



Recycling food packaging & food waste in plastics revolution

STUDY



European Economic
and Social Committee



Recycling Food Packaging and Food Waste in Plastics Revolution

Study

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General information

STUDY FOR *The European Economic and Social Committee (EESC)*

REQUESTING SERVICE *Legislative Planning, Relations with Institutions and Civil Society Directorate*

STUDY MANAGING SERVICE *Foresight, Studies and Policy Assessment Unit*

DATE *October 2020 (corrected version)*

MAIN CONTRACTOR

ADS Insight



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		ISBN	doi
STUDY			
print	<i>QE-03-20-534-EN-C</i>	<i>978-92-830-4882-4</i>	<i>10.2864/539724</i>
PDF	<i>QE-03-20-534-EN-N</i>	<i>978-92-830-4881-7</i>	<i>10.2864/154293</i>

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Abstract

The use of single-use plastics in packaging has grown significantly in the last decades, and with it, the pollution of our environment. There is an urgent need to improve the sustainability of our food systems, which includes also the development of more sustainable food packaging. The objective of this study is to identify and examine successful examples and approaches to food packaging in the EU and beyond, considering consumer safety, environmental, economic, social, legal and food waste reduction considerations. The analysis is based on the principles of a circular economy (reduce-reuse-recycle) and its scope is limited to business-to-consumer operations. Through a careful examination of legislative and sectoral trends at the European and national levels, an extensive literature review and interviews conducted with experts, 19 successful examples of sustainable food packaging have been identified and divided into 5 categories: Prevention/reduction of (over)packaging, Reuse, Recycled Content, Alternative Materials and Active/Intelligent Packaging. Furthermore, the analysis has resulted in the identification of several recommendations for the various actors to foster more sustainable food packaging. Overall, the priority should be given to measures and actions reducing (over)packaging and packaging waste, further supporting reusable packaging by setting binding reuse targets at EU level and other economic instruments and promoting the uptake of recycled, renewable and innovative materials that achieve genuine environmental benefits and avoid burden shifts.

Executive Summary

The primary role of food packaging is to preserve food quality and ensure consumer safety. The use of single-use plastics in packaging has grown significantly in the last decades, which has resulted in increasing generation of plastic packaging waste polluting our environment. There is an urgent need to move towards a more circular economy and improve the sustainability of our food systems, in which packaging plays a key role.

The packaging sector is the biggest user of plastics (around 40%) and plastic packaging is responsible for around 60% of post-consumer plastic waste in the EU, most of which is only used once and then discarded (European Plastics Strategy, 2018). Globally, less than a fifth of plastic packaging waste is recycled, and the rest ends up in the environment, is incinerated or landfilled (Heinrich Böll Foundation, 2019). Packaging waste generation in the EU is high and growing, with 173 kg of packaging waste generated per inhabitant in the EU in 2017, which represents a ~10% increase in packaging waste generated in the EU from 2007. Food and beverage packaging represent two-thirds of total European packaging in terms of market share value (Eunomia, COWI et al, 2020).

The objective of this study is to identify and examine successful examples of and approaches to sustainable food packaging in the EU and beyond, taking into account consumer safety, environmental, economic, social, legal and food waste reduction considerations. This is done using the principles of a circular economy, including redesign, prevention, reuse and recycling. The scope of the study is limited to business-to-consumer operations and covers food packaging (excluding beverage packaging). Furthermore, the study analyses the current and future EU political debate and provides an overview of other trends and drivers at the EU, international and national levels behind the transition to more sustainable food packaging.

Moving away from the single-use, throw-away culture through rethinking design, reducing resource use and waste and supporting reuse and recycling are key to achieving a circular economy for food packaging and to decreasing its environmental impact. Sustainable food packaging is therefore about reducing and minimising its environmental impacts as part of improving the sustainability of the packed food, while preserving or improving food quality and consumer safety and reducing food waste. This includes reducing the amount of packaging and packaging waste, promoting reusable packaging and recycled and renewable materials and other innovative packaging solutions, with food safety as an overarching priority.

Circular economy has become an EU priority in the last five years, starting with the introduction of the Circular Economy Package in 2015. Packaging was one of the first sectors of EU focus for the shift towards a more circular economy with concrete measures to stimulate this transition. For example, the revision of the Packaging and Packaging Directive, the adoption of the European Plastics Strategy and the Single-use Plastics Directive, the revision of the Food Contact Materials legislation, among others. Furthermore, several actions are foreseen in this direction in the next few years, as announced in the recently published Circular Economy Action Plan 2.0 and the Farm-to-Fork Strategy, which aim to further stimulate circular economy and sustainable food systems. They include actions to reduce (over)packaging and packaging waste, improve design for reuse and recyclability of packaging, set legally binding food waste reduction

targets, develop a policy framework for bio-based and biodegradable or compostable plastics, establish mandatory requirements for recycled plastic content and plastic waste reduction measures for packaging, and many other.

In addition to legislative and policy drivers, there are other trends and drivers that are stimulating the transition towards more sustainable and circular food packaging at national, EU and global level, including increased consumer awareness and demand for more sustainable packaging.

The study identifies several examples of sustainable food packaging practices, based on the current and future packaging sustainability trends. These include: prevention/reduction of food packaging (packaging-free supermarkets, lightweighting/reducing the amount of packaging used, and edible packaging); reusable packaging; use of recycled and renewable materials; and active and intelligent packaging. Each of them have their benefits and challenges and there is no one-fits-all packaging solution with the best environmental outcome for all kinds of needs.

Prevention/reduction of packaging is the most efficient way to improve resource efficiency and reduce its environmental impacts. There is a growing trend of packaging-free supermarkets across the EU (e.g. Rifuzl, Slovenia) as well as of reducing the size and volume of packaging (e.g. Frazer, Sweden). Furthermore, a more recent innovation is edible or plant-derived packaging, to avoid packaging and decrease food waste by addressing perishability (e.g. Apeel Science, US). Reducing the amount of (over)packaging without compromising food safety and increasing food waste will help achieve more circular food packaging.

Reusable packaging also has many environmental, climate, economic and social benefits. Examples of successful reuse systems for food packaging include ReCircle (Switzerland), Ecobox (Luxembourg), Loop (US) and Tiffin boxes (India). Although such systems are growing, their share is still quite low. Further support is needed to scale them up since currently they are mostly limited to local or regional initiatives for takeaway food, on-the-go consumption and home deliveries.

Recycled plastics, even though still in initial stages, have also been gaining attention. Food manufacturers are increasingly integrating recycled content into their packaging and new upcoming EU measures to increase the uptake of recycled plastics in packaging aim to further stimulate this trend. Examples include INFIA (Germany), Hellman's (Canada) and Mars (US). However, the recent very low prices of oil and thus virgin plastics compared to recycled plastics and food safety concerns related to some recycled plastics other than PET, might undermine or endanger the market for secondary raw materials. More EU and national efforts will therefore be needed to provide economic incentives and stimulate the uptake of recycled content, as this is key for improving the sustainability of (food) packaging.

Alternative materials, such as paper and bio-based and compostable/biodegradable plastics, might provide more sustainable replacements for single-use plastics. However, it should be ensured that such replacements do not lead to greater environmental impacts and burden shifts. The origin and sustainability of the renewable feedstock for bio-based plastics is very important. Replacing food production for bio-based plastics production should be avoided. Accordingly, another important aspect is ensuring adequate collection and recycling infrastructure is in place to treat this material when it becomes waste, including efficient separate (bio) waste collection systems and recycling or composting facilities. An important

benchmark is European standard EN 13432, which sets criteria for the industrial compostability of packaging, including plastic packaging. Note that this only applies for industrial composting and not for home composting for which a European standard is still missing. For all these reasons, and given the current lack of efficient bio-waste separate collection systems and industrial composting facilities in many Member States, as well as the contamination potential of the plastic and bio-waste recycling streams, biodegradable or compostable packaging should be limited to certain applications where it can be beneficial to the environment, for example in agriculture. EN 17033 is the European standard for biodegradable mulching applications in agriculture. Proper labelling should also be ensured in order to avoid misleading consumers to dispose of it in a way that leads to plastic littering and pollution.

Active and intelligent packaging is a more recent, but growing trend, which can deliver significant environmental and economic benefits, and can lead to extended shelf life of products, reduced food waste and improvements in waste sorting and recycling. An example is the HolyGrail project (US) which developed intelligent packaging with embedded digital watermarks that can significantly improve sorting and recycling. Other examples include Mimica Lab (UK) and Glopak (France).

In order to assess all the environmental impacts of food packaging, a comprehensive analysis should be made using a life cycle approach including production, transport and distribution, use and end-of-life management. Each packaging type has to be assessed individually to determine the environmental impacts throughout its full life cycle taking into account its specific conditions and circumstances. The Life Cycle Assessment (LCA) method can serve as a useful tool to determine in a comprehensive way the environmental impacts of food packaging and avoid burden shifts.

The sustainability of food packaging should be seen and assessed together with the packed food content, including the consideration of perishability, since the environmental impact of wasted food is much higher than that of packaging itself.

Circular design is key for improving the environmental performance of packaging and ensuring a circular economy of packaging and packed foods. This includes integrating environmental and circular economy (reduce-reuse-recycle) aspects in the design of packaging, such as reducing the amount of packaging, material and energy use, eliminating toxic and harmful substances, promoting the use of recycled and renewable materials, and designing for reuse and high quality recycling.

Sustainable design of food packaging is also closely linked with the potential for collection and recycling. Packaging should be designed for recycling, which means that it should not only be technically recyclable, but should also consider whether adequate and efficient collection and recycling systems are in place to ensure that the packaging will actually be recycled. Packaging recycling can be improved at the design stage by reducing the amount and complexity of materials used with preference for mono-materials, transparent or light colours, and avoiding certain materials such as black plastics and mixed plastics which are difficult to recycle or where recycling is not economically feasible.

In order to further improve the sustainability of food packaging, a list of recommendations is provided for European businesses, EU and national policymakers, NGOs and civil society. The table below lists the main recommendations for each of these actors. It is however crucial that the various stakeholders cooperate and

bring forward multilateral solutions to tackle this issue and achieve a circular economy for food packaging. In the same vein, there is a need for a comprehensive political approach involving all political levels, from local, regional, national, European and international. Consumers also have an important role in making more sustainable food (packaging) choices.

Recommendations for European businesses, EU and national policymakers, NGOs and civil society to transition to a circular economy for food packaging

National Policymakers

- Make use of taxation, green public procurement and other economic incentives to stimulate waste reduction, reuse, recycling and use of recycled and renewable materials
- Improve collection, sorting and recycling systems, e.g. with Deposit-Return Schemes

NGOs and civil society

- Disseminate knowledge and best practices to avoid consumer confusion and prevent greenwashing
- Promote the shift in consumer behavior and help develop demand for sustainable food packaging

Businesses

- Use a Life Cycle approach to assess the sustainability of food packaging, together with the packed food content
- Optimise packaging functionality, with a view to reducing and reusing packaging, and promoting recycled and renewable materials, whilst maintaining food safety as a priority
- Design packaging for reuse and recycling, taking into account the existence of efficient collection and recycling infrastructure

EU Policymakers

- Implement a comprehensive, clear and enforceable set of essential requirements to promote reduction, reuse and high quality recycling
- Establish targets and other measures to further support waste reduction and reuse
- Develop clear EU definitions, standards and labelling requirements e.g. for bio-based and compostable / biodegradable plastics; plastic recyclability; home composting

Priority should be given to measures and actions reducing (over)packaging and packaging waste, further supporting reusable packaging by setting binding reuse targets at EU level and other economic instruments, and promoting the uptake of recycled and renewable materials that achieve genuine environmental benefits and avoid burden shifts. Another key area with high potential, even though still in initial stages, is active and intelligent packaging, which can help ensure more sustainable use of resources and reduce food waste.

Integrating circular economy aspects will be a key innovation trend for food packaging in the future. In light of the current COVID-19 pandemic and reduced price of oil and thus virgin plastics, the need for supporting sustainable solutions is even greater. The EU should ensure that circular economy, sustainability and resource efficiency, remain the key drivers for Europe's recovery from this crisis, and continue the progress towards achieving UN Sustainable Development Goal 12 on responsible consumption and production.

1. Introduction

The packaging sector has been subject to many policy and other drivers towards more sustainable, circular practices. In particular, plastic packaging has become a highly disputed topic posing challenges to European businesses throughout the distribution chain, given the negative consumer perception about plastics and increased regulatory requirements.

On the one hand, plastic is a useful material with many advantages such as being light, inexpensive and protecting food very well, leading to reduction of food waste while extending the food's shelf life and lowering the transportation costs. However, on the other hand, the use of plastics has resulted in significant negative environmental impacts linked to use of fossil fuels for its production and improper waste management leading to littering. The packaging sector is the biggest user of plastics (around 40%) and plastic packaging is responsible for around 60% of post-consumer plastic waste in the EU, most of which is only used once and then discarded (European Plastics Strategy, 2018). While plastics production is growing, the recycling of plastics is still low. Less than a fifth of plastic packaging waste is recycled globally and a lot ends up in the environment, is incinerated or landfilled (Heinrich Böll Foundation, Plastic Atlas, 2019). In the EU 28+2, only 41,9 % of the 16,7 tonnes of plastic packaging waste was recycled (Eurostats, 2018). In addition, packaging waste generation in the EU is high and growing, with a ~10% increase in packaging waste generated in the EU between 2007 and 2017. Food and beverage packaging represent two-thirds of total European packaging in terms of market share value (Eunomia, COWI et al, 2020).

In view of the many regulatory and other measures and initiatives addressing plastic pollution and promoting a circular economy, European businesses in the food sector are trying to find sustainable food packaging solutions to decrease their environmental and climate footprint. The purpose of this study is therefore to provide guidance to European businesses using food packaging in their selection of more sustainable food packaging options.

1.1 Objectives and scope of the study

The objective of this study is to identify successful examples of and approaches to sustainable food packaging, taking into account consumer safety, environmental, economic, social, legal and food waste reduction considerations. In line with the principles of a circular economy, this study looks at sustainable food packaging, including redesign, prevention, reuse and recycling, as well as the role of packaging in avoiding food waste.

Furthermore, the study analyses the current and future EU political debate and provides an overview of other trends and drivers at the EU, international and national levels behind the transition to sustainable food packaging.

The study examines existing examples of- and approaches to- sustainable food packaging in the EU and beyond. These examples can be used as strategic and guiding models for European businesses and industries that depend on food packaging.

In this study, the scope is limited to business-to-consumer operations and covers food packaging exclusively (excluding beverage packaging). It is based on data and case studies available at the time of research.

1.2 Methodology

To ensure that the collection of sustainable food packaging examples and approaches is representative of the current trends and as such provides a sound basis for the strategic recommendations, a combined methodology was used to gather successful examples and approaches, including:

- Extensive literature review and desk research
- Review of legal documents
- Interviews with experts from academia, NGOs, industry, associations and EU policymakers
- Attending relevant events, workshops, conferences
- Soliciting extensive network of experts
- Monitoring and analysis of relevant EU policy developments and priorities on circular economy

Based on this methodology, over 140 examples of sustainable food packaging from more than 25 countries across the world were identified (of which more than 110 are listed in Annex A). The majority of the sample originates in EU Member States, however the examples spread out across the world.

1.3 Definition of Sustainable Food Packaging

In order to identify successful examples of and approaches to food packaging ('sustainable food packaging') for the purpose of this study, the principles of the circular economy were followed. The primary role of food packaging is to preserve food quality and ensure consumer safety. In order to become more sustainable, food packaging has to transition from a current linear to a more circular model where its value is maintained for as long as possible, where resource use and waste are minimised and where at the end of its life it can be used again for the same purpose without compromising consumer safety. Moving away from the single-use, throw-away culture through rethinking design, reducing resource use and waste and supporting reuse and recycling are key to achieving a circular economy for food packaging and to decreasing its environmental impact.

Accordingly, sustainable food packaging is "an essential element of response to address key challenges of sustainable food consumption on the international scene, which is clearly about minimising the environmental footprint of packed food" (Guillard et al, 2018).

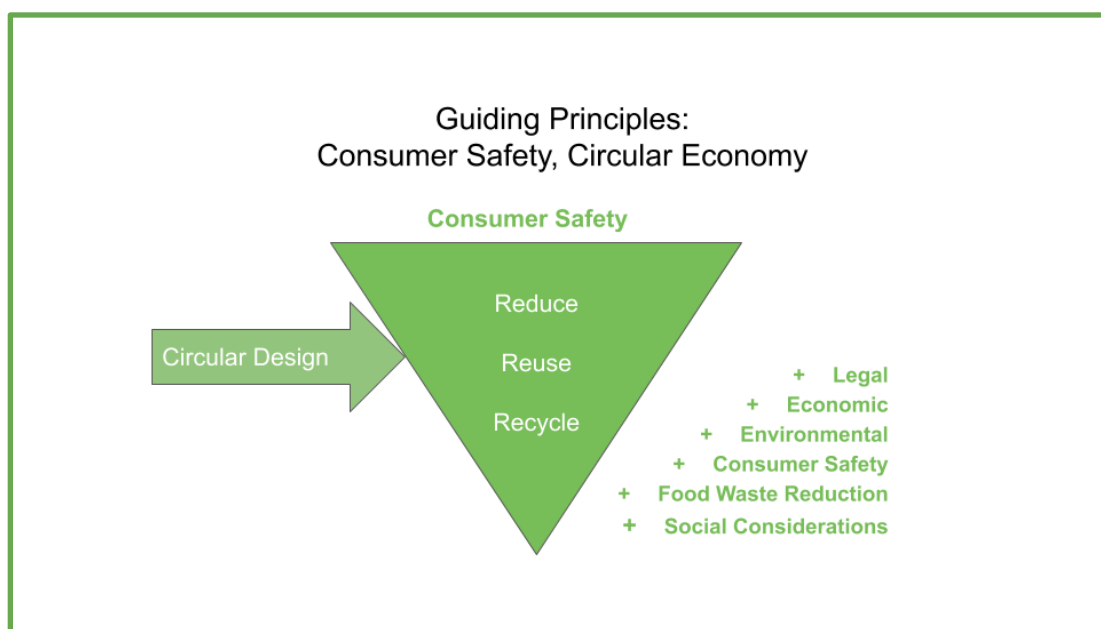
Sustainable food packaging is therefore about minimising the environmental impacts of food packaging as part of improving the sustainability of the packed food, while preserving or improving food quality and consumer safety.

Circular economy has become one of the EU priorities. According to the European Commission, "in a circular economy, the value of products and materials is maintained for as long as possible. Waste and resource use are minimised, and when a product reaches the end of its life, it is used again to create further value" (European Commission, 2018). Circular economy was defined by the Ellen MacArthur Foundation as "an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-

life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models” (Ellen MacArthur Foundation, 2019). Similarly, Kate Raworth developed the ‘doughnut economics’ economic model, referenced by the World Economic Forum¹, which rethinks the economic growth so that it preserves the biosphere.

In this study, all the above-mentioned aspects are considered to the extent possible and using available data to date when selecting successful examples of sustainable food packaging, with consumer/food safety as an overarching priority. The principles of circular economy (reduce-reuse-recycle) are taken into account, as well as other (environmental, economic, social, legal and food waste) considerations. This is in line with the EU waste hierarchy enshrined in the Directive 2008/98/EC on waste which prioritises waste prevention/reduction, followed by reuse and then recycling.

The below chart illustrates the guiding principles and steps in the determination of successful examples of and approaches to sustainable food packaging in the study.



There is however no one-fits-all solution to sustainable food packaging. Life Cycle Assessment (LCA) is a useful tool to determine the environmental impacts of food packaging options and avoid burden shifts. This entails analysing the whole life cycle of food packaging from primary production to processing, distribution, retail, use, to its end-of-life treatment in order to determine in a comprehensive and holistic way its environmental impacts and enable accurate comparisons between the different types of packaging. It should be noted that LCAs should be done ideally on an individual basis in order to assess most accurately the real impacts of a certain food packaging based on its specific circumstances and characteristics and together with the food type in question. The examples identified in this study therefore do not provide a

¹ <https://www.weforum.org/agenda/2018/01/how-to-do-business-with-doughnuts/>

silver bullet solution but show the existing cases that can guide food producers in the selection of packaging that works best for them.

2. Policy and Other Trends and Drivers

This section provides an analysis of EU current and future policy and legislation on packaging, circular economy and plastics, which are relevant for food packaging. Furthermore, other trends and drivers are presented showing that a shift towards a circular model of food packaging is gaining ground in the EU and across the world.

2.1 EU Policy: context, legislation, and binding targets

The European Union has committed to achieving the UN Sustainable Development Goals (SDGs) by 2030. SDG12 on responsible consumption and production calls for a comprehensive set of actions to adopt more sustainable consumption and production practices. The EU has already achieved significant progress towards achieving this goal, in particular with its various measures and actions to transition to a circular economy. However, further efforts are needed to achieve a circular economy, including on reducing waste generation (Eurostat, 2019).

The main piece of EU legislation on packaging is Directive 94/62/EC on Packaging and Packaging Waste, as amended. This Directive provides a set of rules for all types of packaging and packaging waste, with the aim to improve the quality of the environment, protect human health as well as ensure the functioning of the internal market. It requires Member States to ensure that the packaging placed on the market meets the essential requirements set in Annex II of the Directive, which include design of reusable or recoverable packaging, limiting the weight and volume of packaging to a minimum in order to meet the required level of safety, hygiene and acceptability for consumers, and reducing the content of hazardous substances and materials in the packaging material and its components.

The Directive was amended most recently by Directive 2018/852, which was part of the Circular Economy Package released by the European Commission in 2015 to help support the EU's transition towards a circular economy. The Circular Economy Package consists of a combination of non-legislative measures (EU Action Plan for the Circular Economy) and legislative proposals amending the EU waste legislation, including Directive 94/62/EC on packaging and packaging waste as well as Directive 2008/98/EC on waste and Directive 1999/31/EC on the landfill of waste.

The revised body of waste legislation, which entered into force in 2018, sets higher recycling targets, minimum requirements for Extended Producer Responsibility (EPR) schemes, and a target to reduce landfill to maximum 10% of municipal waste by 2035. It furthermore extends separate collection obligations to bio-waste (by end 2023) and other waste streams and strengthens prevention measures requiring for example Member States to take measures to reduce food waste and marine litter.

Regarding packaging, the revised Directive 2018/852 sets a common EU target for recycling of packaging waste of 65% to be achieved by end 2025 and 70% by end 2030, as well as material-specific recycling targets (e.g. 55% for plastic packaging, 85% for paper and cardboard, 75% for glass, 60% for aluminium, all by end 2030). Moreover, the amended Directive sets measures to prevent the generation of packaging

waste and promote reuse and recycling and thereby contributing to a circular economy. It requires Member States to ensure that extended producer responsibility schemes are established for all packaging by 31 December 2024, which should incentivise packaging that is designed, produced and commercialised in a way that allows its reuse or recovery and has minimal impacts on the environment.

Since 2015 with the introduction of the Circular Economy Package, circular economy has become one of the EU priorities. Packaging has been one of the first sectors of focus for the shift towards a more circular economy with concrete measures adopted by the EU to stimulate this transition. In addition to the revised EU waste framework, the EU has increasingly been focusing on addressing the issue of marine litter, and in particular plastic marine litter. For this purpose, the European Commission proposed to amend in 2013 the Packaging and Packaging Waste Directive to include targeted action to reduce the consumption of lightweight plastic carrier bags (Directive 2015/720). This amendment entered into force in 2015.

In view of increased public awareness about plastic pollution, the European Commission stepped up its efforts and adopted in January 2018 the European Strategy for Plastics in a Circular Economy. This is the first time that the EU proposed such targeted action focusing on a specific material, plastics.

The Plastics Strategy identifies the current challenges posed by plastics and sets out a vision to achieve a more circular plastics economy. The Strategy recognises that the packaging sector is the biggest user of plastics (39.9%, data for 2015) and that plastic packaging accounts for around 60% of post-consumer plastic waste in the EU. It sets an objective for all plastic packaging placed on the EU market to be reusable or easily recycled by 2030.

As part of this Strategy, the European Commission put forward an important proposal for a new piece of legislation tackling single-use plastics. This new Directive 2019/904 on the reduction of the impact of certain plastic products on the environment (commonly referred to as Single-use Plastics Directive or SUPD), entered into force in July 2019, and is - according to the European Commission - the most ambitious piece of legislation worldwide tackling marine litter. The Directive targets the 10 most littered items found on Europe's beaches and seas, including food and beverage packaging. For each of those items, it sets specific measures such as product bans, consumption reduction measures, separate collection obligations, extended producer responsibility requirements, design and labelling requirements, as well as awareness raising measures. For the first time, the Directive also introduces mandatory recycled content in single-use plastic beverage bottles, namely 25% in PET bottles by 2025 and 30% in all beverage bottles by 2030.

In the case of food containers, the new Directive bans food and beverage containers made of expanded polystyrene from July 2021. It also requires Member States to achieve ambitious and sustained reduction in the consumption of single-use plastic food containers by 2026. Food containers are accordingly subject to wider extended producer responsibility requirements introduced in this Directive, which will oblige producers of those items to cover the costs of waste management, litter clean-up and awareness raising measures. Furthermore, the Directive requires Member States to take measures to raise awareness, including on the availability of reusable alternatives to single-use plastic food containers and reuse systems as well as on the impact of littering and other inappropriate waste disposal of those items. The Directive covers both conventional as well as bio-based and biodegradable/compostable single-use plastic items.

In addition to transitioning towards a circular economy, food packaging most importantly needs to ensure that food is safe. For this purpose, the EU has in place Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with food (entered into force 2004). This Regulation provides a harmonised legal EU framework and sets out the general principles of safety and inertness for all Food Contact Materials (FCMs). FCMs include all materials that come into contact with food including packaging. The Regulation provides that these materials shall not transfer their components into food in quantities that could endanger human health or change the composition or organoleptic properties of the food. It also lays down the procedure to perform safety assessments of substances used to manufacture FCMs as well as rules on labelling, compliance documentation and on traceability.

Moreover, Regulation (EC) No 2023/2006 sets out rules on good manufacturing practice for materials and articles intended to come into contact with food, which ensures that the manufacturing process is well controlled so that the specifications for FCMs remain in conformity with the legislation.

In addition to the general FCM legislation, certain FCMs are covered by specific EU legislation, including plastics and recycled plastic.

Plastic materials are covered by specific rules set in Commission Regulation (EU) No 10/2011 on ‘plastic materials and articles intended to come into contact with food’. This Regulation establishes rules on the composition of plastic FCMs and a Union list of substances that are permitted for use in the manufacture of plastic FCMs. The Regulation ensures the safety of plastics materials by using migration limits, which specify the maximum amount of substances allowed to migrate to food.

Recycled plastic materials in contact with food are regulated in Commission Regulation No 282/2008 on recycled plastic materials and articles intended to come into contact with foods. This Regulation determines the requirements for recycled plastic materials and articles that come into contact with food, and is thus very relevant for the use of recycled plastics in food packaging. It provides that recycled plastic materials can only be placed on the market if they contain recycled plastic obtained from a recycling process that is authorised in accordance with this Regulation. It establishes the application procedure for authorisation of these plastic recycling processes, which is done by the European Commission based on an assessment of compliance with the safety criteria provided by the European Food Safety Authority (EFSA). The Commission has in 2018 and 2019 issued authorisations for about 140 different plastic recycling processes (mainly for PET) to support the uptake of recycled plastics in food contact applications.

The EU food contact legislation as well as the Packaging and Packaging Directive are currently being revised in order to further facilitate the transition towards a circular economy, and many new measures on circular economy are being proposed, as described in more detail in the following part.

2.2 Future EU political debate and priorities

The new European Commission, which took office on 1 December 2019, has included the European Green Deal as one of its key priorities for the next five years. Circular economy is an essential component of the European Green Deal and is as such a key priority for the EU.

In December 2019, the European Commission published a communication on the European Green Deal, which announces various measures on circular economy. These include a new Circular Economy Action Plan 2.0, and the Farm-to-Fork Strategy.

The new Circular Economy Action Plan was published by the European Commission on 11 March 2020 laying out measures it plans to take in the next years to achieve a more circular economy. It identifies seven priority sectors which include packaging and plastics.

Regarding packaging, the Action Plan stresses the ongoing review of the essential requirements for packaging under the Packaging and Packaging Waste Directive 94/62/EC in order to improve the design for reuse and promote high quality recycling. The objective of this review is to ensure that all plastics packaging placed on the EU market is reusable or easily recycled. The review should be finalised in 2021 and will also consider other measures, with focus on:

- reducing (over)packaging and packaging waste, including by setting targets and other waste prevention measures;
- driving design for re-use and recyclability of packaging, including considering restrictions on the use of some packaging materials for certain applications, in particular where alternative reusable products or systems are possible or consumer goods can be handled safely without packaging;
- considering reducing the complexity of packaging materials, including the number of materials and polymers used.

The Action Plan also lays out several measures on plastics, which include developing in 2021 a policy framework for bio-based and biodegradable or compostable plastics in order to avoid consumer confusion and achieve genuine environmental benefits. This policy framework will focus on:

- Sourcing, labelling and use of bio-based plastics, based on assessing where the use of bio-based feedstock results in genuine environmental benefits, going beyond reduction in using fossil resources;
- Use of biodegradable or compostable plastics, based on an assessment of the applications where such use can be beneficial to the environment, and of the criteria for such applications. It will aim to ensure that labelling a product as 'biodegradable' or 'compostable' does not mislead consumers to dispose of it in a way that causes plastic littering or pollution due to unsuitable environmental conditions or insufficient time for degradation.

Furthermore, the Commission will establish rules for the safe recycling into food contact materials of plastic materials other than PET. To increase the uptake of recycled plastics and contribute to the more sustainable use of plastics, the Commission will propose in 2021/2022 mandatory requirements for recycled plastic content and plastic waste reduction measures for packaging. It will also develop in 2021 methodologies to track and minimise the presence of substances of concern in recycled materials and articles made thereof. The Commission also plans to put forward a legislative proposal for a sustainable product policy initiative in 2021, under which it will launch an initiative on reuse in food services to substitute single-use food packaging with reusable products in food services.

Another initiative under the Green Deal of relevance is the Farm-to-Fork Strategy (COM(2020) 381) published on 20 May 2020, which addresses comprehensively the challenges of sustainable food systems. The Commission wants to stimulate sustainable food systems by introducing measures focusing on circular business models in food processing and retail, including food packaging and marketing standards. The Strategy recognises that food packaging plays a key role in the sustainability of food systems, and that tackling food loss and waste is key to achieving sustainability. As a means to incentivise the food industry and retail sector to take initiatives to reduce the environmental footprint, the Commission plans to develop an EU code of conduct for responsible business and marketing practice, and to introduce requirements for the food industry to integrate sustainability into corporate strategies. The Commission will also propose legally binding targets to reduce food waste across the EU, based on the new methodology for measuring food waste and the data expected from Member States in 2022. The Commission will furthermore seek commitments from food companies and organisations to take concrete action on health and sustainability, focusing also on reducing packaging.

Regarding food contact materials (FCM) legislation, the European Commission launched at the end of 2017 a full evaluation of the FCM legislation. The overall purpose of this evaluation is to assess to what extent the current EU legislative framework for FCMs is fit for purpose and delivers as expected. It also aims to improve food safety and public health (in particular in reducing the use of hazardous chemicals), support the use of innovative and sustainable packaging solutions using environmentally-friendly, reusable and recyclable materials, and contribute to food waste reduction. The evaluation will provide a basis on which the Commission will consider what, if any, possible steps need to be taken in the future concerning the regulation of FCMs in the EU. This evaluation process is ongoing and a legislative proposal may follow in 2022. Similarly, Regulation (EC) No 282/2008 on recycled plastic materials and articles intended to come into contact with foods is also currently being amended to authorise the recycling processes of PET and other plastics based on EFSA's opinions and contribute to the implementation of the EU Plastics Strategy.

In addition to new policies and legislation, the European Commission will ensure timely implementation of the revised waste legislation, which Member States have to transpose by 5 July 2020, and the Single-use Plastics Directive which needs to be transposed by 3 July 2021. The Commission will also have to consider by the end of 2024 the feasibility of setting quantitative targets of reuse of packaging and any further measures to promote the reuse of packaging, as required by the revised Packaging and Packaging Directive.

All in all, these existing and upcoming EU measures and priorities indicate the future direction and trends for more circularity in product and packaging sectors. Integrating circular economy aspects will be a key trend for packaging in the future.

2.3 Other Trends & Drivers

In addition to legislative and policy drivers, there are other national, regional and global trends and drivers that are stimulating the transition towards more sustainable and circular packaging, including food packaging. A lot of them revolve around the problem of plastics pollution.

Many initiatives led by regional organisations, governments, industry and NGOs have emerged worldwide to tackle this global issue. Public awareness on the issue of plastic pollution has significantly increased over

the past years, which has been one of the key drivers of many of these initiatives and policies tackling the plastics problem.

At the European level, the European Commission and the European Economic and Social Committee launched in March 2017 **the European Circular Economy Stakeholder Platform** which brings together stakeholders in the field of circular economy across Europe and provides a platform for exchange of information and best practices. In December 2018, the European Commission launched the **Circular Plastics Alliance** under the European Strategy for Plastics to help boost the EU market for recycled plastics to 10 million tonnes by 2025. The Alliance includes the full plastics value chains with over 175 organisations from industry, academia and public authorities.

Moreover, the **European Plastics Pact** was launched in March 2020 led by France and the Netherlands. It is a public-private coalition bringing together governments and frontrunners from across the whole value chain to accelerate the transition towards a European circular plastics economy. It aims to complement existing initiatives, such as the Circular Plastics Alliance and others.

At a global level, the G20 Environment Ministers adopted the **G20 Implementation Framework for Actions on Marine Plastic Litter**, aimed at facilitating further concrete action on marine litter on a voluntary basis. Under this framework, G20 members committed to promoting a comprehensive life-cycle approach to prevent and reduce plastic marine litter and to pursuing actions including environmentally sound waste management, clean-up of marine plastic litter, reduction of plastic waste generation and international collaboration to advance innovative solutions such as for product design, resource efficient and circular approaches and other.

In addition, the **Global Protocol on Packaging Sustainability**, launched in 2011 by the Consumer Goods Forum, aims to provide a framework and measurement methods to ensure that companies worldwide have a common language for discussing and assessing the sustainability of packaging.

More recently, the **New Plastics Economy Global Commitment** led by the Ellen MacArthur Foundation and the UN Environment Programme was announced in October 2018. It gathers over 290 of the world's leading packaging brands, with a commitment to ensure 100% of plastic packaging can be reused, recycled or decomposed by 2025. The signatories represent over 20% of plastic packaging produced globally.

Several other coalitions of major industry players have surfaced to address the issue of plastic pollution, with the objective of preserving the benefits of plastics whilst eliminating their negative externalities. For example the **Alliance to End Plastic Waste** launched in 2019 rallies over 30 major corporations pledging over 1 billion \$ to develop waste management infrastructure in developing countries, foster innovation in post-use solutions and clean up actions. Similarly, **FoodDrinkEurope**, representing Europe's food and drink industry, adopted a sustainable packaging roadmap² in 2018, with the aim to improve the circularity of packaging.

Initiatives have emerged on other continents, for example the **African Plastics Recycling Alliance**, launched in March 2019 by a group of international consumer goods companies operating across Africa

² https://www.fooddrinkeurope.eu/uploads/publications_documents/FoodDrinkEurope_Sustainable_Packaging_Roadmap.pdf

with the aim to transform plastics recycling infrastructure across sub-Saharan Africa through collective action.

There are also various other initiatives at national and local levels promoting more sustainable (plastic) packaging. For example, the **Swedish Food Retailers Federation** published a roadmap³ on plastic consumer packaging that aims to deliver 100% recyclable plastic packaging by 2022, and fully renewable/recycled packaging by 2030.

From a civil society perspective, NGOs have been very active in their advocacy efforts at tackling plastic pollution, with many global initiatives aimed at promoting the development of a circular economy for plastics and achieving a zero-waste society. For example, the **Break Free From Plastic** movement joins over 1900 NGOs from around the world that aim to achieve a peak in plastic usage by 2025 and transition towards a zero-waste society via national and regional advocacy campaigns such as the one led by the **Rethink Plastic Alliance** at the European level on the European Plastics Strategy.

The fact that there are so many initiatives, pacts and alliances on the global, regional, national and local levels demonstrates and affirms the strong movement of the current transitioning towards a circular economy, including that of (food) packaging. All these initiatives show the need for cross-sectorial stakeholder involvement and commitment to achieve a circular economy. It also manifests the increased consumer awareness and pressure on policymakers and businesses to take concrete action and adopt strategies to reduce the use of (virgin) plastics and to look for innovative solutions and alternative packaging models to ensure food quality and safety while decreasing environmental and climate impacts. However, in light of the current COVID-19 pandemic, the price of oil and thus virgin plastics has dropped significantly, which might undermine the market for secondary raw materials and sustainable packaging solutions replacing single-use virgin plastics.

In addition to the initiatives tackling plastic pollution, another trend seen in food packaging is the increased popularity of buying local⁴ and organic produce. Buying locally-produced food implies shorter supply chains, less transport, less need for ensuring long shelf life and thus less packaging. This is demonstrated with an increase of urban zero (plastic) packaging stores, sourcing locally produced food products. Furthermore, the rise in demand for organic produce, driven by consumers' preference for healthier and more sustainable products, implies a similar desire for more sustainable consumption, a part of which is increasingly sustainable packaging.

³ https://circulareconomy.europa.eu/platform/sites/default/files/plastic_pledge_statement_svdh.pdf

⁴ <https://www.livsmedelsforetagen.se/lokalproducerat-hetaste-trenden-2020-enligt-svenska-livsmedelsforetag/>

COVID-19 and its impacts

Even though the effects the pandemic will have on people and economies are not yet fully known, preliminary consequences of the global COVID-19 crisis can already be predicted:

- Although it is highly unlikely that people can contract COVID-19 from food or food packaging (WHO, 2020), it remains possible that one may get infected by touching a contaminated packaging surface. Proper cleaning and the prevention of cross-contamination are critical in the control of foodborne illnesses, as all types of food can be contaminated through contact with contaminated equipment, surfaces or environments.
- To prevent the spread of infections, the emergence of the coronavirus has led to more stringent health and safety practices across the food chain, including packaging; The meat packing sector having been particularly exposed to risk.
- A tendency to re-introduce plastic food packaging for health safety measures has already been seen (AGFO, 2020). As a consequence, plastic (over)packaging and related plastic pollution can increase under the pretext of ensuring food safety and result in relegating the sustainability of food packaging to a secondary role given the paramount importance of preventing contamination.
- In addition, an already low oil price, exacerbated by Covid-19 has led to a significant drop in the price of (virgin) plastics, threatening the economic viability of reusable and non-plastic food packaging solutions as well as plastic recycling and the use of recycled plastics.
- Faced with this challenge of low oil prices and potential increase in plastic production, the EU has a key role in ensuring that the European Green Deal and circular economy remain the main priorities and drivers for Europe's recovery from the crisis. This should include further reduction of plastic packaging waste and stimulating more sustainable, circular solutions.
- The European Commission has proposed a €750 billion recovery package to alleviate the impact from the pandemic and €1.1 trillion for the budget period 2021 -2027 focusing on the ambitions of the Green Deal. As such, additional (research) funding will likely become available to increase the sustainability of food packaging, in particular via the Farm-to-Fork strategy. Green and digital transitions are at the centre of the recovery package.
- In addition, given the impact of the virus on long supply chains of imported food (50% of the food in the EU is imported), a probable (positive) consequence might be a shift towards more local, shorter value chains, that can lead to reductions of (plastic) food packaging.

3. Circular Design

Circular design is key for improving the environmental performance of packaging and ensuring a circular economy of packaging and packed foods. Eco-design / design for circularity are similar terms referring to integrating environmental, health and safety elements in the design and development of products and packaging with the aim to reduce their negative impacts on the environment throughout their entire life cycle from the extraction of raw materials, to production, distribution, use and end-of-life treatment

(Radonjič, 2014). This includes dematerialisation / reduced use of materials and energy, eliminating toxic substances and substances of concern and design to enable reuse and recycling.

Life-cycle thinking is also promoted in the EU legislation on packaging and the Single-Use Plastics Directive, which stresses that plastic products should be manufactured taking into account their entire life span and their design should always take into account the production and use phase and the reusability and recyclability of the product.

Life Cycle Assessments (LCAs) can serve as a useful tool for businesses to assess the environmental impacts of the packaging and the packed food and help them decide on the most sustainable and suitable solution for their packaging.

When it comes to food packaging, its environmental impacts should be looked at together with the packed food, in order to determine the most suitable and sustainable packaging solution. Packaging represents only a small percentage of the overall environmental impact of the packed food. According to a study by Wohner et al (2019) “in most cases, packaging accounts for only 1%–12% (typically around 5%) of greenhouse gas emissions in a life cycle assessment of a food packaging system”. This indirect environmental impact of packaging is insufficiently considered in the current food LCA practice according to Molina-Besch et al (2019). Therefore, the environmental impact of food and food loss should be considered in the selection of food packaging.

Furthermore, when designing and deciding on sustainable food packaging, food producers should consider the recyclability/recycling of the packaging. This includes two aspects, namely whether the packaging is technically recyclable and also whether it will actually be recycled (i.e. whether efficient collection and recycling systems are in place in order to ensure proper end-of-life management of the packaging).

Although there is currently no EU definition of recyclability, a definition was developed for recyclability of plastic packaging by the plastics recycling associations from the EU (Plastics Recycling Europe) and the US (The Association of Plastic Recyclers from the US). They specify four conditions a plastic product must fulfil to be considered recyclable, which include:

- The product must be made with a plastic that is collected for recycling, has market value and/or is supported by a legislatively mandated programme;
- Must be sorted and aggregated into defined streams for recycling processes;
- Can be processed and reclaimed or recycled with commercial processes; and
- The recycled plastics become a raw material that is used in the production of new products.

According to Steve Alexander, President and CEO of The Association of Plastic Recyclers, “recyclability goes beyond just being technically recyclable there must be consumer access to a recycling program, a recycler must be able to process the material, and there must be an end market.” Innovative materials should also demonstrate that they “can be collected and sorted in sufficient quantities, must be compatible with

existing industrial recycling processes or will have to be available in sufficient quantities to justify operating new recycling processes”, according to the two plastic recycling associations.⁵

Furthermore, KIDV (Netherlands Institute for Sustainable Packaging) prepared a document⁶ with tips and tricks to improve recyclability of five types of packaging and developed a checklist on how to improve recyclability, which include:

- Always put the functionality of packaging first
- Avoid the use of harmful substances in packaging materials
- Create a clean material stream that can be recycled easily
- If possible, use recycled or renewable raw materials
- Keep logistical efficiency in mind when developing packaging
- Include information on packaging concerning the proper disposal behavior for consumers

Accordingly, Basic Facts Report on Design for Plastic Packaging Recyclability developed by Mepex Consult AS in 2017 provides useful guidelines and recommendations for sustainable plastic packaging design. It includes detailed guidelines on plastic packaging design including the most important types of plastics used for packaging products (LDPE, HDPE, PP, PET and PS), providing recommendations on the use of different additives, barrier materials, colours, inks, labels and other elements for different material types of plastic packaging. The report for example recommends using transparent or light colours and avoiding black plastics which are difficult to recycle as well as avoiding combining different colour pigments and barrier materials to prevent down-grade of the material. It also demonstrates how design for recyclability is good for both industry and the environment. Similarly, RecyClass⁷ has also developed useful guidelines on design for recycling for different types of plastic packaging.

As recommended in this and other reports and as also confirmed in the interviews conducted with various stakeholders for this study, multi-material packaging products are not ideal when it comes to recycling and mono-material and mono-layer solutions and coatings should be promoted to enable the best recyclability.

There are several other tools and reports available aimed to help assess and select sustainable packaging options. These include for example the following:

- GaBi Packaging Calculator⁸, an LCA (life cycle assessment) calculator specifically designed for packaging that helps to identify the most sustainable packaging design by creating life cycle assessments and comparisons with alternative packaging designs. It measures the level of circularity based on the Material Circularity Indicator (MCI) developed by the Ellen MacArthur Foundation and Granta Design.
- KIDV tool ‘Five perspectives on sustainable packaging’⁹ can help develop an optimal and tailor made sustainable product-packaging combination. It includes five key areas to be taken into account when designing sustainable packaging, namely choice of material and packaging process;

⁵ <https://waste-management-world.com/a/global-definition-of-plastics-recyclability-from-international-recycling-associations>

⁶ <https://recyclability.kidv.nl/>

⁷ <https://recyclclass.eu/recyclclass/design-for-recycling-guidelines/>

⁸ <http://www.gabi-software.com/international/software/gabi-envision/gabi-packaging-calculator/>

⁹ <https://hoeverpakjeduurzaam.kidv.nl/?lang=en>

packaging and the product (functionality); packaging in a circular economy (maximise reuse/recycling and minimise waste), consumer behaviour; and policy and strategy.

To summarise, the following key messages should be taken into account when designing sustainable food packaging solutions:

- Packaging should be seen together with the packed food, therefore environmental impacts of food and food loss should also be considered. Producers should not opt for alternative packaging seen as ‘more sustainable’ if this will mean more food waste and thus bigger environmental impact or compromised consumer safety.
- To optimise packaging, reuse should be integrated as much as possible, the amount of packaging should be reduced and recycling and use of recycled and renewable materials should be promoted.
- Sustainability of food packaging is closely linked with collection and recycling, therefore design of sustainable packaging should consider if there is adequate collection and recycling infrastructure in place.

This is even more pertinent now with the EU objective for all packaging to be reusable or easily recycled by 2030. In view of this goal and as part of the Ellen MacArthur Foundation’s New Plastics Economy Initiative, several food and drink producers, including Mars, Evian, PepsiCo, Coca-Cola, Unilever, and Nestlé, have committed to work towards 100% reusable, recyclable or compostable packaging by 2025 or earlier (FoodDrinkEurope’s Sustainable Packaging Roadmap, 2018).

4. Examples of sustainable food packaging

In order to help food producers decide on the most sustainable packaging, the following chapters describe some of the current sustainability trends in packaging, namely waste prevention/reduction, reusable packaging, use of recycled materials in packaging, use of alternative materials and smart/intelligent packaging. Each of these trends is described with their respective benefits and challenges and examples of food packaging are provided which can help determine sustainable food packaging options.

However, in order to determine the most sustainable food packaging option, it is advisable for food producers to use a Life Cycle Assessment (LCA) tool on a case-by-case basis which will determine more accurately the full environmental impacts, both direct and indirect, of food packaging and packed food taking into account their individual characteristics and circumstances.

The study compiled a sample of over 120 examples of sustainable food packaging from more than 25 countries from across the world (see Annex C for the examples). At first glance, this heterogeneity of the sample denotes that the trend towards sustainable food packaging is global, and not limited to developed countries.

Furthermore, the composition of the sample reveals that currently the most common solution adopted by food businesses opting for more sustainable packaging solutions is the switch to alternative materials to

replace single-use plastics. This is followed by reuse and prevention. Finally, the use of recycled content and active/intelligent packaging are more recent trends which are still in the early stages of development but will likely have an important role to play in the future sustainability debates for packaging.

4.1 Prevention/reduction of (over)packaging

Packaging waste constitutes around one third of municipal waste and continues to increase in most EU Member States. On average, the amount of packaging waste generated per capita increased from 150 kg to 173 kg between 2009 and 2017 (Eurostat, 2020). This is why prevention and reduction of packaging, in particular overpackaging, has an important role in achieving more sustainable and circular food systems.

Waste prevention is the most efficient way to improve resource efficiency and to reduce the environmental impact of waste (PPWD). Prevention, which is on top of the EU waste hierarchy, should be prioritised before reuse and recycling and is a key element of circular packaging.

This category examines examples of zero packaging supermarkets, reduced/optimised packaging and edible packaging, all of which lead to waste prevention and reduction.

Reducing the amount of (over)packaging without compromising food safety and without increasing food waste will help achieve more circular food packaging. According to the Ellen MacArthur Foundation and the “New Plastics Economy”, 30% of the plastic packaging market by weight will never be reused or recycled. The solution is to prevent, redesign or introduce innovative delivery models.

Prevention has many benefits and addresses all the main challenges posed by single-use plastic packaging, as shown in the table below, such as littering, packaging made for single-use and the lack of sufficient collection and recycling systems to its waste.

Single-use plastic packaging challenges	Zero packaging
Littering	✓
Single-use	✓
Lack of collection/recycling infrastructure	✓
Fossil-fuel based	✓
Not biodegradable	✓
Complex material	✓

In addition to improving circularity of packaging through waste prevention and reduction, food waste concerns also need to be taken into account when determining the sustainability of food products.

According to the Commission’s Circular Economy Action Plan, an estimated 20% of the total food produced is lost or wasted in the EU. While foods sold without packaging can prevent the generation of packaging waste and the related negative externalities surrounding the packaging production, use and end-of-life management, they could in some cases lead to increases in food waste. This could have a much more significant environmental impact than packaging waste since packaging represents only a small percentage of the overall environmental impact of the packaged food.

The table below summarises the benefits and challenges of **reducing the amount of packaging** for food content:

Benefits	Challenges
<ul style="list-style-type: none"> ● Prevention of packaging waste and littering ● Reduction of GHG emissions and other negative externalities related to manufacturing, transport, use and waste management of packaging ● Reduced resource use ● Zero cost for packaging 	<ul style="list-style-type: none"> ● Shorter shelf life and possible increase in food waste, potentially leading to increased environmental impact ● Lack of package functionality (marketing, protection of the food, food safety etc.)

4.1.1 Packaging-free supermarkets

Zero (plastic) packaging supermarkets have become a trend which is on the increase across Europe. They can contribute to significant reduction of (plastic) packaging waste and littering. Some of them are also addressing the potential food waste concerns by using the unsold fruits and vegetables as compost.

Below is one example from Slovenia, Rifuzl, which sells products in bulk with zero plastic packaging encouraging consumers to bring their own containers. There are multiple other similar packaging-free retailers, as can be seen in the knowledge base developed by Bepakt which contains a list¹⁰ of more than 500 zero-waste supermarkets across the globe.

¹⁰ <https://www.bepakt.com/>

Rifuzl

Description: Zero-waste grocery shop, offering products in bulk without single-use plastic packaging, mostly locally and sustainably sourced and organic.

Country of origin: Slovenia

Development Stage: In operation

Use: Mostly locally produced and organic foods including fruits & vegetables, dairy products, pasta, nuts, pastries etc.

Packaging material: Zero plastic packaging encouraging consumers to bring their own sachets/containers

Website: <https://rifuzl.si/>



4.1.2 Reduced use of (over)packaging (resource efficiency)

In order to help move towards circular food packaging, the use of resources should be optimised and unnecessary or over-packaging should be avoided. Many food and packaging producers have been looking into ways to optimise the resources used in their food packaging, for example by reducing the size and weight of the package, which is an efficient way of reducing packaging waste. This 'light-weighting' of packages (decreasing the unit weight) has been observed since the 1990s and combines the commercial benefit of lower unit and transport costs with improved resource efficiency (Eunomia et al, 2020; Pongrác, 2007).

Fazer (Skogaholm)

Description: Fazer was founded in Finland in 1891 and today operates in nine countries, focusing on bakery, confectionery and biscuit products. Skogaholm, owned by the Fazer group, is a Swedish-based bakery and bread producer. As part of their sustainability strategy Skogaholm has reduced the size of/and thinning of the plastic packaging for wrapping bread.

Country of origin: Sweden

Development Stage: Commercialised

Use: Bread

Packaging material: Plastics (PET)

Website: <https://www.skogaholm.se/hallbarhet/panta-din-plastpase/>



4.1.3 Edible and plant-derived food packaging

Edible packaging is still in initial stages of development. The idea is to cover the food with a bio-based material which can help extend the shelf life of the product and reduce food waste. Such material is designed

to be eaten or biodegrade efficiently like the food it contains, with the most famous example being the ice cream cone.

Apeel Science

Description: Apeel Science was founded in 2012, using a grant from the Bill and Melinda Gates Foundation with the aim to reduce food waste and prevent global hunger. The company developed a thin ‘peel’ of edible plant material, which is placed on the surface of the fruit, where it acts as a barrier to prolong its shelf life and avoid spoilage.

Country of origin: US

Development Stage: Commercialised

Use: Fruit (avocados, lime, apples)

Packaging material: Edible or plant-derived coating

Website: <https://apeelsciences.com/>



4.2 Reuse

Reuse is, after prevention, at the top of the EU waste hierarchy, enshrined in the Waste Framework Directive, and is promoted in the EU legislation. Reusable packaging is defined in the Packaging and Packaging Waste Directive as “packaging which has been conceived, designed and placed on the market to accomplish within its lifecycle multiple trips or rotations by being refilled or reused for the same purpose for which it was conceived” (Article 3(2a)).

In line with this Directive, Member States have to take appropriate measures to encourage the increase in the share of reusable packaging placed on the market and of systems to reuse packaging. Such measures can include the use of deposit-return schemes and other incentives, such as setting quantitative or qualitative targets, taking reuse into account for the attainment of recycling targets, and differentiated financial contributions for reusable packaging under extended producer responsibility schemes for packaging. Furthermore, the EU has set an objective in the European Strategy for Plastics to ensure that by 2030 all plastic packaging placed on the EU market is reusable or easily recycled.

In order to move away from a linear, single-use, throw-away economy towards a circular economy for food packaging, reuse systems need to be further promoted as they can help achieve the needed systemic changes in our production and consumption patterns and lead to environmental and other benefits.

The environmental, climate, economic and social benefits of reusable packaging have been recognised in several reports. According to the report ‘Reuse - Rethinking Packaging’ by the Ellen MacArthur Foundation, reusable packaging is ‘a critical part of the solution to eliminate plastic pollution’. If done properly, reusable packaging can have significant climate and other environmental benefits, helping to eliminate plastic waste and pollution and leading to important reductions in greenhouse gas (GHG)

emissions and other negative externalities. Reusable packaging is also a USD 10+ billion innovation opportunity that can deliver significant user and business benefits (Ellen MacArthur Foundation, 2017).

The mentioned benefits of reusable packaging compared to single-use packaging will depend on how many times the packaging is reused and the efficiency of the reuse system (in terms of transport, localised distribution, energy use for washing etc.). The more times the packaging is reused in an efficient reuse system, the better the environmental performance compared to single-use packaging.

The table below summarises some of the key benefits and challenges of **reusable packaging**.

Benefits	Challenges
<ul style="list-style-type: none"> ● Reduction of plastic waste and pollution ● Reduction of GHG emissions and other negative externalities linked to single-use packaging use ● Economic benefits (long-term cost savings for businesses) ● Achieving a circular economy ● Cheaper than single-use food packaging over the long term 	<ul style="list-style-type: none"> ● Higher initial cost ● Need to have infrastructure in place (washing facilities) ● Need to ensure efficiency of the system in order not to lead to higher environmental costs ● Normally local initiatives

Reusable packaging has most widely been used in the beverage sector, for example refillable glass or PET bottles based on a deposit-return scheme. Deposit-return schemes for beverage bottles have proven to be a very effective system stimulating reuse and leading to high quality collection and recycling.

When it comes to food packaging, reusable packaging is becoming more common, even though its share is still quite low. Deposit-return schemes are starting to be introduced also for food packaging to enable reuse, some of which are described in more detail below. Most of the reuse examples identified in the study are for takeaway food, on-the-go consumption and home deliveries, and are local or regional initiatives.

ReCircle

Description: Launched in 2016, ReCircle provides reusable lunch boxes to restaurants across Switzerland for take-out food, with a deposit scheme of EUR 10, which is given back to the customer when the package is brought back. Users receive their takeaway food in ReBOX reusable containers which they can after use drop off at any participating vendor. An LCA¹¹ conducted by ReCircle showed that reuse has 15-20 times better environmental performance compared to single-use.

Country of origin: Switzerland

Development Stage: Start-up

Use: Various foods and meals, with over 1000 participating restaurants

Packaging material: Polybutylene terephthalate (PBT) plastic with glass fibre

Website: <https://www.recircle.ch>



Ecobox

Description: Reusable packaging used for take-aways in restaurants and canteens, based on a deposit of EUR 5. The system is financed by the Luxembourg Ministry and has more than 120 partners in Luxembourg. The benefits of this system include reduction of single-use packaging waste, food waste reduction and cost savings.

Country of origin: Luxembourg

Development Stage: Commercialised

Use: Various foods and meals

Packaging material: Polybutylene terephthalate (PBT) plastic, with cover made from polyethylene (PE)

Website: <https://ecobox.lu/fr/>



¹¹ <https://www.recircle.ch/fr/what#toc431>

Loop

Description: Developed by TerraCycle, Loop is an online and physical store shopping platform that features redesigned products from brandowners (e.g. P&G, Nestlé, Unilever), and start-ups, in superior reusable packaging. All packaging is picked up, cleaned, and refilled.

Country of origin: US, now also in France, UK and soon in Japan, Germany and Canada

Development Stage: Pilots

Use: Grocery (desserts, condiments, frozen foods, pasta, beverages, snacks and other)

Packaging material: Depends on the brand owner participating in Loop; all packaging is reusable

Website: <https://loopstore.com>



Tiffin box (dabbawala)

Description: Reusable tiffin boxes (dabbawalas) originated in India as part of a lunch delivery and return service to offices. They are now used in many countries, in Europe and Asia. In Belgium, there is a list¹² of restaurants that offer this option for takeaway food, against a one-off fee of €25 for the box. In the UK, start-up DabbaDrop uses them for ready-made meals delivery, against a £15 fee on first delivery.

Country of origin: India

Development Stage: Commercialised

Use: Various foods and meals

Packaging material: Generally steel, sometimes aluminium; enamel and plastic versions also available

Website: <https://tiffin.be/quels-restaurants-utilisent-tiffin/>;
<https://dabbadrop.co.uk>



4.3 Recycled Content

While the use of recycled content in food packaging made of paper, glass and metal is quite common, the use of recycled plastics is still a challenge and remains low (FoodDrinkEurope's Sustainable Packaging Roadmap, 2018).

According to the European Plastics Strategy, 'using more recycled plastics can reduce dependence on the extraction of fossil fuels for plastics production and curb CO2 emissions', with the potential annual energy savings of 3.5 billion barrels of oil per year, if all global plastic waste was recycled. The Strategy also

¹² <https://tiffin.be/quels-restaurants-utilisent-tiffin/>

underlines the objective of the use of recycled plastics in food-contact applications, which is to prioritise high food safety standards, while also providing a clear and reliable framework for investment and innovation in circular economy solutions.

The market uptake of recycled materials therefore needs to be promoted in order to ensure the circular use of plastics, as stated also in Recital 17 of the Single-use Plastics Directive.

As a result of the EU policy and other developments promoting the use of recycled content, many industry actors have made commitments to increase recycled content in their products. For example, Evian committed to using 100% recycled plastic in its bottles by 2025. Nestlé announced in early 2020 an investment of up to CHF 2 billion to lead the shift from virgin plastics to food-grade recycled plastics with plans to source up to 2 million metric tons of food-grade recycled plastics. Nestlé plans to allocate more than CHF 1.5 billion to pay a premium for these materials between now and 2025 to create a market for food-grade recycled plastics.

Aside from beverage packaging, the progress in the up-take of recycled plastics in food packaging is still in initial stages. This is in particular because of food safety concerns and strict legal requirements under EU food contact legislation requiring EFSA authorisations of plastic recycling processes for recycled plastic materials to be placed on the market. So far PET is the only plastic for which EFSA has given approval for use in food contact materials. Besides PET most other plastics are difficult to recycle for food packaging, as they can be mixed with plastics from non-food applications (e.g. detergents) which can lead to contamination and compromise food safety. Therefore most recycled plastics aside from PET are currently not permitted to be used in food contact materials as they cannot meet the necessary quality and food safety requirements with the existing recycling processes, as required under Commission Regulation No 282/2008. This leads to a limited supply of food-grade recycled plastics as well as limited investments in this kind of recycling facilities. The EU is currently reviewing this Regulation in view of facilitating the uptake of recycled plastics.

The table below summarises some of the key benefits and challenges of using **recycled plastics in food packaging**.

Benefits	Challenges
<ul style="list-style-type: none"> ● Reducing GHG (CO₂) emissions and other negative externalities related to virgin plastic production ● Reducing use of raw materials ● Ensuring circular use of plastics ● Boosting recycling innovation 	<ul style="list-style-type: none"> ● Ensuring food-grade quality and food safety (possible contamination, chemicals of concern) ● Legal restrictions for some plastics where no EFSA approval yet ● Higher price compared to virgin plastics

- Reducing dependence on fossil fuel extraction and imports of oil for fossil fuel production

- Low demand for recycled plastics: need to create a market for food-grade recycled plastics and ensure sufficient volume and quality
- Need more scale and standardisation of recycling facilities in Europe

Klößner Pentaplast (KP) food packaging made of recycled content

Description: KP is one of world's largest suppliers of films for different industries, including food packaging; KP's food packaging made of 100% recycled PET (rPET) includes for example strawberry punnets from their sister company INFIA

Country of origin: Germany

Development Stage: Commercialised

Use: Strawberries and other berries, food-to-go, bakery and other

Packaging material: 100% post-consumer recycled PET plastics (rPET), approved by EFSA

Website: <http://www.infia.it/>



Hellman's

Description: Hellman's, a Unilever brand, uses 100% post-consumer recycled plastic (rPET) in all its mayonnaise bottles and jars across Canada from March 2020. The packaging has a slightly darker tint as a result of the use of non-virgin packaging, and the label provides instructions on how to recycle correctly. According to Hellman's, this action should save over 1 million kg of virgin plastics a year, and will support Unilever's pledge to use 25% of recycled plastics in its packaging by 2025. Hellman's also plans to use recycled content in its plastic polypropylene (PP) caps.

Country of origin: Canada

Use: Mayonnaise bottles, jars and caps

Packaging material: Recycled PET plastics for bottles and jars and recycled PP for caps

Website: <https://www.hellmanns.com>



Mars

Description: Mars uses recycled board for almost all trays (secondary packaging for small packs, pouches, bottles) in Europe. In the UK, Mars corrugated cases are made of 100% recycled content.¹³ Mars also uses rPET trays for Christmas seasonal items. It made a pledge to have 30% average recycled content in its plastic packaging by 2025.

Country of origin: US

Development Stage: Commercialised

Use: Trays (secondary packaging)

Packaging material: Recycled PET (rPET) and recycled board

Website: <https://www.mars.com>



According to the FoodDrinkEurope sustainable packaging roadmap, ‘food and drink manufacturers will continue to promote a market for secondary raw materials by integrating recycled content into their primary and/or secondary packaging on a case-by-case basis, ensuring that food safety requirements and EU rules on food contact materials are respected’. The European Commission will also further promote the uptake of recycled content in packaging, as announced in the new Circular Economy Action Plan.

In conclusion, the issue of integrating recycled plastics into food packaging is still in its initial stage. Given the new EU legislative and policy measures promoting the uptake of recycled plastics as well as climate-related commitments (with recycled plastics leading to significant CO2 emission reductions and reducing Europe’s dependence on imported fossil fuels contributing to the Paris Agreement commitments), many businesses have started to look at how to increase recycled plastics in their products and have made specific commitments towards this goal. However, the current very low price of virgin plastics is a real challenge for advancing this issue and establishing a well-functioning market for secondary raw materials. Therefore more EU and national efforts will be needed to provide economic incentives and stimulate the uptake of recycled content, as this is key for improving the sustainability of food packaging.

4.4 Alternative Materials

In view of increasing consumer pressure and adoption of policy measures addressing plastic pollution and banning or limiting the use of certain plastic products and packaging, many producers are moving away from plastic packaging by switching to other materials for their packaging, such as paper or bioplastics.

While some of these material substitutions can indeed lead to genuine environmental benefits and are thus more sustainable, this is not necessarily always the case. In order to avoid burden shifts from one material to another, a life-cycle analysis conducted on a case-by-case basis will serve to determine the real environmental impact of the food packaging and find the most sustainable solution. For example, in the

¹³ <https://circulareconomy.fooddrinkeurope.eu/improve-packaging-design/>

case of paper, several aspects should be considered in addition to carbon footprint, namely sustainable sourcing of wood and impacts of acidification and eutrophication (D'souza, 2019).

Bioplastics has also been gaining a lot of attention as a potential alternative to conventional, fossil fuel-based plastics. The table below compares bioplastics with conventional plastics, showing that while bioplastic packaging addresses some of the challenges posed by fossil-based packaging, in particular the use of fossil fuels and in case of compostable bioplastics also the issue of biodegradability, many challenges remain and are the same as with fossil-based plastics (e.g. littering, single-use, lack of efficient collection and recycling systems). Furthermore, bioplastics is also more expensive than fossil-based plastics (at least two times or more, depending on feedstock and method of production).

Fossil-based plastic packaging challenges	Bioplastics
Littering	✗
Single-use	✗
Lack of collection/recycling infrastructure	✗
Fossil-fuel based	✓
Not biodegradable	✗(for non-compostable plastics) ✓ (for compostable plastics)
Complex material	✗

Data shows that the global production of bioplastics has been increasing and this trend is set to continue with an expected increase from around 2.1 million tonnes in 2019 to 2.4 million tonnes in 2024 , of which about 50% is biodegradable (European Bioplastics’ annual market data update, 2018). However, compared to the total global production of plastics (350 million tonnes in 2017), bioplastics represents a very small market share (less than 1%). In Europe, bioplastics packaging has been increasing, however it still represents only 1% of the total share of the plastic packaging market (Eunomia et al, 2020).

Furthermore, there is a common confusion about the different terms used, such as ‘bioplastics’, ‘bio-based plastics’ and ‘biodegradable’/’compostable’ plastics. While currently there are no EU legal definitions of these terms, the European Commission has announced in its new Circular Economy Action Plan that it would develop in 2021 a policy framework on bio-based and biodegradable or compostable plastics in order to avoid consumer confusion and achieve genuine environmental benefits, going beyond reduction in using fossil fuels.

Bio-based plastic means that it is derived from bio-based feedstock (biomass) / renewable resources rather than fossil fuels, as is the case with conventional plastics (ADEME, 2016; Hann et al, 2020) . The feedstock for bio-based plastics can be corn, starch, sugarcane, cellulose and other. Bio-based plastics have however been criticised for sourcing produce intended for food production, similar to the debate around biofuels (van den Oever et al, 2017). This should indeed be avoided and bio-based plastics should instead come from feedstock not intended for food or from agricultural waste.

Bio-based plastic is also not necessarily biodegradable and/or compostable. All compostable plastic is biodegradable, while not all biodegradable plastic waste is necessarily compostable (ADEME, 2016). Biodegradation is a “chemical process during which microorganisms that are available in the environment convert materials into natural substances such as water, carbon dioxide, and compost” (European Bioplastics). There are however no harmonised EU standards on biodegradation. The process of biodegradation will depend on various conditions such as temperature, humidity and location (e.g. biodegradation on land, in water, in oceans etc.), as well as materials/polymers used (e.g. different types of plastics biodegrade at very different rates). Biodegradation will thus only take place under very specific conditions which are not necessarily found in a natural environment. Therefore labelling a plastic packaging as biodegradable can confuse consumers which might get the false impression that they can throw it into nature.

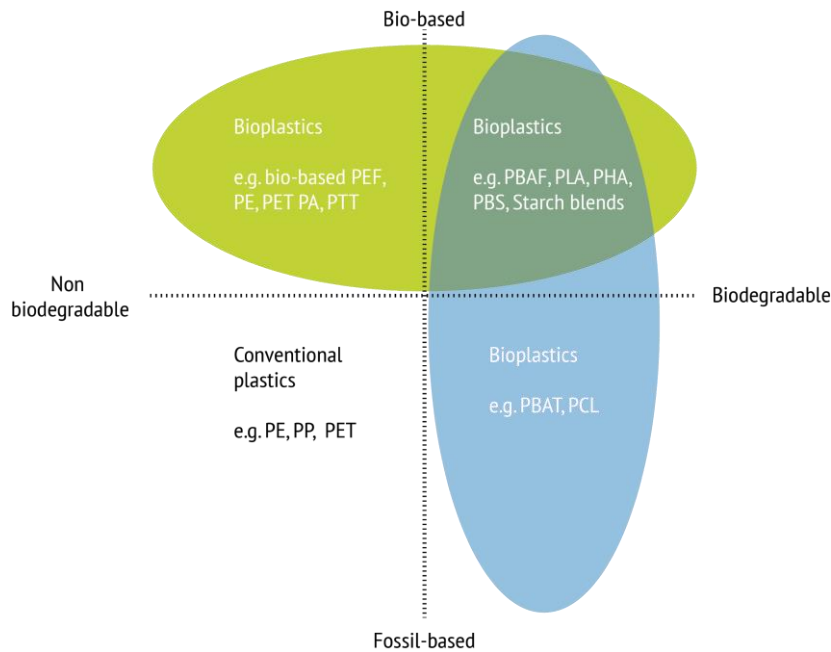
Compostability on the other hand is defined in the harmonised European standard EN 13432, which sets criteria for the industrial compostability of packaging, including plastic packaging. According to this standard, a biodegradation level of at least 90% must be reached in less than 6 months and 90% of the initial dry mass must disintegrate in less than 3 months. If these criteria are fulfilled, bioplastic packaging can be treated in industrial composting plants.

This standard however only applies to packaging recoverable by industrial- and not home- composting. There is currently no international or European standard on conditions for home composting of biodegradable plastics. There are a few national standards such as the Austrian norm AS 5810 “Biodegradable plastics - biodegradable plastics suitable for home composting”, and OK compost home certification scheme developed by Belgian certifier TÜV Austria Belgium, which requires at least 90% degradation in 12 months at ambient temperature.

The labels on the packaging should therefore clearly indicate the specific conditions under which the packaging is biodegradable, e.g. in industrial or home composting, in order to avoid consumer confusion. The upcoming EU policy framework will also address this issue by assessing the applications where the use of biodegradable or compostable plastics can be beneficial to the environment, and aiming to ensure that labelling a product as ‘biodegradable’ or ‘compostable’ does not mislead consumers to dispose of it in a way that causes plastic littering or pollution due to unsuitable environmental conditions or insufficient time for degradation.

The European Bioplastics Association has categorised bioplastics into three different types of bioplastics, which are shown in the below chart. These include bio-based (or non-fossil based) plastics which are biodegradable (e.g. PLA, PHA, starch blends); bio-based plastics which are non-biodegradable (e.g. bio-based PET, PE) and fossil-fuel based plastics which are biodegradable (e.g. PCL, PBAT).

Types of Bioplastics



Source: European Bioplastics

For the purpose of this study, the focus is on the two groups of bioplastics (bio-based plastics):

- Non-compostable/non-biodegradable bio-based plastics
- Compostable bio-based plastics

4.4.1 Non-compostable/non-biodegradable bio-based plastics

Today the most common non-biodegradable bioplastics derived from renewable resources, such as corn, sugar cane or cellulose, are bio-PET and bio-PE. Packaging made of these materials can be collected and recycled in existing standard plastic recycling facilities without fear of contamination and without complicating the recycling system.

The main advantage of bio-PET and bio-PE is that they have the same optical and physical properties as traditional fossil-based PET/PE, are fully recyclable and can be collected, sorted and recycled in the standard PET/PE recycling stream.

Other non-biodegradable bio-based plastics are PEF and PTF, which are furan polymers currently in development using 100% renewable sources, but not yet commercially available on the market. They are recyclable with a better gas barrier performance compared with standard PET. However, these materials may not be recyclable in the standard PET stream.

Arvid Nordquist

Description: Swedish family owned company producing a range of food and non-food products, including coffee. As part of their sustainability strategy, they introduced a 70% bio-based and renewable packaging for their coffee products. The remaining 30% is fossil-based material needed to seal and protect the coffee beans from oxygen exposure.

Country of origin: Sweden

Development Stage: Commercialised

Use: Coffee packaging

Packaging material: 70% Bio-PE from rapeseed sunflower oils and sugarcane, 30% fossil-fuel based plastics

Website: <https://www.arvidnordquist.com/coffee/sustainability/greener-packaging/>



Kraft Heinz Europe

Description: The Kraft Heinz company introduced bio-PET based ketchup bottles in 2011. It is now planning to make the Ketchup PET plastic bottle fully circular by 2022 by using recycled material that can be made back into food-grade packaging.

Country of origin: US

Development Stage: Commercialised

Use: Ketchup

Packaging material: Bio-PET

Website : <https://news.kraftheinzcompany.com>



4.4.2 Compostable bio-based plastics

Some of the biodegradable bio-based plastics or naturally biodegradable polymers are polylactic acid (PLA), polyhydroxyalkanoates (PHA) and Poly- β -hydroxybutyrate (PHB). PLA is the most common biodegradable bio-based plastic today. It is derived from renewable resources such as corn, starch, tapioca or sugar cane and used in bags, jars and films. PHA is biodegradable thermoplastics, produced by microbial fermentation of carbon-based feedstocks (Stefan, 2019). Furthermore, PHB is also seen to have potential, however the volume is still very low with high production costs.

Even though a product made of the aforementioned materials is biodegradable it can only be decomposed under specific temperature and humidity conditions in industrial composting facilities, and therefore not in home compost. Abandoned, littered or landfilled, it can take many years to fully biodegrade or might never fully biodegrade.

Another challenge with compostable plastics is the risk of contamination of the recycling process if these materials are mixed with conventional plastic in the recycling stream. For compostable bio-based plastics, separate collection for bio-waste is needed to enable industrial composting, which does not yet exist in all

EU Member States. This was also highlighted in the study “Relevance of Biodegradable and Compostable Consumer Plastic Products and Packaging in a Circular Economy” commissioned by the European Commission which states that: “Industrial composting and anaerobic digestion infrastructure as well as organic waste collection practices differ considerably across the EU and are not all effective at treating compostable plastic” (Hann et al, 2020). EU legislation however requires Member States to set up separate collection for bio-waste by 31 December 2023, which will improve the situation. Furthermore, a dedicated recycling/composting infrastructure is needed, which is a costly investment, and currently there is not enough volume of compostable bioplastics on the market to justify such an investment. Therefore, given the current situation of lack of efficient bio-waste separate collection systems and industrial composting facilities in many Member States, as well as the contamination potential of the plastic and bio-waste recycling streams, biodegradable or compostable packaging should be limited to certain applications where it can be beneficial to the environment.

One application where compostable bio-based plastics could be beneficial is in the agriculture sector. The EU-funded Multibiosol¹⁴ project (2015-2018) developed and demonstrated fully biodegradable mulching films and fruit protection bags for sustainable agricultural practices using biodegradable polymers from starch, corn, cereals, potatoes and vegetable oil. An OK soil biodegradability certification was reached in compliance with the EN 17033 standard (used for mulching applications in the agricultural sector not intended to be removed). Costs for farmers using the biodegradable plastic developed in the project were found to be negligibly higher compared to conventional plastics. The overall project results were positive showing reduction of non-renewable waste, reduced GHG emissions, improved soil and crop quality as well as savings in time for farmers (Multibiosoil Layman's report, 2018). There are other examples using biodegradable bio-based plastics in the agricultural sector, such as the mulch film Bio-Flex produced by the German company FKur which is certified using a different European standard EN 13432 used for biodegradable packaging designed for treatment in industrial composting facilities (Langenberg, 2020).

Sabert BePulp

Description: Sabert produces food containers made of plant based and renewable resources (starch). The containers disintegrate at a temperature of 65C in 120 days and as such must be composted in an industrial facility. The fact that it is laminated, is said to extend shelf life of the food content for up to 6 days.

Country of origin: Belgium

Development Stage: Commercialised

Use: Take-away or street food, suitable for both chilled and hot food containers

Packaging material: Starch-based PLA (polylactide)

Website: <https://www.sabert.eu/solutions/sustainable/>



¹⁴ LIFE 14 ENV / ES / 00486 / MULTIBISOL, <https://multibiosol.eu/en/>

BioCosi and EggPlant

Description: EU funded project together with the Puglia region and several other partners, Eggplant, a start-up developing 100% biodegradable and compostable bio-based plastics for food preservation and packaging using waste water from the dairy supply chain.

Country of origin: Italy

Development Stage: Research

Use: Various foods

Packaging material: PHA (polyhydroxyalkanoates) sourced from waste water in the dairy supply chain

Website: <http://www.eggplant.it/>



To summarise, when looking at the bio-based plastics packaging options, the origin of the feedstock is very important, making sure that the land use does not replace food production, that it maintains the sustainability of the agricultural production and that efficient separate waste collection systems and recycling or composting facilities are in place to ensure proper end-of-life treatment. At the same time, it should be ensured that the bio-based plastic packaging leads to genuine environmental benefits compared to other packaging solutions in order to avoid greenwashing and misleading the consumers.

The following table summarises some of the main benefits and challenges of **bio-based plastics (compostable and non-compostable) packaging:**

Benefits	
Non-Compostable	Compostable
<ul style="list-style-type: none">● Based on renewable resources● Decreased dependence on fossil-based raw material● Easily recyclable	<ul style="list-style-type: none">● Based on renewable resources● Decreased dependence on fossil-based raw materials● Compostable / biodegradable● Increased sustainable agricultural practice (mulch and fruit protection)

Challenges	
Non-Compostable	Compostable
<ul style="list-style-type: none"> ● Consumer confusion and risk of greenwashing ● Does not solve the single-use and littering problems ● Replacing food production and other negative externalities linked to agricultural production ● More expensive compared to fossil-based plastics 	<ul style="list-style-type: none"> ● Consumer confusion and risk of greenwashing ● Does not solve the single-use and littering problems ● Replacing food production and other negative externalities linked to agricultural production ● More expensive compared to fossil-based plastics ● Not enough volume, lack of investments ● Possible contamination of plastic/biowaste recycling stream ● Need separate collection of biowaste and industrial composting plants ● Lack of international/European standard for home composting

In addition to bioplastics, other new materials are being developed to replace fossil-based plastics, for example microbial cellulose, as described in the case below.

From Peel to Peel

Description: The project used microbial cellulose, a kind of pure cellulose produced by bacteria and yeasts, as a material to produce disposable packaging and disposable tableware, substituting paper and plastics. Fruits and vegetables' leftovers from the local producers were used in the production of cellulose enhancing the value of the entire cycle by using the useful parts thrown away.

Country of origin: Italy

Development Stage: Research

Use: Suitable for dry foods or short usage (takeaway or street food)

Packaging material: Symbiotic colony of bacteria and yeast used to grow cellulose

Website : <https://frompeeltopeel.tumblr.com/>



Furthermore, different coatings for packaging are being developed in order to replace plastics and increase the product's shelf life, such as for example Qwarzo.

Qwarzo

Description: Startup producing paper with special coating made of water, sand and alcohol, giving it similar properties to glass. Special sol-gel nanotechnology used creates a thin, flexible, strong layer of pure silica dioxide adhering chemically on any material making it water-proof and grease-proof.

Country of origin: France

Development Stage: Start-up

Use: All types of foods, including oily foods, ham and cheese, straws and cups

Packaging material: Paper (100% grease and water proof, home compostable)

Website : <https://www.qwarzo.com/>



4.5 Active / Intelligent Packaging

This category comprises packaging solutions that aim to go beyond their conventional purpose. These two trends of sustainable food packaging, active and intelligent packaging, are placed in the same category because they serve the same purpose which is minimising the loss of the product, be it the contained food product or the material that was used for the packaging.

Intelligent packaging is defined in Regulation (EC) No 450/2009 on Active and Intelligent Materials and Articles intended to come into contact with food. The Regulation defines it as packaging that contains a component that enables the monitoring of the condition of packaged food or the environment surrounding the food during transport and storage. Intelligent packaging is thus a system that provides the user with reliable and correct information on the conditions of the food, the environment or the packaging itself. This can help reduce food waste by delivering precise information on whether the food within has spoiled, or increase the recyclability of the packaging itself by improving sorting and recycling processes.

On the other hand, active packaging is designed to enhance the protection of the food product that is packaged, by enabling the release or absorption of substances into or from the packaged food or the environment surrounding the food. It is a system in which the product, the package, and the environment interact in a positive way to extend shelf life, improve the condition of packaged food or to achieve some characteristics that cannot be obtained otherwise. This can help reduce food waste by greatly increasing the shelf life of products, in particular fresh ones such as meat or cheese. A common solution is to integrate within the packaging either some element that reduces the development of microbial life, which can affect the safety of the product, or remove oxygen, which in the case of red meat for example, alters the appearance of the product, and thus its appeal.

The main benefits and challenges of **active and intelligent packaging** are listed in the table below.

Benefits	Challenges
<ul style="list-style-type: none"> ● Increases the shelf life of products ● Increases the safety and quality of food products ● Decreases human error and prevents inadvertent food waste ● Improves and increases sorting and recycling ● Increases sustainability of the whole food chain by replacing time-consuming, expensive and destructive analytical techniques used to monitor packaged food product (Intelligent packaging) 	<ul style="list-style-type: none"> ● Not fully technologically viable yet ● More expensive than conventional/virgin plastic packaging

Intelligent and active packaging have for now few commercially viable applications, as most applications are still in the research/pilot stage. The examples provided below do however demonstrate that once viable, these trends in packaging can deliver significant environmental and economic benefits. The first two examples are for intelligent packaging and the third one is for active packaging.

HolyGrail project

Description: Intelligent packaging with embedded digital watermarks, developed by Procter & Gamble, Tomra and Digimarc. This aims to significantly improve sorting of post-consumer packaging and as a result increase recycling. The use of watermark technology enables sorting facilities to distinguish between food and non-food packaging as well as to identify opaque, black or multilayer packaging, increasing its recyclability greatly.

Country of origin: US

Development Stage: Pilot

Use: For now, air and fabric fresheners, with aim to expand to all packaging.

Website: <https://www.newplasticseconomy.org/assets/doc/Holy-Grail.pdf>



Mimica Lab

Description: Temperature-sensitive indicator cap or label for food freshness. This cost-effective, intelligent packaging allows the consumer to accurately identify when the food really spoils, rather than relying on the (worst-case scenario) expiry date, which is often too early.

Country of origin: United Kingdom

Development Stage: Pilot

Use: Juice, dairy and red meat

Website : <https://www.mimicalab.com/>



Glopak

Description: This EU funded project aims to develop an active biodegradable packaging, that incorporates both oxygen scavengers that remove or decrease the level of oxygen in the package and antimicrobial emitters that release antimicrobial agents to suppress the growth of microorganisms, overall greatly extending the product's shelf-life.

Country of origin: France

Development Stage: Research

Use : Fresh foods (meat, cheese, etc.)

Website : <https://glopak2020.eu/about/>



5. Conclusions and Strategic Recommendations

In order to improve the sustainability of food packaging and reduce its environmental impacts, we need to transition from the current linear economic model of take-make-dispose, to a more circular economy model where food safety is prioritised alongside (packaging and food) waste prevention and reuse, followed by recycling. The coronavirus crisis has highlighted even more the need for a sustainable and resilient food system that can ensure access to sufficient and affordable food supply for citizens. Packaging is part of such a sustainable food system.

Several sustainability trends in the food packaging sector were identified in the study, including prevention/reduction of packaging waste (e.g. packaging-free supermarkets, lightweighting/reducing the amount of packaging used and edible packaging); reusable packaging; use of recycled materials; alternative materials to replace single-use plastics such as paper and bio-plastics; and active and intelligent packaging.

Each of these categories has its benefits and challenges and there is no one-fits-all packaging solution for all kinds of needs.

Many elements need to be taken into account when assessing the sustainability of food packaging, including environmental, climate, economic, legal, social and food waste considerations. Life cycle thinking should be integrated in this assessment taking into account the whole life span of the packaging and the packed food, based on the individual circumstances and characteristics of the food production process. Circular design has an integral role in achieving a more circular economy and includes questions related to the reduction of the weight/volume of the packaging used, stimulating reuse and recycling, as well as use of recycled and renewable materials. In addition to design for recycling, the existence of efficient waste collection and recycling systems/infrastructure also need to be integrated into the consideration of sustainable packaging solutions, in order to ensure that packaging is actually recycled.

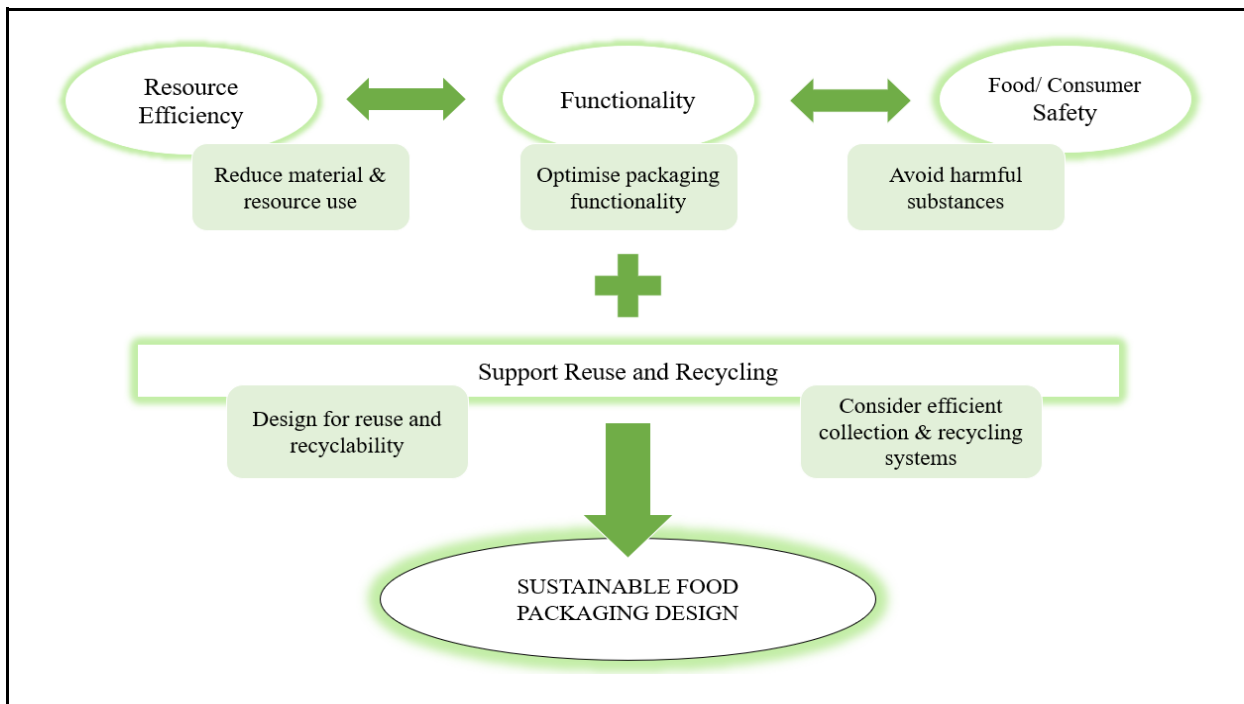
Based on the analysis conducted throughout this study, below is a list of recommendations for European businesses, EU and national policymakers, and NGOs and civil society, regarding sustainable food packaging, in order to drive Europe's transition to a circular economy, in which they play a key role. This transition is even more important in times of COVID-19 as resource-efficiency and the circular economy should be at the heart of Europe's recovery from the pandemic. It is also key in maintaining the progress towards the achievement of the UN Sustainable Development Goal 12 (Responsible Consumption and Production) by 2030. It is however crucial that the various stakeholders cooperate and bring forward multilateral solutions to tackle this issue and achieve a circular economy for food packaging. Furthermore, there is a need for a comprehensive political approach involving all political levels, from local, regional, national, European and international. Consumers also have an important role in making more sustainable food (packaging) choices.

5.1 Recommendations for European Businesses

There is no 'one-size-fits-all' solution for sustainable food packaging or the perfect choice of material as there are many variables and factors involved in the selection of packaging and each material has its strengths and weaknesses. Economic considerations are of particular importance, especially in the current context of COVID-19 pandemic. Among other factors, the recent pandemic has accentuated the fall in the price of oil, and as a result, virgin plastics. Choosing a solution that is both sustainable and economically viable has become more challenging. In order for businesses to reduce their environmental footprint and make more sustainable choices when it comes to food packaging, the following recommendations can provide useful guidance.

<u>Life Cycle approach</u>
<ul style="list-style-type: none"> ➤ Life cycle thinking approach should be used when assessing the sustainability of the food packaging (including direct and indirect environmental impacts) ➤ Packaging is only one part of the overall life-cycle of the packaged food and should be assessed together with the packed food, taking into account also the food waste considerations ➤ Life Cycle Assessments (LCAs) can provide a useful tool to determine the total environmental impacts of packaging
<u>Food packaging design</u>
<ul style="list-style-type: none"> ➤ Food/consumer safety should be the key priority (the use of harmful substances should be avoided) ➤ Reducing packaging and the overall amount of resources and energy used in its production (resource efficiency) ➤ Optimising the packaging functionality ➤ Promoting reuse and recycling ➤ Design for recycling should take into account two aspects, namely: <ul style="list-style-type: none"> ○ Is the packaging <i>recyclable</i>? In order to improve the recyclability of packaging, it is recommended to use mono-materials and mono-layers, as well as transparent or light colours and avoid black plastics and mixed materials which are difficult to recycle. ○ Will the packaging <i>actually be recycled</i>? It is recommended to look at whether efficient collection and recycling systems are in place that will enable the actual recycling. If the packaging is recyclable but is not actually recycled, its value is lost. ➤ Ensure adequate and clear labelling to avoid consumer confusion and inform about proper waste disposal options
<u>Guidance and training</u>
<ul style="list-style-type: none"> ➤ Various different tools and guidebooks are available on sustainable packaging design which can provide further guidance to European businesses (see more under Chapter 3)

The following graph summarises the key issues to consider in the design and selection of sustainable food packaging options.



1.1 ADS Insight Infographic on Design and Selection of Food Packaging Options, 2020

5.2 Recommendations for EU policymakers

Reinforced essential requirements for packaging
<ul style="list-style-type: none"> ➤ A comprehensive, clear and enforceable set of essential requirements for packaging under the current review of the Packaging and Packaging Waste Directive, to further promote waste reduction, reuse, high quality recycling and the use of recycled materials ➤ Ensure equal treatment of all packaging to prevent market distortion due to imported packages
Waste reduction
<ul style="list-style-type: none"> ➤ A set of meaningful targets and other waste prevention measures to reduce (over)packaging and packaging waste ➤ Consider setting further restrictions on packaging materials where reusable alternatives exist or where food products can be dealt with safely without packaging, and on the number of materials and polymers used to reduce complexity of packaging materials ➤ Reduce food waste by setting legally binding reduction targets and revising rules on date marking ('use by' and 'best before' dates)
Reuse

<ul style="list-style-type: none"> ➤ Introduce additional measures to support the reuse of packaging, also by setting quantitative targets for reuse of packaging in the Packaging and Packaging Waste Directive ➤ Promote the extension of deposit-return schemes beyond beverage bottles to include also other applications such as food containers
Recycled content
<ul style="list-style-type: none"> ➤ Promoting increased uptake of recycled materials including by setting mandatory requirements for recycled plastic content for certain food packaging while ensuring food safety
Bio-based and biodegradable packaging
<ul style="list-style-type: none"> ➤ A comprehensive EU policy framework on bio-based, and biodegradable and compostable plastics with clear definitions and labelling requirements to avoid consumer confusion and achieve genuine environmental impacts, and specifying applications where compostable plastics is appropriate ➤ Consider establishing an EU-wide standard on home composting
Separate collection
<ul style="list-style-type: none"> ➤ Improving separate collection systems for packaging and bio-waste including by harmonising separate collection systems and establishing EU-wide labelling
Design for recycling
<ul style="list-style-type: none"> ➤ Consider establishing an EU-wide definition of recyclability of (plastic) packaging, and promote discussions at a global level towards a global definition
Awareness raising, exchange of best practices, and funding
<ul style="list-style-type: none"> ➤ Promoting awareness raising and education across Europe about sustainable food packaging ➤ Facilitate and promote the exchange of best practices among Member States ➤ Further funding support for infrastructure and technology for collection, sorting, high quality recycling and composting, as well as for sustainable and innovative food packaging solutions, through e.g. Horizon Europe, LIFE, Cohesion Funds, EIB, Just Transition Fund, Recovery Fund ➤ Prioritisation of circular economy and promotion of circular/sustainable food packaging in light of the COVID-19 to drive Europe's recovery from the pandemic

5.3 Recommendations for National Governments

National and regional authorities are encouraged to
<ul style="list-style-type: none"> ➤ Ensure timely and complete transposition of revised EU legislation on waste and the Directive on Single-use Plastics ➤ Improve/put in place efficient Extended Producer Responsibility (EPR) systems for packaging, including eco-modulation of EPR fees to stimulate waste reduction, reuse and recycling, as well as use of recycled and renewable materials ➤ Make use of taxation and other economic incentives to promote the market for secondary raw materials ➤ Introduction/extension of deposit-return schemes for beverage and food packaging, to stimulate high quality separate collection and recycling ➤ Invest in infrastructure for collection, sorting, recycling and composting facilities and support sustainable and innovative food packaging solutions; avoid investments in incineration and landfilling ➤ Use green public procurement to support sustainable food packaging (reusable, recycled and renewable materials) ➤ Establish/improve separate collection systems for organic waste to improve recycling and industrial composting ➤ Promote awareness raising campaigns on sustainable food packaging, in cooperation with multi-stakeholder partnerships; the nudge theory can be a useful instrument to influence social behaviour and promote sustainable consumer choices; see ‘smartnudges.com’

5.4 Recommendations for NGOs and Civil Society

As NGOs and civil society at large have an important role in forging multi-stakeholder partnerships with an inherent potential to influence business and regulatory agendas, they are best suited to:

Disseminate knowledge and good practices
<ul style="list-style-type: none"> ➤ Help disseminate this study, share knowledge and best practices to promote sustainable food packaging solutions with genuine environmental benefits, and prevent consumer confusion and green washing. In particular, European and national consumer organisations can play an important role in promoting a shift in consumer behaviour and help increase the demand for sustainable food packaging.
Other examples of concrete measures and activities
<ul style="list-style-type: none"> ➤ Launching targeted awareness-raising and educational campaigns, to raise awareness about the importance of sustainable packaging in the context of sustainable consumption and circular

economy, as well as advocacy towards EU and national policymakers to help them make informed decisions

- The EU Platform on Food Losses and Food Waste can serve as a useful communication and dissemination tool
- Promote sustainable food packaging options i.a. by considering an award system for most innovative and sustainable solutions

6. Closing remarks and further research needs

Integrating environmental and circular economy aspects in the design of food packaging has been gaining ground. However, more efforts are needed to achieve a fully circular economy for food packaging, which will require multi-stakeholder collaboration and partnerships.

In terms of further research needs, total environmental impact assessments of the different packaging materials are needed to facilitate the decision towards a more sustainable, environmentally friendlier food packaging option, and avoid burden shifts. More focus should be given to innovation for further reduction of packaging and packaging waste, scaling up reusable packaging and innovative, recycled or renewable materials, and intelligent packaging. More knowledge on these areas would be key to accelerating Europe's transition to a circular economy and achieving the goals of the European Green Deal.

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Appendix

A. Sample of sustainable food packaging examples

Examples	Country	Category
Reseau Vrac	France	Prevention
BERNHARDT	France	Prevention
The Barn	Belgium	Prevention
Färm	Belgium	Prevention
Bepakt	Poland	Prevention
BIOreç	Poland	Prevention
Rifuzl	Slovenia	Prevention
Zelena Japka	Slovenia	Prevention
Das Gramm	Austria	Prevention
Svegro	Sweden	Prevention
Skogaholm	Sweden	Prevention
Santa Maria	Sweden	Prevention
Apeel	United States	Prevention
Nestlé	Switzerland	Prevention
Danone	France	Prevention
RETURNR	Australia	Reuse
Algramō 1.0	Chile	Reuse
MIWA	Czech Republic	Reuse
ALLGoods	Denmark	Reuse
Jean Bouteille	France	Reuse
Carrefour Bio "Bulk Wall"	France	Reuse
Ma Bonne Etoile	France	Reuse
Dabbawala	India	Reuse
Ecobox	Luxembourg	Reuse
SharePack	Netherlands	Reuse
Ozarka	Netherlands	Reuse
Recircle	Switzerland	Reuse
Waitrose 'Unpacked'	United Kingdom	Reuse
Less Mess	United Kingdom	Reuse
DabbaDrop	United Kingdom	Reuse
The Wally Shop	United States	Reuse
Fresh Bowl	United States	Reuse
Go Box	United States	Reuse
Ozzi	United States	Reuse
Liviri	United States	Reuse
Deliveroo	Belgium	Reuse
Deliveraround	Belgium	Reuse

Regio Delivery	Germany	Reuse
ReCircle	Germany	Reuse
Vanilla Bean	Germany	Reuse
ReCup	South Africa	Reuse
IVL Svenska Lkjöninstitutet	Sweden	Reuse
Loop	United States	Reuse
Revolv	United States	Reuse
Nestlé	Switzerland	Recycled content
Herta	Switzerland	Recycled content
Hellman's	Canada	Recycled content
Mars	United States	Recycled content
Klöckner Pentaplast	Germany	Recycled content
Detry	Belgium	Recycled content
Cellugy	Austria	Alternative Materials
Sabert	Belgium	Alternative Materials
Do Eat	Belgium	Alternative Materials
Melinda	Italy	Alternative Materials
Biopak	United Kingdom	Alternative Materials
Pond Biomaterials	Denmark	Alternative Materials
Paptic	Finland	Alternative Materials
Lactips	France	Alternative Materials
Green Gen Technologies	France	Alternative Materials
Cycle Pack	France	Alternative Materials
Alter Eco	France	Alternative Materials
LYS Packaging	France	Alternative Materials
Superseven	Germany	Alternative Materials
Ecovio	Germany	Alternative Materials
Arekapak	Germany	Alternative Materials
Green Box	Germany	Alternative Materials
Bioplastech	Ireland	Alternative Materials
UBQ Materials	Israel	Alternative Materials
Novamont Renewable Chemistry	Italy	Alternative Materials
Levissima	Italy	Alternative Materials
Zerbinati	Italy	Alternative Materials
From Peel to Peel	Italy	Alternative Materials
Fiorini International	Italy	Alternative Materials
Quarzo	Italy	Alternative Materials
KitKat Japan	Japan	Alternative Materials
Kaneka Corporation	Japan	Alternative Materials
Risupack	Japan	Alternative Materials
Futaruma	Japan	Alternative Materials

Suntory Tennensui	Japan	Alternative Materials
Ecoshell	Mexico	Alternative Materials
Kraftpak	Netherlands	Alternative Materials
Cateromarket	Poland	Alternative Materials
Makarun	Poland	Alternative Materials
CuanTec	United Kingdom	Alternative Materials
Green HOme	South Africa	Alternative Materials
Eco Pack	South Africa	Alternative Materials
Marine Innovation	South Korea	Alternative Materials
Greenlina	Sweden	Alternative Materials
Gaia	Sweden	Alternative Materials
Seelution	Sweden	Alternative Materials
StoraEnso	Sweden	Alternative Materials
Arla	Sweden	Alternative Materials
Skipping Rocks Lab	United Kingdom	Alternative Materials
University of New South Wales	United Kingdom	Alternative Materials
Marina Tex	United Kingdom	Alternative Materials
Eco To Go Food Packs	United Kingdom	Alternative Materials
Marinatex	United Kingdom	Alternative Materials
GoodStart Packaging	United States	Alternative Materials
TAG Packaging	United States	Alternative Materials
Elevate Packaging	United States	Alternative Materials
World Centric	United States	Alternative Materials
Graphic Packaging	United States	Alternative Materials
No Waste Technology	United States	Alternative Materials
Heinz	United States	Alternative Materials
Biomer	Germany	Alternative Materials
Biotec	Germany	Alternative Materials
TIPA	Israel	Alternative Materials
Egg Plant	Italy	Alternative Materials
Amcor	Switzerland	Alternative Materials
Loving Earth	Australia	Alternative Materials
Evoware	Indonesia	Alternative Materials
Buffalo Mozzarella PDO	Italy	Active / Intelligent Packaging
Mimica Lab	United Kingdom	Active / Intelligent Packaging
Marks & Spencer	United Kingdom	Active / Intelligent Packaging
HolyGrail project	United States	Active / Intelligent Packaging
Glopack	Belgium	Active / Intelligent Packaging
Spartech	Germany	Active / Intelligent Packaging
UPM Raflatac	Finland	Active / Intelligent Packaging

B. Interviews

Name	Position - Organisation
Greta Borg, Bastiaan Schupp, Jonathan Briggs	DG SANTE, European Commission
Peter Ragaert	Project Manager, Pack4Food (Belgium)
Johannes Weber	European Affairs Manager, Nestlé (Belgium)
Elena Schägg	Project Manager Circular Economy, Deutsche Umwelthilfe (Germany)
Clarissa Morawski	CEO & Director – Reloop Platform (Belgium)
Prof. Gregor Radonjič, Phd.	Professor, Head of Department of Technology and Environmental Protection, Faculty of Economics and Business, University of Maribor (Slovenia)
Asa Stenmarck	Group Manager, IVL (Sweden)
Svetlana Eskebaeck	Business Development Packbridge (Sweden)
Ann Lorentzon	Project Leader, RISE (Sweden)
Larissa Copello	Consumption and Production Campaigner, Zero Waste Europe (Belgium)
Karen van de Stadt	Packaging expert, KIDV (Netherlands)
Ana Fernández and Aida Cierco Corominas	Innovation Director, Food Packaging; and Global Sustainability Manager, Klöckner Pentaplast (Germany)

C. List of analysed EU legislation and policy

European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste, as amended with Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018

Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste, as amended with Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, as amended with Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018

Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food

Commission Regulation (EC) No 2023/2006 of 22 December 2006 on good manufacturing practice for materials and articles intended to come into contact with food

Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food

Commission Regulation (EC) No 282/2008 of 27 March 2008 on recycled plastic materials and articles intended to come into contact with foods

Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A European Strategy for Plastics in a Circular Economy COM/2018/028 final

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A new Circular Economy Action Plan For a cleaner and more competitive Europe COM/2020/98 final

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Closing the loop - An EU action plan for the Circular Economy COM/2015/0614 final

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system COM(2020) 381 final

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions The European Green Deal COM/2019/640 final

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation: options to address the interface between chemical, product and waste legislation COM/2018/032 final



European Economic and Social Committee

Rue Belliard/Belliardstraat 99
1040 Bruxelles/Brussel
BELGIQUE/BELGIË

Published by: "Visits and Publications" Unit
EESC-2020-69-EN
www.eesc.europa.eu



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Print
QE-03-20-534-EN-C
ISBN 978-92-830-4882-4
doi: 10.2864/539724

Online
QE-03-20-534-EN-N
ISBN 978-92-830-4881-7
doi: 10.2864/154293

EN