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RESEARCH ARTICLE

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Understanding the views of the UK food packaging supply chain in order to support a move to circular economy systems

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This study set out to better understand the feelings of stakeholders from the UK food packaging supply chain towards a move to circular economy (CE) systems. The research areas studied included current and future challenges facing supply chain stakeholders, the consideration of transformative technologies (TT) to enable packaging solutions in the move to CE systems and what CE systems using TT would look like for the UK's chilled food packaging sector. A questionnaire was selected to obtain data from across the UK food packaging supply chain. Participants were selected from six industry stakeholder groups, with 24 completing the questionnaire. This study has clearly shown there is a large spectrum of solutions in a move to CE, each with their own benefits and limitations. TT has an ability to enable these, but in selecting the best one for a specific packaging solution, a decision maker must take into consideration business constraints of the supply chain and the consumer's behaviour towards new solutions.

KEYWORDS

circular economy, consumer behaviour, FMCG packaging, transformative technology

1 | INTRODUCTION

Food is the largest packaging end-use sector in the United Kingdom, representing 36.6% of overall sales in 2015 [1]. From design conception to end of life disposal, food packaging goes through a complex lifecycle, alongside the product's lifecycle, involving multiple stakeholders. Important decisions must be made at each point in the packaging lifecycle (Figure 1) to ensure that the pack safely and efficiently performs, minimizing the waste of both packaging and food materials.

Globally, the food packaging industry is seeing vast change in the range of food products being sold, how they are manufactured, and how they are protected and presented by packaging. This has been driven by technology, cultural change and the economy [2]. A key current focal area, driven from both consumers, and within the industry, is the need to move to circular economy (CE) approaches for the delivery of chilled fast-moving consumer goods (FMCG) packaged food. This is a vast change from the current supply chain model, which are characterized by linearity (take-make-dispose patterns), that have been the dominant production system for the last 150 years [3,4]. FMCG are nondurable retail products including food, beverages, personal care, furniture, textiles, household care, and packaging goods that are bought frequently, are cheap, and typically have a shorter service life than durable goods [4]. It has been found that while food, beverages, clothing, and packaging account for approximately 35% of materials used globally, around 80% of the materials used for FMCG end up in landfills, incinerators, or wastewater [4].

Transformative technologies (TT) has been discussed in literature as an enabler to developing CE solutions within the FMCG sector [4]. The focus of this paper is to explore the views of UK packaging stakeholders on whether TT can enable the adoption of CE (plastic) packaging systems within the United Kingdom's chilled convenience food supply chain, overcoming the sustainability challenges from government and consumers.

FIGURE 1 UK food packaging supply chain model

2 | LITERATURE

2.1 | Moving towards CE systems within FMCG food packaging

This section assumes a working knowledge of CE thinking and concentrates on CE issues within the food packaging sector.

2.1.1 | Global and local targets

The need to move to more sustainable food life cycles is supported by several global and local goals and targets. On a global scale they factor in the United Nation's Sustainable Development Goals (SDGs) [5] and The European Commission's Circular Economy Package [6]. Within the UK, Department for Environment Food & Rural Affairs (DEFRA's) environment plan includes increasing resource efficiency and reducing pollution and waste. This policy is directly related to packaging, with a key aim being to "make sure that resources are used more efficiently and kept in use for longer to minimize waste and reduce its environmental impacts by promoting reuse, remanufacturing and recycling," [7]. However, the ambitions are vague, with no values or legal requirements for businesses to adhere to.

There has also been a government call for a cross-sector plan for plastics following public concern over packaging, alongside the announcement in 2017 that China plans to ban imports of 24 grades of waste materials including plastics [8]. Among the minister's goals reported after an industry round table on 1 December 2017 are greater recycling and recyclability and more incentives for producers and consumers [9]. In December 2018, the UK government published "Our Waste, Our Resources: A Strategy for England." Their goal for the strategy is to "maximize the value of the resources we use, minimize the waste we create, cut emissions and help create a cleaner, greener, healthier planet."[10] They aim to focus on "known problems" looking to "reduce our reliance on single-use plastics, cut confusion over household recycling, tackle the problems of packaging,"[10] while also addressing food waste and waste crime.

The packaging industry is likewise facing pressure from nongovernmental organisations (NGOs) such as The Waste and Resources Action Programme (WRAP), World Economic Forum (WEF), and the Ellen MacArthur Foundation (EMF), who recently published *The New Plastics Economy: Catalysing Action* [11]. All are advocates of improving recyclability rates and promote the use of recycled materials in packaging. Recently, they have collectively driven the UK Plastics Pact, a voluntary agreement with 42 signatories from large companies (responsible for 80% of the United Kingdom's plastic packaging use), which (among others) aims to move to 100% recyclable packaging and 30% recycled content by 2025 [12].

2.2 | The New Plastics Economy: CE approaches

The vision of the New Plastics Economy offers a new way of thinking about plastics as an effective global material flow, aligned with the principles of the CE [13]. The system diagram (Figure 2) illustrates the continuous flow of technical and biological materials through the "value circle" [14]. Niero et al[15] believe that the packaging sector and packaging waste management should be given high priority in the CE agenda. They explain, using research completed by Hopewell et al in 2009, that "packaging is, by its nature, transient. Most one-way packaging is discarded after use, entering the waste stream after a use period of typically less than a year."[16] One of the main principles of the CE as stated by de Koeijer et al[3] is "waste equals food," which relates to cycles in which recycling can occur without loss of quality. The continuous material cycle concept is of primary importance for packaging development [3].

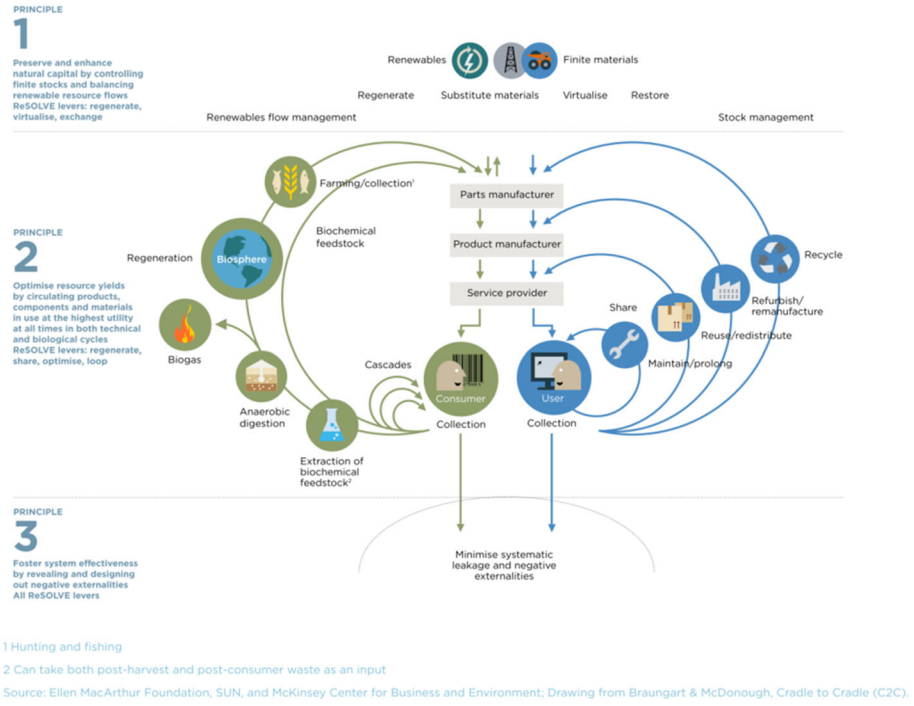

FIGURE 2 Outline of a circular economy [11]

Many innovations and improvement efforts show potential, but to date, these have proved to be too fragmented and uncoordinated to have impact of scale. Existing studies focus on packaging minimization. The aim of such studies is to rationalize material use, therefore decreasing the pressure on finite raw material sources and ultimately reducing the impact on the environment. In doing so, packaging designers must remain mindful of a pack's functionality: to protect, preserve, and promote the product inside. Svanes et al[17] disagree, emphasizing that a long-term sustainability strategy for packaging should not be based solely on material minimization. They believe the focus must be on packaging optimization in terms of environmental sustainability and that consideration must also be given to the pack's distribution costs, market acceptance, and user-friendliness. In overcoming these drawbacks, an opportunity beckons; using innovation in plastics technology to move the packaging industry into a positive spiral of value capture, including economic benefits and better environmental outcomes[13].

2.3 | Approaches

In order to move towards a CE, there is a need for new approaches, skills, and knowledge throughout the supply chain. De los Rios and Charnley state that "A variety of new capabilities are key to design for a sustainable future. These range from deeper knowledge of material composition to rich understanding of social behaviour." [18] The WEF (2017) suggest three transition strategies to accelerate a shift towards CE thinking, see Figure 3 (*Note*. these are based on global packaging value chains, not specifically the UK chain or to FMCG packaging) [11].

Following a conference held in April 2016 by global sustainability services provider Anthesis and ThePackHub, attended by representatives across the packaging sector, some common themes emerged. First, the need to consider sustainability as a mainstream business consideration, but also recognition that cross supply chain collaboration, and engagement with stakeholders beyond the normal business supply chain (such as waste collection, recycling, and reprocessing sectors) will be essential to meet many of the waste-related sustainability targets [15]. This is supported by the United Kingdom's 25-year environment plan where DEFRA suggest the "need to make data more available to support processes such as industrial symbiosis—ie, where two or more industrial facilities or companies join up and the wastes or by-products of one become the raw materials of another," [7] and through the launch of the Plastics Industry Recycling Action Plan (PIRAP) developed to establish cooperation across the entire waste plastics supply chain [19].

Niero et al[15] propose that a systems approach is required, with connections among all the stakeholders in the value chain, from suppliers to recyclers, and with repercussions at different levels, from technology (eg, recycling technology) to logistics and waste management as well as for different actors (ie, customers and consumers) [16].

2.4 | TT as an approach

Advancements in technology that impact the packaging industry have become more innovative, robust, and widespread recently and can often play a dual role in preventing unwanted circumstances and propelling new opportunities for sustainability. Stakeholders within

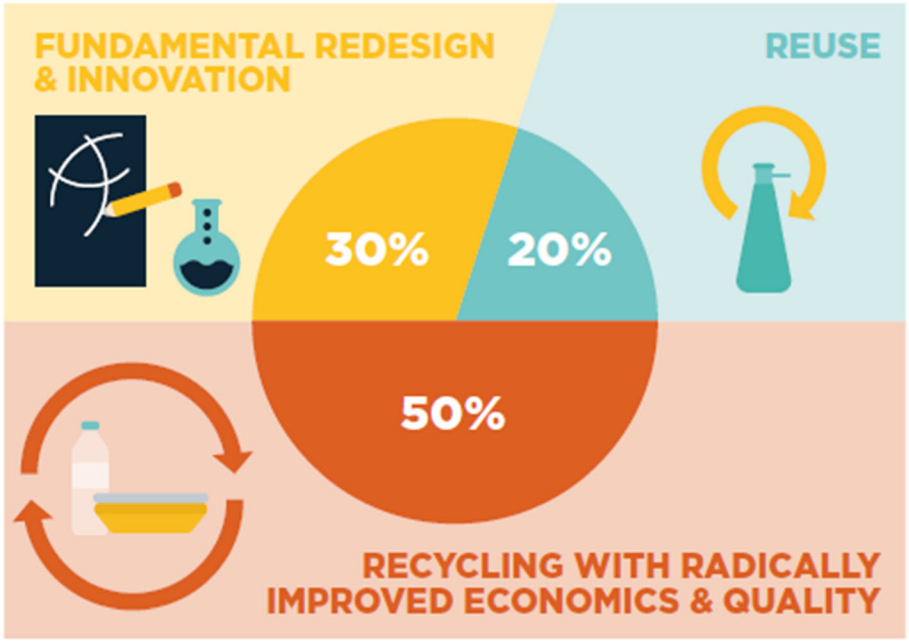

FIGURE 3 Three distinct transitions strategies to accelerate the shift towards the new plastics economy (share of plastic packaging market by weight) [11]

packaging supply chains are continually looking to connect innovation to opportunity to develop creative and sustainable packaging that minimizes waste. In their book *Waste to Wealth*, Lacy and Rutqvist divide these so called "transformative technologies," which can create an advantage in a CE into three groups,[20] see Figure 4 as follows:

1. Digital Technologies.
2. Engineering Technologies.
3. Hybrid Technologies.

Transformational technologies can reduce waste, improve performance, and change and develop relationships with consumers. Further opportunities and benefits of using TT found within literature are outlined in Table 1.

2.5 | Limitations of TT

However, literature also highlights some limitations to using TT in a move to CE systems. For FMCG products with low environmental impact, investments in these technologies may be too high from both economic and environmental perspectives. The "functional positives of the technologies may be outweighed by the costs." [25] It is also important to "monitor and manage any possible negative effects of new technologies on packaging recycling" (*ibid*). Richard Hughes

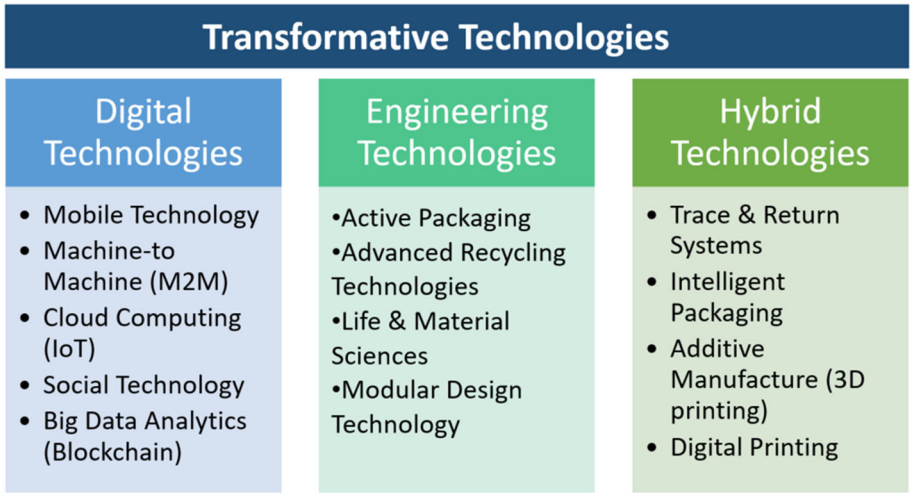

FIGURE 4 Defining transformative technology groups (adapted from Lacy and Rutqvist [21])

TABLE 1 Opportunities and benefits of using TT

Opportunities and Benefits of Using TT	Reference
Allow real-time information exchanges among users, machines, and management systems.	Lacy and Rutqvist[21]
They're intrinsically customer-focused and provide the connections needed to maintain a relationship far beyond the point of sale.	Lacy and Rutqvist[21]
Enhance remote visibility and control of assets	Lacy and Rutqvist [21]
Alter way we interact with physical and digital assets	Lacy and Rutqvist[21]
Enable Dematerialization—Can ultimately transform value chains so they no longer need additional resources to grow.	Lacy and Rutqvist[21]
Cost-effective solutions for collecting, returning, and processing goods and materials for recycling and remanufacturing.	Lacy and Rutqvist[21] (p.140)
Encoding information about ingredients in the materials themselves, in a kind of "upcycling passport" that can be read by scanners and used productively by future generations.	Braungart et al[22] (p.178)
Used to encourage perceptions of material value	World Economic Forum[13]
Using renewable resources, carbon-efficient manufacture, refillable packaging, recycling data, and systems thinking approaches with the ultimate aim of a move to socio-technical systems innovation	Ceschin et al[23] and Gaziulusoy and Brezet[24]

concludes in his conference paper, *The EU Circular Economy package—life cycle thinking to life cycle law*, "How then can the Life Cycle Engineering (LCE) community ensure that the expected revolution expected to be brought about by both the "Internet of Things" and "Industry 4.0" deliver the European Commission's goal of creating a CE in the years to come? [25]

2.6 | Sustainability challenges facing the UK food packaging supply chain

The UK plastic packaging industry is currently facing a number of challenges alongside the general packaging challenges of food waste reduction and shelf life extension. These can be divided into economic, environmental, and social challenges, and some of these as found in the literature are presented in Table 2.

Niero et al[15] highlight the additional challenge "attributed to the increasing web of material producers, packaging component manufacturers, packaging equipment suppliers, users, retailers, and waste recovery facilities and reprocessors that might have different priorities and interests." [16] Brouwer et al[31] go onto explain that the current "open loop recycling" approach used is far from The New Plastics Economy's proposed ideal of circular global plastics economy, where there is an "effective after-use market for plastics and improved qualities of the recycled plastics" collected [31]. Currently, the "composition of sorted plastic packaging products is described with broad specifications" leading to "blended materials" of reduced quality and with increased contamination due to the complex nature in which packaging materials have been used. The importance of consistent waste management systems is essential to a CE system, with Brouwer et al[31] explaining that "the complexity in the current recycling network thus makes 'cradle to cradle' or 'closed loop recycling' nearly impossible."[31] The authors therefore believe that it is difficult to apply conventional terminology or frameworks such as cradle-to-cradle, closed loop, open loop, upcycling, or downcycling to the complex reality [31].

TABLE 2 Current challenges facing the UK Plastic Packaging Industry in 2018 [7,11,19,26-30]

Economic	Environmental	Societal
Vulnerability of changing market conditions	Pressure to move from finite to renewable raw material sources	Poor value perception of plastic packaging
Changes to legislation and tax systems	Reliability of supply of postconsumer recyclate	Growth of value retail mindset
Commercial viability of single use plastics	Quality of postconsumer food grade plastic	Consumer perception of packaging vs food waste
Pressure for improved packaging line efficiencies	Traceability of recycled material through reprocessing cycles	Pressure to be plastic free by consumers and the media
Squeezed price margins	Plastic reprocessing capabilities and capacity	
Constant change of percentage packaging costs in relation to retail unit price	End of Life considerations for flexible films	
	Pressure to move to cyclical material flows while protecting food throughout the lifecycle	

Although briefly considered by De Koeijer et al[3] and Niero et al,[15] another issue rarely discussed in literature is the impact moving towards CE approaches will have on the UK consumer and what they will be willing to adopt [32,33]. The sometimes-conflicting nature of consumer behaviour and convenience lifestyle trends can create a challenging conundrum for the food packaging supply chain. These examples act to further highlight the consumer as a key stakeholder and the importance of fully understanding consumer behaviour towards packaging and food waste to develop systems that will work for all actors in the supply chain [33].

2.7 | Conclusions to literature

The literature review supports the need to move towards a CE within the UK FMCG food packaging industry. It has highlighted the rapid development of TT which could change the way we interact with everyday plastic food packaging and consider its future use within a CE. However, further exploration of the challenges and opportunities for stakeholders within the FMCG food lifecycle is needed to fully understand the landscape before goals can be set.

The literature has also emphasized the need to reduce household food waste as a priority area and an additional challenge to the food packaging industry of a tax or ban of single-use plastic packaging in the United Kingdom alongside the need for plastic packaging to move from a linear to CE. Secondary research has shown that there is currently a gap in knowledge relating to consumer behaviour towards CE packaging solutions, their willingness to adopt new system approaches, and their understanding of the environmental benefits, both in reducing packaging waste and food waste. An awareness of these consumer issues within the food packaging industry will be one focus area for this study. Expanding on this, there is little research in this field for how designers can use TT, while considering consumer behaviour in the design of plastic food packaging solutions for the CE.

Therefore, the aim of this study was to improve the understanding of the views of stakeholders from the UK food packaging supply chain (excluding consumers for this study) towards a move to CE systems. The research areas discussed in this paper include the current and future challenges facing supply chain stakeholders in a move to CE goals, the consideration of TT as enablers in the move to CE systems, and the impact of consumer behaviour when designing for CE systems.

3 | MATERIALS AND METHODS

This study aims to explore industry stakeholders' feelings towards a selection of food packaging industry related topics, explicitly asking the following:

1. What are the challenges facing the UK food packaging industry at a government, supply chain, and consumer level?
2. How can TT be used to enable packaging solutions implemented in a collaborative CE food supply chain?
3. What do CE systems using TT look like for the United Kingdom's chilled food packaging sector?

A questionnaire was selected as the best tool to obtain data from across the UK food packaging supply chain [34] in order to gain a broad understanding of the research area from multiple stakeholders. Related questions were grouped together in the relevant research question themes. Participants were selected from across six industry stakeholder groups as shown in Figure 5, using the researcher's prior knowledge of professionals within the UK food packaging supply chain. Invitation emails were sent to 30 industry professionals, with

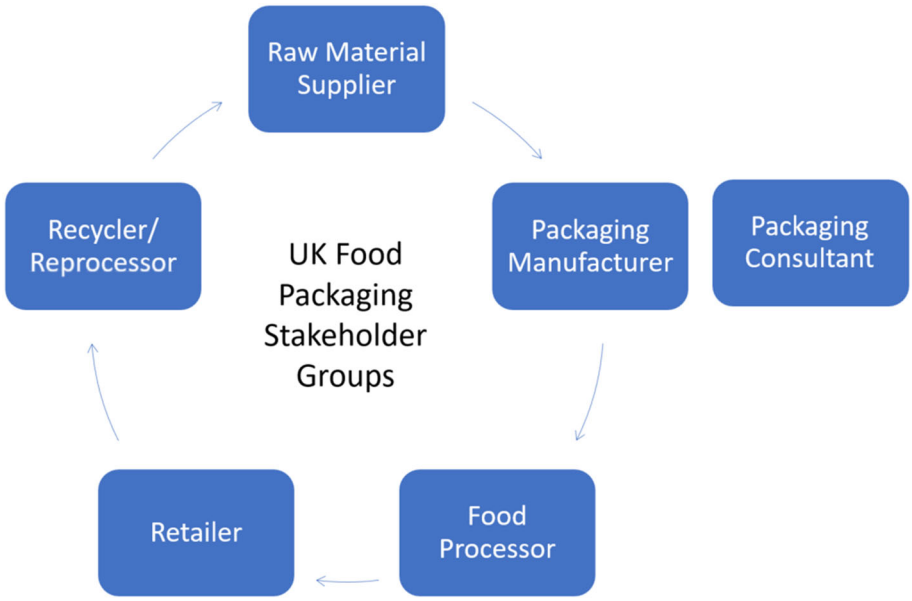

FIGURE 5 UK food packaging stakeholder groups

24 completing the questionnaire. The questionnaire layout and the understanding of the wording were pretested with two industry professionals prior to conducting the final questionnaire.

Each section contained a series of questions to gain both quantitative and qualitative data from the participant. Quantitative questions used either importance ranking from 1 to 8 with 1 being least challenging and 8 being most challenging, nominal data selection tick boxes or a 5-point Likert item scale ranging from 1 (*not at all important*) to 5 (*very important*). Qualitative data was obtained by either asking the participant for a one-sentence answer to a question or asking them to complete a predefined sentence.

Section A focused on collecting data to answer the research question: What are the challenges facing the UK food packaging industry at a government, supply chain, and consumer level? Section B asked questions to answer the research question: How can TT be used to enable packaging solutions implemented in a collaborative CE food supply chain? These sections comprised of six questions. Section C comprised of seven questions, with the intention of collating answers to the research question: What do CE systems using TT look like for the United Kingdom's chilled food packaging sector? Section D collected information about the participant. All of the participants names were anonymized during the analysis stage using an identification code. A full copy of the questionnaire can be found as a supplementary file.

Quantitative data was analysed using SPSS. Variable fields were used for each answer category with answer codes entered into the dataset against the participants ID code. Frequency tables and graphs were used to analyse the data output.

Qualitative data responses were initially grouped into subject themes to give an overview of the pattern of answers to the researcher. A full thematic analysis of the qualitative answers was conducted with each response being coded against a subject topic from the literature review. "The process of coding is part of analysis (Miles and Huberman, 1994), as you are organizing your data into meaningful groups (Tuckett, 2005). However, your coded data differ from the units of analysis (your themes), which are (often) broader." [35] By completing the process, clear groupings of themes in the participants' answers were found and research knowledge gaps were identified.

4 | RESULTS

The questionnaire was completed by 24 UK food packaging supply chain professionals. The split of respondents by stakeholder group and job function can be seen in Table 3.

4.1 | Analysis of challenges facing the UK packaging industry

When asked to explain the challenges currently facing their UK business in 2018, the participants gave a range of answers which were thematically analysed and grouped into economic, environmental, and social challenges, see Table 4 for further detail.

This paper focusses on the challenges of understanding and responding to consumer behaviour with chilled food packaging in a move to a CE. The results relating to these subject areas will be reported in more detail in the following two sections.

TABLE 3 Split of scoping study participants by Stakeholder Group and job functions

Stakeholder Group	Number Participants	Job Function	Number of participants
Raw Material Supplier (carton board)	2	Research and Development	2
Packaging Manufacturer (carton)	4	Technical	8
Packaging Manufacturer (rigid and flexible plastic)	4	Sales and Marketing (inc. buying)	7
Food Processor	4	Sustainability	3
Food Retailer	4	Packaging Manager/Consultant	4
Recycler/Reprocessor	2		
Packaging Consultant	4		

TABLE 4 Future challenges facing the UK Food Packaging Supply Chain in 2018

Economic Challenges	Environmental Challenges	Social Challenges
Impact of rising costs on level of industry investment	Packaging material considerations including legislation changes	The impact of reducing packaging on food safety and security
Impact of recession on the food retail sector	Uncertainty of what is meant by "sustainable packaging"	Consumer perception of food packaging
Impact of rising costs at home for the consumer	Waste management concerns	Need for better packaging education for consumers

4.1.1 | Consumer behaviour challenges

Participants responses to consumer behaviour challenges facing the industry in 2018 could be split into four main themes as follows:

- Rising costs at home for the consumer.
- Consumer perception of food packaging.
- Changing shopping habits.
- Reducing household food and packaging waste.

The increase in cost of living is of concern to the industry, including the impact it will have on consumers purse strings and their purchasing decision priorities. Participants felt it may also bring a limitation in lifestyle choices due to rising costs at home. The study revealed that the effect of the UK recession on supermarket pricing has brought challenges to the whole supply chain, not just consumers.

When asked to rate the challenge of the media's influence on consumer perception, half of the respondents gave this the highest rating of 8, the most challenging issue facing the UK food packaging supply chain currently. Another 12.5% gave this a rating of 7. This shows the level of concern industry places on how media is currently influencing consumer's understanding of packaging.

Eighteen participants (75%) felt that changing shopping habits was either quite or a very important challenge to their business. These participants were from all stakeholder groups, proving this is a challenge facing the whole supply chain. Those participants rating the category unimportant were from the Food Processor and Retail stakeholder groups.

Seventeen participants (71%) felt that reducing household food and packaging waste was either a quite or very important challenge to their business. Participants from five stakeholder groups felt that the category was very important, they represented; Retail, Packaging Consultant, Packaging Manufacturer (cartons), Packaging Manufacturer (plastics), and Food Processor. Interestingly, three out of four of the Plastic Packaging Manufacturer's rated this category as very important, showing how vital it is to their industry sector. The functional benefits of plastic packaging can play an important part in extending shelf life and reducing household food waste.

The need for better education for consumers came through as a strong theme and challenge facing the industry. The participants agreed on the importance of knowledge transfer from industry to consumer, and that it needs development. One participant stated that "the biggest challenge will be that consumer behaviour will not have changed and consumption will not have abated thus increasing debt and increasing waste," another agreed stating that "education of consumers to the role packaging plays in sustainability is the biggest challenge facing the industry." The study revealed that the industry stakeholders want to improve communication with consumers throughout the supply chain. One stakeholder explained how they want to "fully engage with everyone in supply chain. Share when things go wrong and connect with end of supply chain (consumers)."

Looking forward to 2025, the consumer behaviour challenges raised by the participants include the following:

- Consumer education on the role packaging plays (increase knowledge transfer).
- Changing shopping habits (increased use of mobile technology).
- More choice in shopping methods (increase in omni-channel shopping).
- Ability to attract new customers to brands (improve brand trust and loyalty).

4.1.2 | CE challenges

Half of respondents felt that a move to CE systems could be challenging, giving the category a 6 or above for its level of challenge to the industry in 2018. The respondents from this half came from a range of seven stakeholder groups showing the level of challenge spans across the supply chain. The highest frequency of respondents came from Retail with three participants from this group giving a score in this upper range.

Packaging material challenges was a theme which emerged during the thematic analysis, which included the following considerations:

- Which material to use and justification for selection.
- What is meant by "sustainable packaging?"
- End of life considerations for packaging materials.
- Keeping up with demand for pack innovation within the sector.
- Uncertainty around raw material certification.

The traceability of materials as a challenge to the supply chain received varying levels of response across stakeholder groups. Those scoring a 7, feeling it was highly challenging, came from Recycling/Reprocessor, Retail, and Pack Consultant stakeholder groups; however, there were Retail, Food Processor and Packaging Manufacturer participants who gave a score of 2. One participant went onto explain that the industry has "got to have a means for identification (of materials). Technology can enable this identification and connect material through whole supply chain." The word "materials" used in this study is broad, further research is needed to find out traceability concerns by specific material type to fully understand the challenge facing industry in a move to CE systems.

When asked to rate the challenge of legislation changes on the industry there appeared to be a more equal split about how this will affect the food packaging supply chain with 46% of participants scoring the challenge on the lower scale of 4 or below; however, a quarter of respondents did rate the category on the highest levels of the scale at a 7 or 8.

Responses to the challenge of food waste reduction seemed more split across the stakeholder groups. Of the six respondents who scored the category a 7, three were from Packaging Manufactures

(two plastics, one carton). The remaining three came from Retail, Raw Material, and Packaging Consultant groups.

Looking forward to 2025, the CE challenges raised by the participants include the following:

- Raw material challenges (rising raw material costs, stable supply of recycled materials within the supply chain, the identification of materials)
- Commercial viability of a move to CE systems (ability for business growth, business investment plans, surviving a competitive market environment)
- Traceability of materials through waste streams and the introduction of new renewable materials into existing waste streams
- Carbon and energy used in a move to CE systems
- Sustainable packaging design (what is it, how do you go about it?)
- Risk of increase in waste (both food and packaging)

4.2 | Analysis of how TT can be used in a move to CE systems

4.2.1 | Where in the UK food packaging supply chain can TT effectively reduce packaging waste?

Participants selected which groups, from a list of predefined stakeholder groups, they felt could most effectively use TT to reduce food packaging waste. They could select more than one group. The results, in order of ability, can be seen below in Table 5.

It is interesting to see that in the top four ranking stakeholder groups, three of them are during consumer or postconsumer use. It is only the Packaging Manufacturer from early in in the supply chain cycle, which remains high on the list. This shows the level of importance the supply chain believes TT has to effectively reduce packaging waste at home and during the collection, sorting, and recycling/reprocessing stages. One Retail participant added an "other" category, which was that it "was more about food waste, tracking it properly, shelf life extension and temperature control in the chilled chain."

TABLE 5 Ranking of stakeholder groups who can effectively reduce packaging waste in the UK food packaging supply chain

Rank Position	Stakeholder Group	Percentage of Votes
1	Recycler/Reprocessor	75
2	Waste Collection	71
3	Packaging Manufacturer	71
4	Consumer	67
5	Retail Store	63
6	Food Processor	58
7	Raw Material Supplier	50
8	Distribution Chain	46

4.2.2 | The importance of using consumer behaviour attributes in a move to CE systems

Two thirds of participants answered that they feel a move to CE design approaches is very important for the UK food packaging industry.

When asked to select the consumer attributes that they currently consider during packaging project development the following results, in order of popularity, were revealed; see Table 6. Each participant could select all relevant consumer attributes for their business from a predefined list.

There are a lot of high-scoring categories here, but what is highlighted is that shelf presence is still the most important design consideration. Consumers must be attracted to the pack and product sales targets must be met. "Ease to dispose of" came in joint third place with "Target Consumer Demographic."

Some other notable comments were made by participants. A Food Processor stated they consider shelf life and the use of barriers and materials. A Plastic Packaging Manufacturer focuses on the convenience of the pack with the aim to prevent spillage. A Recycler/Reprocessor stated that this question was not applicable to their sector, suggesting the missing link for this stakeholder group between what they do, and packaging design considerations made earlier in the food packaging supply chain.

4.2.3 | Is using TT a sustainable solution for the UK food packaging industry?

Two thirds of participants answered that using TT is a sustainable solution for the UK food packaging industry. The remaining third were unsure. All participants were asked to explain their response in one sentence. Following the analysis of the responses, three clear themes emerged explaining how the stakeholders feel TT could aid the UK food packaging industry in a move to more sustainable solutions. These themes are as follows:

1. To aid collaboration across the supply chain.
2. Help to reduce waste and increase the value perception of materials.

TABLE 6 Ranking of consumer attributes currently considered during the food packaging development process

Rank Position	Consumer Attribute	Percentage of Votes
1	Impact at point of purchase	92
2	Opening experience	88
3	Ease to dispose of	83
4	Target consumer demographic	83
5	Storage at home	79
6	Ease to pack and transport home	79
7	Repeat usage	63

3. To change consumer behaviour.

The need to grow consumer understanding of the benefits of food packaging came through as a strong theme within the answers given. Participants feel that the functional benefits of TT packaging can be used to help increase the perception of pack value with consumers as well as aid consumer motivation in selection of packaging in the product purchasing decision process. Stakeholders believe that providing education, so consumers can understand the benefits of TT within CE packaging systems, is important. One participant stated they believed "TT could revolutionize how consumers interact with food packaging."

However, the questionnaire responses also highlighted the following considerations to ensure that TT works effectively as a sustainable solution for the UK food packaging industry in a move to CE systems:

1. Need for common goals, correct purpose and clear objectives that the supply chain can use.
2. Input from Government and Legislation in the decision-making process.
3. The speed of industry to react and implement technologies.
4. The possibility that there could be other solutions which provide quicker benefits.
5. The end of life considerations in using technologies and their cost and impact on the recycling process.
6. Assessment of end of life options for Active and Intelligent packaging.

4.3 | Analysis of what CE systems using TT would look like for the UK's chilled food packaging sector

4.3.1 | CE packaging solutions currently being considered within industry

The participants were asked to select which CE packaging solutions their business is using from a predefined list, they could select all relevant categories. See Table 7 for CE solutions in order of popularity.

The last two solutions are very much linked, with refillable packaging often needing to be part of a Product Service System to successfully operate. It is interesting that these are least popular amongst the food packaging supply chain when one of the historically successful, long running refillable packaging schemes was indeed in the food and beverage market sector, milk!

Three participants noted other CE packaging solutions they were considering in their business. A Plastic Packaging Manufacturer is considering "looking beyond existing materials to renewable materials," a Recycler/Reprocessor is researching into Chemical Recycling methods, and a Retailer is looking in more depth at the management of waste.

TABLE 7 Ranking of CE solutions currently being used by stakeholder groups in the food packaging supply chain

Rank Position	CE Packaging Solution	Percentage of Votes
1	Design for recyclability	88
2	Redesign of products	71
3	Reusable packaging	67
4	Refillable packaging	54
5	Systems design	38

Abbreviation: CE, circular economy.

4.3.2 | Analysis of the benefits for the UK to move to CE packaging systems

When asked whether they felt the United Kingdom could benefit from a move to CE packaging systems, 22 participants believed yes it could, while two participants were unsure. When asked to explain their answer the following three themes emerged, each beneficial to the sustainability of the food packaging industry in the United Kingdom. However, there were concerns too, and these are discussed in a fourth theme.

Environmental

Participants believed there was a possibility for short- and long-term environmental benefits if the United Kingdom moved to CE packaging systems. Reducing resource demand and the capture of resource and energy for another use was highlighted by multiple participants as a key benefit. Responses highlighted the importance of developing new packaging materials and that CE systems could drive demand for more food contact-grade sustainable materials.

Reduced packaging waste was another popular response with participants explain how CE systems could lead to improved material traceability and better understanding of material flows through the packaging system, ultimately leading to less waste to landfill. They hoped a move to CE systems could help improve recycling rates of valuable materials, ensuring material resources retain their value within food packaging systems, avoiding material downcycling.

Economic

Responses strongly agreed on the economic benefit for the industry to achieve raw material self-sufficiency through using CE systems. A move to self-sufficiency retains materials within the United Kingdom and reduces reliance on external countries imports. Reusing materials as a nation and putting them back into the UK economy to create an economic circle of material value is seen as a huge benefit and a step towards a new emphasis on making things in the UK post-Brexit.

Participants believe that CE packaging systems could promote packaging as a valuable resource. It would help avoid packaging materials from being perceived as "disposable" and would allow the revaluing of packaging postconsumer use, helping to retain material value. One participant felt that "using a percentage of recycled content could solve some of the current issues faced by the packaging

industry," while others believe in the long-term opportunity of "waste to wealth" if across the industry they could successfully achieve recovery of waste packaging products within CE systems.

Social

It was clear from the analysis that stakeholder groups want to grow consumer understanding and responsibility using CE packaging systems. One participant stating it "gives the public more ability to manage worldwide resources efficiently." As an industry, they believe they need to develop consumer understanding of packaging as a valuable resource that cannot be squandered

Participants in the study also believe that the UK government would benefit from a move to CE packaging systems. It was remarked that the UK government could use the EU CE package to establish CE systems for the country. There could be a benefit from learning from EU nations: sharing CE project success and failure. When asked, only 15 participants were aware of the EU CE package and its implications for UK law. Many participants believe there is a need for UK government and local authority support to implement packaging legislation change in a move to CE systems.

Industry concerns

Although mainly positive in their responses, the participants did also have some concerns about moving to CE packaging systems, and these are presented in Table 8.

4.3.3 | The part technology must play in enabling solutions in a move to CE packaging systems

When asked how much they feel technology has a part to play in enabling solutions in a move to a CE system for UK food packaging, 58% of the participants believe it plays an essential role. Only one participant, a Recycler/Reprocessor, said that technology was unimportant.

All, but one of the participants believed that technology could be used to improve the overall value, quality, and supply of packaging material collected for recycling. The one participant that did not agree with the majority was from the Food Processing industry and answered unsure. All participants then explained their answers. Following a thematic analysis of the explanations given, the following four themes emerged.

Technology to aid the sorting and traceability of material

The participants believe that technology can be used to enable solutions that provide fast and accurate information on packaging usage and disposal by using TT enablers in packaging, which can identify itself postconsumer use to improve the sorting of packaging waste.

Industry stakeholders hope technology could connect packaging material through the whole supply chain using track and trace systems, allowing the verification of materials both for material origin and suitability for future applications. Portals could be developed to help stakeholders understand how materials can be used in multiple cycles of use within a CE system. The participants believe this, connected with an appropriate infrastructure, could help maintain packaging materials value within the CE. One participant suggest that Big Data could be used so the supply chain can course correct as they develop and implement new technologies.

Importance of education, communication, and knowledge transfer

Stakeholders questioned believe that technology can be used as a vehicle for educating about the value of packaging materials throughout the supply chain, including the end consumer. It would allow easier communication within the supply chain and could create an open collaborative environment. Stakeholders could learn from the mistakes of their own business and others in supply chain, especially consumer behaviour and material selection mistakes, as noted by one participant.

Consumer considerations when designing packaging that uses TT

The results showed that stakeholders believe packaging using TT can aid the simplification of consumer identification of materials at point of disposal (in and out of the home), with the use of smart apps to provide convenient, user-friendly solutions.

The participants strongly believed that TT should be used in packaging to improve consumer awareness of packaging's benefits and drive consumer behaviour change to value packaging material and act responsibly when disposing of packaging waste. TT could help engage consumers with a brand in a move to acting more sustainably within a supply chain.

However, it was noted that it needs to be consistent in approach and consider "design for all" principles if these technologies are to be successful on a large scale.

TABLE 8 Industry concerns in moving to CE packaging systems

Cost Implications	Importance of Consumer Behaviour	Unintended Consequences
Financial and environmental cost considerations	Consumer considerations in how CE packaging systems will work	Risk of it resulting in an increase in CO_2 emissions
Cost of implementing versus added value	Consumer pressure could prevail to move away from plastics, therefore no need for CE	Not the be all and end all solution; need for a multi-solution approach
Initially no financial benefits, will take time		

Abbreviation: CE, circular economy.

Technology to develop a new waste recovery system in a move to CE

Responses from this survey clearly highlighted that technology has an essential role in ensuring commercial viability of the recycling value chain and that there is a need for a unified consistent system to gather and process waste. Technology could be used in design to consider the suitability for postconsumer recycling into products. It could also be used in the development of plastic films that are easier to recover and recycle or in the improvement of alternative end of life solutions for packaging materials such as to speed up composting systems or using advanced technologies in the development of chemical recycling.

5 | DISCUSSION

5.1 | Challenges facing UK Food packaging industry at a government, supply chain, and consumer level

The literature review clearly highlighted the current push by NGOs, government, and the media for the packaging industry to move from linear to circular systems to reduce the environmental, economic, and social impact packaging is currently having globally. This was echoed in the study with two thirds of participants feeling a move to CE design approaches is very important for the UK food packaging industry. However, half of participants in this study also felt a move to CE systems was a huge challenge to the industry both in 2018 and looking forward to 2025. Raw material supply, commercial viability of systems, traceability of materials, energy use, sustainable design practices, and the risk of increased waste (both food and packaging) were all raised as challenges facing the industry. These important categories should all be considered when looking to implement a successful CE system in the food packaging industry.

The threat of legislation changes and its impact on the packaging industry was less clear from the scoping study evidence. Changes to packaging legislation were unclear during conducting the study with the *Governments Waste and Resource Strategy for England* published 10 months after the research was completed. The stakeholders surveyed in this study have mixed feelings about how changes could impact their own business. It is also fair to point out that the survey had respondents from both the carton and plastics industry. Plastic packaging currently has a negative perception in the media born from documentaries, such as *Blue Planet*, and future legislation changes which ban or tax the use of plastics [10].

The study showed that the participants in this study agree that a collaborative approach is very important to solve the current challenges being faced by the industry, agreeing that the supply chain needs to work towards a common goal, communicate regularly across the whole supply chain, form working relationships, and transfer knowledge between stakeholder groups.

The media's influence on consumer perception of packaging as raised in the literature review is supported by study findings, with participants giving the challenge their highest rating of concern. The stakeholders were clear on the functional benefits of plastic packaging: promoting its protection and preservation qualities within their responses, both essential for helping reduce food waste in the United Kingdom's food supply chain. Their concern lies with how to communicate this knowledge to consumers and help educate them about the important role packaging plays.

Evidence from the literature review highlighted the inefficiencies of current household waste management systems in the United Kingdom. This was echoed in the study, with stakeholders stressing the importance of improving the consistency of waste management systems for food packaging. The stakeholders interviewed feel consumer's changing shopping habits and a rise in single-households intensifies the need for convenient smaller pack formats. However, they are aware that this may increase the number of packs produced and could lead to a growth in the volume of packaging waste.

5.2 | Can TT be used as an enabler to packaging solutions implemented in a collaborative CE supply chain?

Technologies are currently used by the stakeholders interviewed to accelerate sustainable change, increase efficiencies, and help reduce waste (both food and packaging). Reducing waste through packaging design was also highlighted in the literature review by Wikstrom and Williams, "opportunities to redesign product-packaging configurations to help consumers reduce waste through a selection of pack sizes and other convenience features." [36] Consideration of stakeholder needs and the current expectations of technology by the supply chain were deemed important by stakeholders.

Evidence from this study show that stakeholders surveyed believe that TT is a sustainable solution that will aid collaboration, reduce waste (both packaging and food), increase value perception, and change consumer behaviour in a move to CE packaging systems. They think that technology plays an essential part in enabling solutions in a move to CE systems in the UK food packaging industry. However, the survey responses also raised additional considerations such as a need for common goals, input from government legislation, speed to react and implement technologies, availability of other solutions, and the unintended end of life impacts (both environmental and economic).

The study highlighted the need to change consumer behaviour with packaging by using TT in sustainable packaging solutions to grow consumer understanding, increase the perceived pack value, revolutionize how they interact with the packaging, provide education on the benefits of CE packaging systems, and to ultimately aid the purchasing decision making process towards more sustainable packaging choices.

5.3 | What could CE systems using TT look like for the United Kingdom's chilled food packaging sector

The need for supply chain management, both Business to Business (B2B) and Business to Consumer (B2C) as stated in literature by

Korhonen et al [37] was backed by the study which highlighted the need for a collaborative supply chain approach to implement CE systems. The stakeholders expressed the importance of common goals, trust, and transparency but also the need for industrial symbiosis, as proposed by DEFRA, with vertical integration being suggested by participants in the study. Both literature and the study findings aim for a simplification and change in the supply chain approach to solve the challenges it currently faces.

Currently, Design for Recyclability is the most popular CE solution with the participants surveyed, with systems design at the bottom of the list of waste management solutions. The ease to implement, capacity of existing mechanical waste management systems, and knowledge of system design could all have a part to play in this result. Three participants are already implementing or considering CE solutions, which include looking at new renewable materials, research into chemical recycling methods, and in-depth waste management projects.

However, the study showed a real drive by stakeholders to work towards the United Kingdom being self-sufficient in raw materials for packaging. They linked this to the important part recycling would play in ensuring the consistent supply of high-quality recyclate to achieve this, using traditional mechanical recycling and new chemical recycling technologies. The stakeholders surveyed believe that TT could aid sorting and traceability of material within a new waste recovery system and the need for a unified consistent system to gather and process waste. However, many participants agreed there are no "silver bullets" to solving the current challenges and that a range of solutions would be needed. Current concerns in moving to CE systems amongst stakeholders include cost to implement, environmental impact, and consumer design considerations.

Ease to dispose of came third in the list of consumer behaviour attributes considered during packaging project development; however, impact at point of purchase was still the most important design consideration by stakeholders in the food packaging supply chain. Consumers must be attracted to the packaging in the first place, and a sale must be secured.

6 | CONCLUSIONS

This study set out to better understand the feelings of stakeholders from the UK food packaging supply chain towards a move to CE systems. The research areas studied included current and future challenges facing supply chain stakeholders, the consideration of TT to enable packaging solutions in the move to CE systems, and what CE systems using TT would look like for the United Kingdoms's chilled food packaging sector.

A move to CE systems from the traditional linear make-use-dispose is no doubt a huge challenge to the food packaging industry both in 2018 and looking forward to 2025, with industry stakeholders concerned about a range of economic, environmental, and social implications associated with adapting their industry to a cyclical approach. The commercial viability of systems, the speed to implement technologies, and the unintended environmental consequences are being raised as major risks in this study.

With legislation changes unclear at this moment in time, the stakeholders have mixed feelings towards how they may impact their business and seek a collaborative supply chain approach to support themselves during this time of uncertainty. The stakeholders agree that the food packaging supply chain needs to work towards a common goal, improve communication between stakeholder groups, and most importantly, share valuable knowledge to protect and nurture their industry. They view TT as a sustainable solution which can aid this collaboration while also reducing waste.

With the media feeding consumer's current perception of packaging, the stakeholders' current concern lies with how to communicate practical packaging knowledge to consumers to help educate them about the important role it can play in a sustainable, time-poor lifestyle. The study has shown that stakeholders want to use TT to increase the value perception of packaging by consumers and change their disposal behaviour in a move to CE packaging systems. If TT can achieve this, it could ultimately aid the purchasing decision-making process of consumers towards more sustainable packaging choices.

Both literature and the study findings suggest a need for a simplification in the current food packaging supply chain approach to solve the challenges it currently faces. Improving recyclability of materials and the associated waste management infrastructure are the most popular CE solutions with the participants surveyed in this study. There is a real drive by stakeholders to work towards the United Kingdom being self-sufficient in raw materials for packaging. Recycling technologies would play an essential part in ensuring the consistent supply of high-quality recyclate to achieve this.

More than once it was mentioned in the survey that there are no "silver bullets" to the challenges the packaging supply chain faces and that a spectrum of solutions would be required. This was echoed in the literature review. However, the stakeholders are mindful that ultimately the consumer is key; if they do not adopt new CE systems, it won't be successful, and the issues we face now could be multiplied.

The literature and findings from this study have clearly shown there is a large spectrum of solutions in a move to CE, each with their own benefits and limitations. TT has an ability to enable these, but in selecting the best one for a specific packaging solution, a decision maker must take into consideration business constraints of the supply chain and the consumer's behaviour towards new solutions. A knowledge gap exists exploring consumer behaviour towards CE food packaging solutions. Their willingness to adopt new system approaches and their understanding of the environmental and economic benefits now needs investigating in order to reduce both food and packaging waste. There is also a need to better understand, and plot, the economic implications of system solutions using TT versus the environmental and social gains. The outcome of research into these areas will hopefully assist decision makers within the food packaging supply chain to decide which TT has the best benefits for their packaging project to create the most value economically, socially, and environmentally.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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