil fuel packaging with similar lower impact options

Case Study #1:

"The war on plastics"

Plastics have been subject to major criticism in recent years, with images of plastic pollution rife on social media and news outlets (22). Whilst plastics, especially single-use plastics, have enabled a large technology leap in not only the packaging industry (i.e., healthcare etc), their low-cost manufacturing process and mainly lightweight design means that plastic is often used unnecessarily such as blister packaging for vitamins that do not need it (23).

The plastics industry is continually innovating in efforts to increase the sustainability profile of a highly targeted sector. From a carbon perspective, a transition away from plastics may not always be the best option, especially given the increased criteria for recycled content, through the Plastic Packaging Tax. In addition, the durability and lightweight nature of plastics, makes it an ideal option for reducing packaging weight in transportation. A whole life cycle approach is needed, and a standardised approach towards assessing the environmental impact of materials will provide transparency for industry and consumers alike.

Replacing fossil fuel-based packaging with existing renewable options

A more risk averse sustainability choice is to replace existing materials with more renewable, but well-established options. For instance, online shopping retailers, such as Amazon, have made the switch from single-use plastic packaging to corrugated cardboard (24). These alternatives sometimes require less energy to produce than traditional fossil-based options. Furthermore, biomaterials frequently encounter limitations in terms of manufacturing capacity when compared to conventional alternatives, and there is a lack of comprehensive data regarding their environmental impact.

However, for the food and beverage industry, paper-based packaging may not have the necessary material requirements and may not always be suitable for the intended purpose such as cases when packaging needs to be watertight.

Bio-based material

The growing shift from plastic to fibre-based packaging is a prominent and widespread trend in the industry. This transition has led to significant advancements in the development of fibre-based packaging, resulting in improved strength, durability, and barrier properties. Fibre-based packaging has gained popularity due to its biodegradable nature and ease of recycling. However, it is important to note that there are still certain applications where fibre-based alternatives may not be suitable or feasible.

Stakeholders have expressed considerable interest in other more novel bio-based packaging; however, many face obstacles in terms of sourcing sufficient raw materials on a large scale and ensuring compliance with existing supply chains, such as compatibility with kerbside recycling collections. Moreover, there is a significant amount of misinformation regarding the sourcing of biomaterials, leading to consumer concerns about potential impacts on existing food chains. In order to make the bio-based packaging industry economically viable and scalable, it is estimated by stakeholders that the UK should have at least two manufacturers with the capacity to produce approximately 300kt of material per year.

Compostable material

Compostable packaging is a type of bio-based packaging that can break down into non-toxic components. An example of this is the Co-op's compostable carrier bags, which were introduced after the company found that using "bags for life" did not significantly reduce carrier bag sales (25). However, in addition to requiring an established industrial composting infrastructure at a waste collection level, this type of material may not perform as well as traditional materials and may not be suitable for packaging used in high-temperature environments or that require specific barrier properties.

Challenges and opportunities towards making the right material choice

Although some have found the transition to alternative packaging easy – such as the likes of Tesco and the Co-op who have switched to recyclable or compostable packaging for own brand products (26), there have been challenges for retailers and brand owners in determining the best material options. One concern is the difficulty in making data-driven only have accurate data on established materials. Additionally, many manufacturers do not publish decisions about novel alternative options, as life cycle assessment (LCA)

processes often their LCA data and make their own assumptions on the scope of their analyses, which limits the validity of comparison and can introduce uncertainty into the decision-making process.

To facilitate the decision-making process for packaging materials, robust LCA data on current and future material needs to be available for manufacturers and brand owners. Improving the data quality for LCAs in the packaging industry allows for more informed decisions on packaging materials through identifying the environmental impact of packaging options e.g., global warming potential, eutrophication, acidification, soil depletion.

Case Study #2

Minding the data gap

Nestlé has highlighted the need for qualitative and independent reviews of primary LCA data to ensure validated figures are used in the decision-making process (25).

This requires collaboration with brand owners to identify overlaps in supply chains. LCAs for new materials require further research, and carbon impacts and material properties must be estimated from small scale/pilot data. Risks and opportunities for scale up of pilot programmes need to be determined.

Case Study #3

Developing standard practice for data (27)

Europur (the European trade association for flexible polyurethane foam) is currently in the process of standardising the impact of material used across the industry to ensure all their members can make better data driven choices.

This data will be available in a disaggregated form on both GaBi and Ecoinvent databases so that the industry can developed more robust figures.

Comparing material options on a consistent basis becomes challenging due to the lack of alignment among different manufacturer Life Cycle Assessment (LCA) studies. In an ideal world, brand owners will have data for each type of packaging material, including novel packaging options, and then for added granularity, each individual packaging product.

Currently there is uncertainty in calculating the carbon impact of plastic bio-based and chemically recycled material. Approaches like mass balance[3] are being introduced to certify that a proportion of the material has been recycled or is from a bio-based source. There are several mass balance certifications schemes such as the one offered by the International Sustainability and Carbon Certification (ISCC) scheme which requires an audit trail for companies to verify the chain of custody. And the industry has yet to

[3] Mass balance is an audit approach to track the amount and sustainability characteristics of chemically recycled or bio-based products.

determine how to validate such schemes, adding to the challenge of accurately assessing the environmental impact of packaging materials.

Generating a specific carbon footprint for individual products, with respect to packaging, transportation, material content and expected shelf-life, will allow businesses to identify carbon emission hotspots. A breakdown of each category, i.e., manufacturing processes of packaging, emissions associated with raw material extraction etc., will then further pinpoint the area of the value chain which requires sustainable innovation. This is also valuable information (from a more holistic viewpoint) for the consumer as it informs their choices with regards to the carbon footprint of products. Whilst a breakdown of information may not be necessary for in-store display, QR codes on packaging could provide consumers with further details of the 'journey' the product and its packaging have taken to arrive at the store.

Case study #4:

Supply chain collaboration (28)

Announced in March 2023, major UK supermarkets are collaborating on tackling Scope 3 emissions, through trialling a new harmonised approach to measuring carbon emissions as part of WRAP and WWF's "Retailer Net-Zero Collaborative Action Plan".

Associated behavioural change

Educating consumers in carbon literacy for packaging will be valuable for encouraging behavioural change. Promoting the adoption of uniform labelling across packaging, empowers consumers to make well-informed purchasing choices. This practice garners support from reputable organizations like the British Standards Institution (29). According to their ethical consumer report, consumers express a need for recognizable, consistent, and easily comprehensible labelling that facilitates informed decision-making. Claims such as '*saving the equivalent carbon emissions as a flight to Paris'* will likely be limited unless they can be backed up with robust data, in line with the Green Claims Code[4] (30). An alternative option is a traffic light system for carbon emissions associated with packaging (as with nutritional values on food).

Fiscal levers are often the incentive for change, especially for businesses, with examples such as the Plastics Packaging Tax (31) increasing recycled content within plastic packaging. Considering this lever at a social level, and in a similar vein to the success of the charge for plastic carrier bags and the sugar tax, which is contributing to tackling obesity (32), concepts such as a carbon tax on products and packaging with high associated carbon emissions could be introduced.

[4] The Green Claims code: was first published in 2021 and was designed for businesses with consumer-facing products and services to check whether their environmental claims would be misleading as defined by British consumer law.

Despite the success of these levers, shorter term (though likely smaller and incremental) change in consumer behaviour will result from pull factors, especially with regards to incentivising sustainable purchasing. Consumers could be incentivised through allocating carbon credits[5] to purchases, dependent on the sustainability credentials of the product. These credits could then be used against future purchases. In theory, this idea could be applied to all purchases, and create a financial incentive to shop sustainably. Although metrics upon which the credits are based would need to be determined e.g., carbon footprint, biodiversity, etc, supermarkets already have experience with this concept through existing reward schemes. Rewarding consumers who make sustainable choices, through extra bonus loyalty card points when purchasing products with more environmentally friendly packaging is an example of a near-term solution. In turn, this could lead to greater awareness of the environmental impact of packaging, developing education through incentivisation, with retailer leadership being the necessary lever.

5.1.2. Reducing the carbon emissions of production processes

Reducing carbon emissions in the manufacturing of packaging could include a movement away from fossil fuel energy at an individual business level, but even more preferably, at a national or international energy-grid level. This is especially relevant to industries requiring high amounts of energy – such as glass or metals. Alternative fuel sources, such as the renewable energy sources of green hydrogen, solar, wind etc., as well as biobased energy sources such as biofuels and biomass, are promising for the future of low carbon energy. This also needs to be matched with an equal effort towards minimising wasted energy e.g., heat loss from operations, and the adoption of a new generation of machinery: more energy efficient and powered by renewable electricity. Efforts such as these are not unique to the packaging sector, and whilst collaboration within the industry is likely to be transformative, cross-industry collaboration could be beneficial in an effort to decarbonise the manufacturing process.

Considering the FIs specifically, energy savings can be made with respect to the materials chosen for packaging. An example of this is choosing a plastic which has a low(er) melting point compared to another type of plastic with similar properties, whilst retaining the same level of functionality e.g., replacing polyethylene terephthalate (PET) with polypropylene (PP) as it has a lower melting point. Disregarding the relative prices of chemicals, this has the potential to reduce the energy needed to manufacture certain plastics, therefore reducing carbon emissions from energy used for melting.

[5] Carbon credits are permits that allow the owner to emit a certain amount of carbon dioxide or other greenhouse gases. (33)

5.1.3.Opportunities for innovation

Table 1: Summary of the challenges associated with reducing material impacts and their respective potential solutions.

Key challenges	Potential solution through innovation	Type of innovation
Producing uncontaminated food grade recycled content	Using **digital labelling/codes** on recyclable food grade packaging to separate the material from other packaging.	**Systems improvement**
Unnecessary and/or increased carbon emissions associated with material substitution	Using **artificial intelligence (AI)** in predictive analytics to determine impacts of materials to systems and the environment when produced at a large scale.	**Research**
Standardised approach to LCAs	Cross-competitor collaboration with trade associations and producers to develop an **industry guideline** for LCAs.	**Collaboration**
Validating primary material data	Cross-competitor **collaboration** and participation in developing packaging material profiles. Developing an interface with validated data for brand owners and retailers to access.	**Collaboration**
Incentivising consumers to make more sustainable purchasing choices	**Carbon credits scheme** and determining the appropriate metrics for allocation of credits.	**Consumer behavioural change**
Identifying material that requires less energy to produce	Replacing currently used polymers with polymers with **a lower melting point,** for example.	**Research**
Finding alternatives to high carbon manufacturing processes	**Hydrogen powered or electric arc furnaces** for the glass and metal industry.	**Technology upgrades**

5.2. Mainstreaming reusable and refillable packaging

Reusable packaging is a type of packaging designed to repeatedly fulfil the same or similar function. In contrast to single-use packaging, which is typically thrown away after one use, reusable packaging may be cleaned, refilled, and used repeatedly. This keeps the material resource in the 'in-use' phase for longer, with the packaging ideally also being recyclable, should it become damaged or worn. This often results in a reduction in carbon emissions as fewer units (by volume) are needed to fulfil the same service.

Refillable glass bottles for beverages, reusable plastic containers for food, and high-strength shopping bags made of cloth or other materials are just a few examples of reusable packaging. This packaging is constructed from durable and thick materials such as metal, glass, or premium plastics that are more durable than single-use packaging. To ensure reusable packaging stays in circulation for enough uses that it outweighs the carbon impact equivalent of single-use packaging, consumers need to recognise the value in their reusable packaging and its contents. Stakeholders highlighted that reusable packaging often works better for dry products such as rice and grain and/or products with a high turnaround such as doorstep milk deliveries. The types of products may vary depending on the business model used. Common models include:

I. In-store refill stations

The refillable business model most often involves consumers bringing their own containers to reduce packaging waste. This model is applicable to small independent stores that specialise in refillable products, as well as some large retail stores. Major retailers like Waitrose and Asda have trialled such schemes with some degree of success (34).

One major challenge for the business model is the high maintenance required for refill stations, which must adhere to strict health and safety guidelines due to the risk of cross-contamination between food items. Cleaning processes can be time-consuming and represent additional costs for companies. Furthermore, these setups require sufficient space and investment in refill infrastructure, which leads to refill stations being more likely to be installed in larger supermarkets rather than small convenience stores.

However, the biggest challenge to this model is consumer behaviour, as it often requires consumers to bring in their own containers. In a convenience-driven society, this additional step may inhibit engagement by some consumers and take time for people to establish new habits. Instigating take-back systems is seen as a key driver in developing viable instore refill stations. One potential solution is the implementation of integrated recycling/reuse kerbside collection systems, which enable consumers to dispose of all

items in a single bin. This streamlined approach allows for the sorting, washing, and subsequent return of reusable containers to supermarkets.

II. Home delivery refills

Home delivery refills involve delivering products directly to consumers' homes, either through reusable containers that customers keep or by returning the containers once they are empty. This model works best for high-turnover products and can be operated through an online platform, making reverse logistics easy to manage as there are often frequent trips to the same households to deliver goods and collect packaging from consumers. Several small, local businesses offer such services in major cities, but larger retailers could potentially adopt this business model and offer it to their regular online shoppers. The recent increase in online shopping makes this model more viable to retailers; a company strategically placed to do such is Ocado, who are the biggest retail platform of its kind in the UK and have a regular customer base.

For this model to be economically feasible, businesses need to develop robust supply chains with integrated reverse logistics systems. This could include implementing integrated reuse and recyclable collection systems. An additional step may be necessary to de-label and re-label packaging once it has been returned to the store. While this model has potential, it also faces challenges such as the need for reliable transportation, the risk of product leakage, and the cost of developing and maintaining the necessary infrastructure.

III. Subscription services

Subscription models operate in a similar way to home delivery models but require consumers to sign up to a subscription service. Such models allow for regular collection of reusable packaging but have similar challenges to those outlined in home deliveries.

IV. Prefill products

Prefill schemes are one of the more attractive options as they address many of the challenges faced in traditional refill systems, such as health and safety concerns and the need for consumer behavioural change. It can also be applied to large supermarkets and convenience shops. This model requires an integrated logistic network with take-back schemes that do not require any changes in

Case study #5:

Looping big brands

One of the most popular prefill collaborations have been Loop's partnerships with Unilever and Tesco (35). Tesco reports that pre-fill models have been the most successful trail with consumers (36).

These trials have highlighted that a shift in consumer behaviour is needed for any reuse model.

consumer behaviour, such as integrated reuse and recycling collection, and washing and cleaning processes. A notable illustration of such a setup is the traditional milk delivery system from farms in the UK.

V. Small scale closed loop systems: Events

Refillable packaging has also been successful when a closed-loop system can be more easily implemented, e.g., at closed events such as concerts, sports matches, and other community gatherings, with three in four music festivals now using reusable cups (37). The 'Refill' campaign is widespread throughout the UK and has been successful in several festivals and carnivals.

Case study #6

Collaboration towards refill

In the UK, refill experts at Unpackaged lead 'The Refill Coalition', a partnership involving major UK retailers (M&S, Morrisons, Ocado, Waitrose & Partners) to trial more circular supply chain solutions in the form of innovative refill stations (for both in-store and online purchases) (38).

The main aim of the initiative is to reduce single-use plastics through incentivising behavioural change in consumers. 'Big box' supermarkets are the most ideal candidates for promoting refill and reuse options, as smaller shops which are geared towards 'speedy shoppers' will likely favour convenient, single-use packaging.

Key challenges in reverse logistics

When considering the move towards integrated refill/reuse systems, the logistics become more complex and more difficult to control the movement of packaging materials. This is due to uncertainty surrounding collection, cleaning and redistribution infrastructure and processes to send packaging back to the correct retailer or brand owners. For the successful implementation of an open refill/reuse system, consumers need to see value in the packaging they use, or disposal will become the more convenient and more frequently utilised option. Currently, the packaging value chain is vastly linear at large scale, with few examples of circular behaviours in smaller-scale, local refill shops (with dedicated customers) or trials in chosen supermarkets.

Secondary packaging[6] is another crucial aspect that requires attention. Nestlé has highlighted that 70% of their packaging demand is attributed to secondary packaging, making it a higher priority in terms of volume compared to primary packaging. Suggestions from stakeholders included the reuse of secondary packaging, such as transit packaging. Transit packaging has the benefit of not requiring the aesthetic nature of primary, consumer facing packaging so manufacturers can focus on functionality. Logistics also favour switching from single-use transit packaging, with reverse logistics providing an opportunity for retailers and suppliers to exchange empty/full transit

[6] Secondary packaging serves the role of securing multiple units of goods during transportation to retailers.

packaging (though additional complications arise when multiple deliveries are made in one journey).

Associated behavioural change

In recent years there has been an increase in consumer interest towards reusable and refillable purchasing options. This is part of the global shift towards more sustainable products, with most packaging boasting environmental credentials as a lever for advertising (for both the product and the packaging materials). Regardless of the additional 'effort' associated with reuse and refill, stakeholders have highlighted that it is often cheaper for the consumer to purchase the equivalent product from bulk stock in a reusable container versus the equivalent amount in single-use packaging. Therefore, refill and reuse opportunities are likely to be considered on a case-by-case basis.

Education is often seen as a trigger for instigating behavioural change, but campaigns can only go so far. Consumers often 'stick with what they know'. There needs to be a 'push' or 'pull' metric to incentivise or even force change, with minimal consequences such as a surcharge or additional waste charges. Incentives to reduce packaging have been seen before, e.g., in 2015 with the 5p charge added to plastic bags in supermarkets to disincentivise use and reduce plastic pollution. This was highly successful and has since resulted in a 95% decrease in bags sold by major supermarkets in the UK (39). Furthermore, some charges from bag purchases also contribute to good causes (40). However, there are often unintended consequences to such movements. In this case, whilst the benefits are apparent, retailers saw some consumers shift their view of 'single-use' from the thin plastic carrier bags (a relatively low-carbon option in terms of the production process), to thicker and more material-intense bags-for-life (25). This is also a risk for the shift to reusable and refillable food and drinks packaging, combining a single-use mindset with a more carbon-intensive reusable material. The challenge for the packaging industry is how to ensure that the single-use mindset does not carry forward, and UK consumers recognise value in their packaging materials.

5.2.1. Opportunities for innovation

Table 2: Summary of challenges surrounding the implementation of reuse/refill schemes, and their respective potential solutions.

Key challenges	Potential solution through innovation	Type of innovation
Identifying which products will benefit from a refill/reuse system from a carbon perspective	Small scale **trials** of potential candidate products.	**Research**
Developing integrated take-back/collection schemes through logistics routes and existing recycling streams.	**Reverse logistics trials** for refillable/reusable containers for high-turnaround products purchased through online shopping. **Digital tagging (e.g., PolyTag)** of reusable packaging to easily separate it from recyclable packaging.	**Research** **Systems/ technology improvements**
Removing the single-use mindset of consumers	Identification of key **incentives** which build appetite for refill/reuse in consumers.	**Consumer intervention**

5.3. Expanding kerbside recycling schemes to include flexible films.

Recycling is a crucial component of the waste hierarchy as it can reduce the impact of waste disposal, as well the need for virgin materials, energy consumption, and associated carbon emissions. In addition, recycling maximises the value of the material in the system, with all non-compostable materials in theory reaching the recycling phase at end of life i.e., reusable packaging will eventually become damaged or worn and need to be recycled. Supported by key legislation such as the Packaging Waste Directive, the Plastics Packaging Tax, and the proposed pEPR scheme, recycling is a significant area of interest for manufacturers, brand owners and retailers.

Efficient recycling systems require the industry to focus on three key areas:

Design for recycling

This is the focus on designing packaging so that it is easier to recycle and involves considering the whole lifecycle of the product. The key principles of this include material selection and simplifying design. One such example is Colgate's innovation on the traditional toothpaste tube. Their new tube is primarily made of HDPE, and the cap is made of polypropylene, both of which can be disposed of in normal kerbside collection bins (41). This tube has the same functionality and purpose as the original design, but its material composition has been simplified. Movement towards simpler designs with easily separated components and widely recyclable mono-material packaging will make recycling easier for consumers and ensure that 'wish-cycling[7]' is kept to a minimum. This is a key focus for UK retailers, with many of them designing recyclable packaging for kerbside collection.

[7] Wish-cycling is (for example) placing an item into a recycling bin in the hope of it being recycled, when in fact, it may not or cannot be recycled.

Identifying recyclable material replacements that are both functional and fit the purpose of the packaging is critical and often a key challenge for the industry. One such example is the role of metalized film in food grade packaging that is used to keep food fresh for longer. With food waste as the priority, materials such as these are likely to continue to be used as they serve a critical purpose. However, metalized film currently cannot be recycled in kerbside bins and only some can be recycled in-store if the metalized proportion meets a threshold of less than 10% by weight of the package (42). Organisations such as TerraCycle work with problematic waste to increase the recycling rate of such packaging.

Recycling infrastructure

Recycling is important for the packaging sector since it cuts waste and conserves resources. Recycling helps keep packaging waste out of landfills and incinerators. In the UK, the current recycling rate for packaging is 44% (43).

In general, kerbside collection bins collect paper, cardboard, plastic bottles, metal cans, and cartons, although some of these may vary depending on the local authority. To communicate what can be recycled in an easy, clear, and concise manner, the On-pack Recycling Label (OPRL) (44) offers a simplified way of informing consumers if something is recyclable. It indicates if an item is recyclable, if it can be recycled in store, whether you need to check with your local authority, or if something is not recyclable. The label is either coloured green (for recyclable) or black, as shown in Figure 6 (44). Customers frequently find the distinctions in local recycling categories confusing since they are unsure of the types of recycling material that their local municipality will accept. There is an opportunity for harmonisation across different local authorities to place less burden on consumers.

Figure 6: OPRL labels on packaging

OPRL currently has over 750 members, with 130 of them joining in 2022 (44). This system is described as the global best practice, and while it has a significant impact on recycling rates, there is still a lot that needs to be done. Currently, there is a large burden placed on the consumer to ensure that they place the correct packaging in the recycling bin and that they bring recyclable material to the store with them the next time they shop. However, some stakeholders highlighted that recycling needs to be made as easy as possible for consumers, especially for those who do not read the labelling. This would

mean including flexible film in kerbside collection and developing sorting techniques that can pick up film packaging.

Infrared and ultraviolet (UV) labelling can help with the sorting of recycling waste by enabling automatic sorting technologies to accurately identify and separate different types of materials. This can improve the efficiency and effectiveness of the recycling process, ultimately leading to more recycled materials and less waste going to landfill.

When considering the recycling infrastructure, a large portion of technical innovations are in the form of new technology within Household Waste Recycling Centres (HWRCs) or Material Recycling Facilities (MRFs). Novel sorting technology can differentiate between materials including different forms of plastics and whether the material is food-grade. Enabling recycling of food grade polypropylene (PP) was highlighted as an area for further research via our stakeholder engagement. There is difficulty in distinguishing between food-grade and non-food-grade PP, limiting supplies of recycled food grade PP content. Due to the implementation of the Plastics Packaging Tax, many businesses producing this type of plastic need to pay the tax to comply with legislation.

Case study #7:

AI driven sorting (45)

FCC Environment and re3, have successfully installed an AI-powered waste picking system to remove contaminants from the plastics streams.

This innovation increased yield and resulted in a greater quality output.

The Smart Sustainable Plastic Packaging Challenge (SSPP) run by Innovate UK also highlighted the scale-up of this recycling stream as a challenge for the packaging industry (46). Examples of innovations contributing to increasing recycling rates in these currently hard-to-recycle streams are radio frequency identification (RFID) tags attached to packaging, infrared radiation (IR) equipment installed in recycling facilities to add an extra layer of material detection, and ultraviolet (UV) labels to access information for recyclers which is hidden to the naked eye.

Whilst there is scope for improving recycling facilities and infrastructure in general (e.g., ensure accessible collection points for waste), there is still a need for consumer education to ensure packaging is disposed of correctly.

Recycled content

Although increasing recycled content in packaging is a key goal outlined in both legislation and other initiatives, there are several challenges that need to be addressed. These

include meeting the required flexibility or strength, ensuring availability of recycled material at scale, managing costs, and addressing contamination for food-grade material. Despite these challenges, incorporating recycled content can significantly reduce the carbon impact of packaging by reducing the need for virgin resource extraction. To achieve this in the food and beverage industry, sorting processes need to be able to effectively separate food-grade packaging from other packaging to minimize contamination. Most materials can be processed or recycled, given access to the infrastructure required to recycle it. The limiting factor for recycling often revolves around cost, logistics and provides opportunity as an areas of focus for industry.

Another initiative to increase recycling rates is the introduction of a Deposit Return Scheme (DRS), where a small deposit is added to the product at the point of sale, with the deposit returned to the customer upon return to a designated collection point. DRS aims to tackle end-of-life packaging issues, including littering; Zero Waste Scotland report that £62 million per year is spent to tackle direct and indirect effects of littering, which is likely to reduce dramatically with the launch of its DRS for metal and plastic drinking containers in August 2023 (47). The likely benefits of DRS include the potential for reducing littering, increasing recycling rates, and incentivising behavioural change.

There must also be considerations towards the unintended consequences of the scheme. The Co-op have highlighted that most of their stores are smaller, 'quick grab and go' type shops, with low profit margins on own brand products. The DRS scheme requires the purchasing of large and expensive reverse vending machines. Not only is this a cost burden to some small retailers and independent businesses, but there is also concern over space and the reverse vending machine may displace existing recycling collection points or retail space (such as the frozen food section). Whilst the space issue may be of higher concern to the smaller 'Co-op sized' stores, this is a shared concern amongst many retailers (48). There is emerging innovation in the form of 'Digital DRS', where consumers' phones act as a digital reverse vending machine, which pioneering companies such as 'PolyTag' have shown to be successful in multiple pilot schemes. This new technology would remove concerns of retailers, utilise local authorities and kerbside collection, as well as build upon the convenience driver of consumer behaviour.

Associated behavioural change

Encouraging consumers to correctly recycle is a challenge as it requires a behavioural change and awareness of what can and cannot be recycled. Although labelling changes highlight the recyclability of packaging, it is a challenge to break existing patterns of waste disposal.

Nudge culture[8] has been recognised as an effective way of encouraging people to change their daily habits. This involves using subtle ways of persuading people to recycle, including strategically placing collection bins in areas with high foot traffic, along with reward systems or incentives to encourage people to recycle. Gamification can be used to make recycling more enjoyable through competitions or interactive recycling bins.

Some stakeholders have highlighted that consumer behaviour is only likely to change if there is a financial penalty for incorrect disposal. Prominent examples include consumers having to pay for carrier bags at their local supermarket. In South Korea, financial incentives are used to encourage households to recycle, where households are taxed based on the size of the household and the amount of waste generated, with discounts offered to households that recycle their waste (49).

5.3.1. Opportunities for innovation

Table 3: Summary of challenges associated with increasing the recycling rate of packaging materials and improving the recycling infrastructure, alongside their respective potential solutions.

Key challenges	Potential solution through innovation	Type of innovation
Harmonisation across supermarkets and local authorities for kerbside collection	**Reducing the variance** of where packaging can be recycled to ensure all recyclable material can be disposed of in kerbside collection bins.	**Systems improvements**
Improvements on segregating collected waste	New **sorting technologies** with the ability to separate plastic types and other materials.	**Systems/ technology improvements**
Enabling the consumer to see the value in their packaging	**Reward systems** to encourage recycling.	**Consumer intervention**

[8] Nudge culture is concept where we can alter people's behaviour in a predictable way without forbidding them to choose other options.

6. Outlining opportunities for packaging innovation

Across these three demands, stakeholders identified key innovations that can help the industry decarbonise. These different innovations are summarised below:

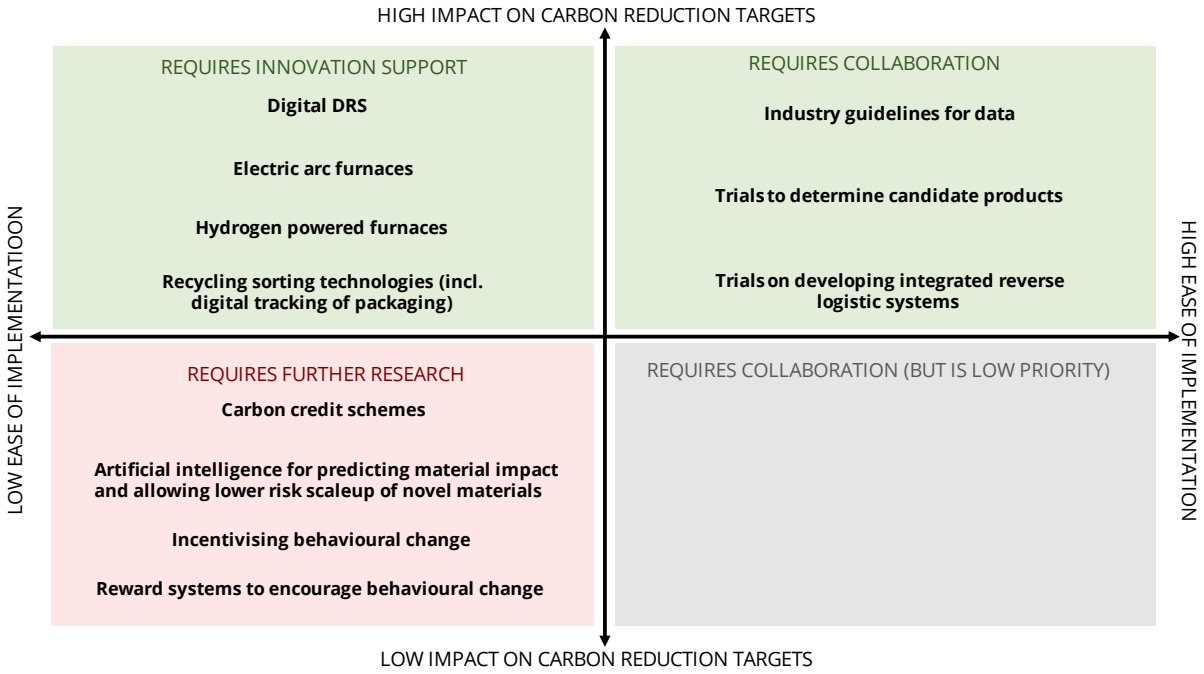

Figure 7: Potential impact of different innovations discussed

Each innovation has been mapped out on a 2x2 matrix and categorised against two criteria based on insights from stakeholders: the innovation's impact on reducing carbon emissions and the ease of implementation. This analysis identifies hotspots for innovation and collaboration (the two quadrants highlighted in green).

The innovations that lie in the top two quadrants could be prioritised from an innovation perspective as these are likely to have the greatest impact on carbon reduction targets. Figure 7 also highlights stakeholder views on the difficulty in focusing on behavioural change to reach net zero, being both hard to implement, and having a low impact on carbon reduction. Stakeholders have emphasised that any innovation needs to be "simple, convenient and consistent" to have any impact on the industry.

Our investigation highlighted that achieving a decarbonised packaging sector requires collaboration and harmonisation across the Government, the waste sector, the different retailers and brands operating across the sector.

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