

Plastic food packaging waste



Plastic packaging is widely used in the food sector but plastic waste in the environment is a growing consumer concern. This POSTnote outlines the main options for reducing packaging waste (removing, reusing, replacing and recycling plastics) and examines the potential to combine them into a coordinated waste strategy.

Background

Plastic packaging is used widely within the food sector because it is cost-effective, hygienic, versatile, light and can extend shelf life.¹ However, plastic waste in the environment has become a key public concern, with recent surveys finding UK adults to be more concerned about plastic waste than Brexit, air pollution or climate change,^{2,3} and 82% trying to reduce the amount of plastic packaging they throw away.⁴ UK policies to reduce plastic waste have focused on increasing recycling. However, this is difficult as not all plastics are captured for recycling and some types of plastic are easier to recycle than others (Box 1).

In 2017, only 46.2% of UK plastic packaging from all sectors was collected for recycling.⁵ Of this 46.2%, 34% was recycled in the UK, with the rest exported for recycling.⁵ Since China banned imports of plastic waste in January 2018, some UK plastic waste is now exported to countries such as Indonesia and Malaysia.⁶ The poorer waste infrastructure in these countries means that only around 10% of all plastic waste is recycled, with the rest being landfilled, burned or entering the environment.⁷ Globally, around 8 million tonnes of plastic packaging enter the oceans each year.⁸ This has led environment groups to call for greater emphasis on policy options to reduce unnecessary packaging, and promote the reuse of packaging materials

Overview

- Options for reducing packaging waste are reducing, reusing, replacing and recycling.
- Each of these can have both positive and harmful environmental effects; this balance can be assessed through life cycle analysis.
- Reducing the variety of packaging plastics would simplify waste recovery processes.
- These options potentially conflict with each other. Unless strategies are well-coordinated, attempts to reduce plastic waste could be ineffective and piecemeal.
- Reform of the waste recovery funding system could help fund consistent waste collections and improved infrastructure.
- Plastic waste is a global, complex problem that requires cooperation both internationally and across supply chains.

Box 1: Types of plastics in food packaging

In the UK, over 2.2 million tonnes of plastic packaging are placed on the market each year.⁵ Some types of plastic are more readily recycled than others. Easily recyclable plastics include:

- Polyethylene terephthalate (PET): used in drinks bottles, yoghurt pots, ready meal containers and fresh produce trays.
- High-density polyethylene (HDPE): used in milk bottles.
- Polypropylene (PP): used in yoghurt pots and trays.

Plastics may be problematic to recycle due to cost-effectiveness, food waste contamination or other physical considerations. Among the types of plastic that are inherently more difficult to recycle are:

- Thin films/flexible packaging/plastic bags: often made from low density polyethylene (LDPE) which is difficult and costly to recycle.
- Composites containing multiple materials: these include coated food trays and laminated materials with a foil layer.
- Polystyrene (PS): used in takeaway containers, some yoghurt pots and plastic cutlery.
- Polyvinyl chloride (PVC): used in some shrink-wrap, packaging and labels. Not widely recycled as it generates hazardous by-products.
- Black plastics: used to improve the appearance of food, for instance in prepared meat trays. These are not generally recognised by the optical systems used in plastics recycling facilities, unless near infra-red reflecting colourants are added.

and the use of alternative materials⁹ as well as increase the efficiency of plastics recycling. All of these can play a role in delivering the UK Government's recent pledge to phase out single-use disposable plastic packaging (Box 2).

Box 2: Legislative background

At the EU level, the Commission has set a framework that will require member states to ensure all plastic packaging placed on the market will be reusable or recyclable by 2030.¹⁰ The EU Single-Use Plastics Directive will impose a ban by 2021 on 10 of the most commonly littered plastic items, including plastic straws, cutlery, plates and drinks stirrers.¹¹ The UK may not be bound by EU-set targets following Brexit, but the government's 25 Year Environment Plan for England (January 2018)¹² pledged to eliminate avoidable plastic waste by 2042. The UK Government's Resources and Waste Strategy (December 2018)¹³ sets out proposals to achieve this.

Reducing and reusing plastic packaging

Options to reduce packaging include:

- **Loose fruit/vegetable aisles**, which are being offered by some major retailers. Many fruits and vegetables can be barcoded using laser marking, a technique used widely by the Swedish supermarket ICA.¹⁴
- **Packaging-free shops or dispensers** where consumers bring their own containers to buy bulk products. For example, Algramo in Chile sells rice, beans, lentils and sugars from automatic dispensers across 1,600 stores.¹⁵
- **Returnable schemes** such as Loop, a new ecommerce platform launched this year in Paris and New York.¹⁶ This subscription service delivers products in durable packaging that is collected, washed and refilled. The meal-delivery service Deliveroo has recently launched a trial in Oxford and Cambridge to allow customers to return containers for reuse.¹⁷ Similar schemes operate for takeaway outlets in some regions of the USA.¹⁸
- **Supplying food ingredients in concentrated form** to reduce packaging. Waterdrop, for instance, sells compressed cubes of plant/fruit extracts to be diluted in tap water as an alternative to plastic bottled drinks.¹⁹
- **Monetary incentives** for customers that reuse food containers, such as coffee cups. Most major coffee retailers offer discounts for customers who bring reusable cups, although such schemes often only have a modest uptake.^{20,21} In Switzerland, customers pay a deposit for takeaway containers from restaurants participating in the Recircle project which is refunded if they return it.²²
- **More public water fountains**. The Drinking Fountains for London project aims to install over 100 fountains across the capital from spring 2019 to reduce usage of plastic bottles.²³ A similar initiative in Amsterdam has been included in efforts to decrease childhood obesity levels by reducing soft drink consumption.²⁴

However, reducing or removing plastic packaging can have disadvantages. Packaging-free shops may potentially pose hygiene risks from inadequately washed containers and removing packaging may reduce the shelf-life of products, such as salad items, which could increase food waste and greenhouse gas (GHG) emissions from landfill.¹ For instance, cucumbers wrapped in plastic last up to 15 days at chilled temperatures and 5 days at ambient temperatures, compared with 9 and 2 days for unwrapped cucumbers.²⁵ Furthermore, if removing packaging places increased reliance on a low temperature supply chain, then the GHG emissions from the energy used in refrigeration may

Box 3: Life Cycle Analysis (LCA)

Focusing on a material's end-of-life disposal can cause environmental and resource costs from production and use to be overlooked. LCA considers the environmental impacts caused throughout the whole value chain. Often LCA is reduced to a single component, such as carbon emissions, producing widely different interpretations between studies. For example, estimates for the number of times a cotton bag should be used before being disposed of vary from 131 to 7,100.^{26,27} More systematic LCA analysis of different packaging materials might consider resource use in manufacturing; land use; greenhouse gas (GHG) emissions; release of pollutants; effects on food waste; impacts on human health; and number of uses and recyclability. The limited LCA data available tends to suggest that many alternatives to plastic food packaging would increase GHG emissions by increasing food waste and transport costs.²⁸ One estimate suggests that replacing plastic packaging in Europe with traditional materials would increase GHG emissions by a factor of 2.7, equivalent to the annual CO₂-emissions of Denmark.²⁹ Besides environmental effects, packaging has wider economic and social effects; for instance, producing compostable packaging material can provide income to farming communities.³⁰ Typically, packaging choice is a trade-off between different effects and is ultimately determined by a primary objective such as minimising GHG emissions.

outweigh those associated with plastic packaging. However, alternative edible coatings (for instance, made from guar gum, potato starch and pea starch) can preserve perishable fruit and vegetables, such as cucumbers and tomatoes, and may also have antimicrobial activity.^{31,32} Conversely, re-usable items, such as coffee cups, use more resources and energy to produce and can require high usage to offset this.³³

Replacing plastic packaging

Where packaging is necessary, plastic can be replaced with more readily recycled materials or compostable packaging.

Glass, metal, paper/card and carton board

Glass and metal packaging have high recycling rates (67.6% and 71.3%, respectively)³⁴ and can be recycled indefinitely. However, this is energy intensive and contamination often means that collected glass is recycled into aggregate for construction rather than new food or drink containers. Also, the limited data from life cycle analysis (LCA, Box 3) suggest that replacing plastic with glass and metal could lead to an overall increase in GHG emissions, since plastic is lighter to transport.²⁹ Paper/cardboard has a recycling rate of 79.0% and can promote sustainable forestry if derived from certified sources.^{34,35} Nevertheless, it can only be recycled a limited number of times.³⁶

Laminated carton boards, such as milk and juice containers, use paper board lined with a plastic (and sometimes aluminium) layer and can reduce the overall plastic content of liquid containers, ready meal trays and take-away containers. Many local authorities collect cartons and send these to a dedicated plant in Halifax (which also recycles coffee cups).^{37,38} The paper board can be recycled for paper rolls, tissue paper and food packaging, and the plastic lining is used in garden furniture and construction materials.³⁷ There is scope to use carton board more widely within the food industry, including for ice cream containers.

Compostable packaging

Certified industrially-compostable packaging is designed to break down in a closed composting facility with collected food waste. Such packaging is made from paper/card, plant material (such as sugarcane or cellulose) and certain compostable plastics. The term 'compostable' should not be confused with 'biodegradable', which has no recognised standard.³⁹ Products carrying 'biodegradable' claims may take years to breakdown fully or disintegrate into microplastic fragments that are now widespread pollutants.^{40,41} While some compostable materials are also suitable for home composting, others will persist in the environment.^{42,43}

A major advantage of compostable food packaging is that it is compostable when contaminated with food waste. This contrasts with plastic packaging, where food waste contamination renders it unsuitable for recycling, so that much of it is landfilled (where it emits GHG). Composting also produces an organic product to fertilise soils. However, for compostable packaging to be effective, separate food waste collections are required. Some local authorities in England currently lack such collections, but the government has proposed for them to be mandatory by 2023.^{13,44} One potential drawback is that most food waste is currently treated in anaerobic digestors, which are mostly not suitable for compostable packaging.⁴⁵ In general, compostable packaging may be best suited for closed environments with dedicated compostable collections (see POSTnote 606).

In addition to food waste collections, other policy options to promote the use of compostable materials include:

- introducing a UK-wide on-pack logo (the lack of which means that much packaging is incorrectly disposed of).
- investing in local collections and composting facilities.
- requiring specific items to be compostable, such as coffee pods, fruit labels and (as in France and Italy) plastic bags.

The proposed EU Directive prohibiting plastic cutlery, plates, stirrers and straws by 2021 has already prompted many retailers to adopt compostable versions.¹¹

Novel materials

Research into biodegradable materials from new sources covers a wide range of materials, including:

- **Food waste** – such as chitin contained in mushrooms and the outer skins of insects and crustaceans, which can be made into packaging material.³⁰ It is estimated that over 10,000 tonnes of chitin may be available each year from waste products of the shellfish industry.⁴⁶ Potential materials also include fruit peels and cutin, a waxy compound in plant leaves and tomato skins.³⁰
- **Seaweed** – is a renewable resource that has already been made into compostable food packaging, including pouches and sauce sachets.³⁰ For example, 'Ooho' is an edible, seaweed-based membrane containing a single portion of water or other fluid. 30,000 Ooho capsules were given out in the 2019 London Marathon.⁴⁷
- **Other materials** – new materials have been used to replace specific types of packaging. For instance, beeswax wraps can be used to replace clingfilm,⁴⁸ and coffee cups have been made from edible wafers.⁴⁹

Box 4: Chemical recycling technologies

Chemical recycling technologies break down plastics to their constituent parts and could potentially recover value from problematic plastics (e.g. sweet wrappers and crisp packets). These include thermal recycling (pyrolysis) which uses high temperatures in the absence of oxygen to break down plastic polymer chains.⁵⁰ This results in a petrochemical raw material that can be used as feedstock for fuels or to make more plastic polymers. Tesco recently launched a trial to send previously unrecycled plastics collected in their stores to UK-based company Recycling Technologies for thermal recycling.⁵¹ US chemical firm Eastman is investigating a similar process that uses a combination of heat, pressure and methanol.⁵² Earlier-stage technologies are looking at selectively degrading plastics using catalysts or enzymes to convert plastics into polymer building blocks or new materials such as novel additives and high-value carbon nanotubes.^{53,54} The UK has the expertise to lead in chemical recycling but this would require sustained investment over 5–10 years.⁵³

An advantage of using food waste or seaweed is that they do not compete with food crops for land-use. However, unless novel materials achieve economies of scale they will remain 'niche' applications. There is also concern that food contact regulations may not fully address potential allergy and toxicity issues associated with novel materials.⁵⁵

Recycling plastic packaging

Current UK recycling is mainly based on kerbside collections organised by local authorities. These are partly funded through a producer responsibility scheme where manufacturers purchase PRNs (Packaging Recovery Notes) or PERNs (Packaging Export Recovery Notes) to contribute to the cost of recycling/recovering the materials they produce.⁵⁶ This system has been criticised for inefficiencies and a lack of transparency, with calls for it to be reformed.⁵⁷

Current issues with UK recycling

- **Widespread confusion as to what can be recycled**, exacerbated by geographical variation in recycling schemes and vague on-pack labelling.
- **Poor economics** – in the UK, PRN revenue only covers 10% of the cost of processing all packaging waste, with the burden of cost paid by local authorities.⁵⁸ The PRN market system also means that it is often more economical to export collected materials for recycling, where its fate is not clear.⁵⁷ There is a limited market for recycled material to remain in the UK, since virgin plastic is typically cheaper and higher quality.
- **Material variation** – the wide variety of plastic packaging (Box 1) and use of inks and glues reduces the amount and quality of plastic material recovered.
- **Non-circularity** – recycling cannot be performed indefinitely because it shortens plastic polymer chains. EU regulations for materials in contact with food restrict the use of recycled content to a quality only currently met by PET bottles and HDPE milk bottles,⁵⁹ so other plastics are typically 'downcycled' into other, non-food, applications.

Options for increasing plastic recycling

Besides new developments in recycling technologies (Box 4), potential ways to recycle more plastic packaging include:

- **Standardising waste collections.** The government has proposed that local authorities collect a common set of materials, including food waste, by 2023.⁴⁴ This would enable a national recycling colour scheme and facilitate simple on-pack labelling. The charity WRAP has devised a framework for this, with three variants to cater for different geographic regions.⁶⁰ Concerns include high infrastructure costs (replacing bins) and the fate of collected materials if there is no concurrent investment in recovery/recycling facilities.⁶¹ See also POSTbrief 33.
- **Using taxation to increase the market for recycled material.** Most plastic packaging is made from virgin material. In the 2018 budget, the UK Government proposed a plastic packaging tax on products containing less than 30% recycled content in an attempt to generate a UK market for recycled plastics and reduce overseas exports.⁶² The packaging industry has expressed concerns such as a lack of material to supply demand, restrictions on using recycled content in food contact applications, impacts on the export market, and difficulty in enforcement.⁶³ See also POSTbrief 33.
- **Deposit return schemes (DRS) for drinks containers.** The UK Government has proposed DRS for glass, plastic and aluminium drinks containers, although it is not clear if this will include all bottle sizes or be restricted to smaller, 'on-the-go' sizes.⁶⁴ Scotland has announced that it will introduce DRS in 2021 for all drinks containers between 50 ml and 3 litres.⁶⁵ DRS can capture materials that evade kerbside collections and improve the quality of recyclate but are expensive for the volume of material they collect.⁶⁶ DRS is already in place in many European countries, although it is uncertain if it would work as well in the UK (see POSTbrief 33).

Funding a more circular economy

Many local authorities already struggle with budget cuts and would require additional funding to increase recycling collections.⁶¹ Furthermore, investment is also needed for improving UK waste infrastructure and researching new technologies. One of the main options for this is to introduce an **Extended Producer Responsibility (EPR) scheme**. This would involve packaging manufacturers and importers paying the full net cost of collecting, transporting, sorting and recycling waste, and educating consumers about recycling.⁶⁷ It may also include clean-up of litter and fly-tipping, although the industry questions if it should be held responsible for these activities.⁶⁸ A model where easy-to-recycle products pay lower fees could ultimately 'design-out' problematic plastics (Box 1). The UK Government has proposed to introduce EPR for packaging from 2023.⁶⁷ Other options for funding a more circular economy include:

- **Innovation funds.** The UKRI 2017–18 Plastics Research and Innovation Fund awarded £20 million to projects that included chemical recycling; changing consumer behaviour and designing out plastic materials.⁶⁹ In 2018, an additional £60 million fund was announced.⁷⁰
- **Challenge funds.** For example, the NextGen Cup Consortium is offering a \$1 million 'challenge fund' to design a more sustainable coffee cup.⁷¹

Coordinated waste strategies

There is wide consensus that voluntary initiatives need to be supported by a coordinated waste strategy enforced by legislation. However, no single measure is likely to be effective in reducing plastic packaging waste. For example, imposing a plastic packaging tax will not increase use of recycled content without investment in recycling infrastructure that can deliver high-quality material.⁷² DRS could lead to the diversion of high-quality recyclate from local authorities, causing them to lose revenue unless they receive funding from EPR.⁷³ Industry is generally more accepting of EPR than DRS, since it could fund investment in standardised collections and new recycling facilities.^{74,75}

One challenge will be to unite these strategies in a coherent framework that can sustain an efficient waste resources model. To date, most packaging has been designed according to short-term aims, rather than from an end-of-life perspective. It is widely acknowledged that more collaboration is needed across all parts of the food chain, including retailers, brands, packaging designers, manufacturers and waste recyclers to design functional products that support a circular economy. In April 2018, WRAP and the Ellen MacArthur Foundation launched The UK Plastics Pact, a collaboration bringing together businesses, NGOs and policy-makers. Members commit to achieving targets by 2025, such as eliminating unnecessary single-use packaging and ensuring all plastic packaging is reusable, recyclable or compostable.⁷⁶

International cooperation

Combatting marine waste has been a key driver behind reducing single use plastics. Most (55–60%) plastics enter the ocean from China, Indonesia, the Philippines, Vietnam and Sri Lanka, with the shores of the US, UK and Europe accounting for less than 2%.⁷⁷ Tackling the root cause of marine plastic will require international cooperation and policies that ultimately reduce the export of packaging waste to these countries. The UK Government has pledged £61.4 million to help developing Commonwealth nations to improve waste management⁷⁸ and is a member of the Commonwealth Clean Oceans Alliance.⁷⁹ Global brands can also drive change, including through voluntary partnerships such as the Alliance to End Plastic Waste⁸⁰ and the Africa Plastics Recycling Alliance.⁸¹ Other options include:

- Funding increased waste infrastructures in developing countries through an EPR scheme.
- UK sharing of best practice to assist countries with poor waste management.
- Increasing the transparency of the global trade in plastic waste through international agreements.⁸²
- Certification schemes to set waste standards. For example, Catch Plastics works with businesses to contain microplastics at the source of production.⁸³
- Investment in strategies to recover plastics from the environment. For instance, the Netherlands-based Ocean Cleanup foundation is trialling using unmanned floating barriers to passively remove plastics from the oceans.⁸⁴

Endnotes

- ¹ Evidence Review: Plastic Packaging and Fresh Produce. WRAP, November 2018
- ² Cited in Abundance Investment, sixth Great British Money Survey
- ³ Plastic Waste Research. Delineate, April 2018
- ⁴ YouGov survey, April 2019
- ⁵ Recoup : UK Household Plastics Collection Survey 2018
- ⁶ Recycling: Where is the plastic waste mountain?. BBC News, 1st January 2019
- ⁷ Kaza, S et al.. What a Waste 2.0 : Washington, DC: World Bank 2018
- ⁸ The new plastics economy: rethinking the future of plastics and catalysing action, Ellen MacArthur Foundation December 2017
- ⁹ A Plastic Planet, Accessed May 2019
- ¹⁰ Closing the loop: Commission delivers on Circular Economy Action Plan. Press Release, European Commission, 4th March 2019
- ¹¹ Circular Economy: Commission welcomes Council final adoption of new rules on single-use plastics to reduce marine plastic litter, European Commission Press Release, 21st May 2019
- ¹² A Green Future: Our 25 Year Plan to Improve the Environment, DEFRA, January 2018
- ¹³ Resources and waste strategy for England, December 2018
- ¹⁴ ICA, Our Sustainability Work, Extensive work on reducing the volume of plastic
- ¹⁵ How one Chilean startup is bringing an end to single-use plastics, 4th July, 2018, The Guardian
- ¹⁶ Loop, <https://loopstore.com/> Accessed May 2019
- ¹⁷ Deliveroo to trial food container reuse service, Packaging News, April 2019
- ¹⁸ GO Box, Accessed May 2019
- ¹⁹ Waterdrop, Accessed May 2019
- ²⁰ Starbucks disposable coffee cup charge trial, July 2018 Impact Report, Hubbub
- ²¹ Poortinga, W & Whitaker, L, Promoting the Use of Reusable Coffee Cups through Environmental Messaging, the Provision of Alternatives and Financial Incentives. Sustainability 10,3 (2018): 873.
- ²² The Story of Recircle Zero Waste Consumption & Production, Zero Waste Europe
- ²³ Drinking Fountains for London, Greater London Authority 2019
- ²⁴ Amsterdam's solution to the obesity crisis: no fruit juice and enough sleep, The Guardian, 14th April 2017
- ²⁵ Dhall, R et al, Effect of shrink wrap packaging for maintaining quality of cucumber during storage. Journal of food science and technology 49.4, 495-499, 2012
- ²⁶ Life cycle assessment of supermarket carrier bags: a review of the bags available in 2006. Environment Agency, February 2011
- ²⁷ Lifecycle Assessment of Grocery Carrier Bags, Ministry of Environment and Food of Denmark, February 2018
- ²⁸ How packaging contributes to food waste prevention, Denkstatt (2014/2017)
- ²⁹ The impact of plastic packaging on life cycle energy consumption and greenhouse gas emissions in Europe, Denkstatt, July 2011
- ³⁰ Exploring the potential for adopting alternative materials to reduce marine plastic litter. United Nations Environment Programme Report, May 2018
- ³¹ Moalemiyan, M. & Ramaswamy, H, Quality retention and shelf-life extension in mediterranean cucumbers coated with a pectin-based film. Journal of food research 1.3 (2012): 159.
- ³² Vignesh, R. M., and Bindu R. Nair. Improvement of shelf life quality of tomatoes using a novel edible coating formulation. Plant Science Today 6.2 (2019): 84-90
- ³³ Analyse du cycle de vie des tasses réutilisables et des gobelets à usage unique, International Reference Centre for the Life Cycle of Products, Processes and Services (CIRAIG) October 2014. As quoted by Reusable or Disposable: Which coffee cup has a smaller footprint?, Pierre-Olivier Roy, Anthropocene Magazine, July 2017
- ³⁴ UK Statistics on Waste, Department for Environment, Food & Rural Affairs (DEFRA), March 2019
- ³⁵ Forest Stewardship Council, Accessed May 2019
- ³⁶ An introduction to Packaging and Recyclability, WRAP, November 2009
- ³⁷ UK Carton Recycling Plant, ACE-UK, Accessed May 2019
- ³⁸ Paper Cup Recovery and Recycling Group, Progress Report, October 2018
- ³⁹ What is the difference between 'biodegradable' and 'compostable'? European Bioplastics, Accessed May 2019.
- ⁴⁰ Biodegradable Plastics and Marine Litter. Misconceptions, Concerns and Impacts on Marine Environments. UN, 2016
- ⁴¹ Marine Microplastic Pollution, POSTnote 528, 5th June 2016, POST
- ⁴² Lambert, S and Wagner, M Environmental performance of bio-based and biodegradable plastics: the road ahead. Chemical Society Reviews 46,22, 6855-71, 2017
- ⁴³ Biodegradable Plastics: Approaches and experiences from 16 Members of the EPA Network, November 2018. European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Plastics – Working paper
- ⁴⁴ Consultation on consistency in household and business recycling collections in England, Department for Environment, Food and Rural Affairs, February 2019
- ⁴⁵ Kale, Gaurav, et al. Compostability of bioplastic packaging materials: an overview. Macromolecular bioscience 7, 3, 255-77, 2007.
- ⁴⁶ Hamed, I., Özogul, F., & Regenstein, J. M. (2016). Industrial applications of crustacean by-products (chitin, chitosan, and chitoooligosaccharides): A review. Trends in Food Science & Technology, 48, 40-50.
- ⁴⁷ London marathon runners to be given edible water bottles as organisers vow to cut down on plastic waste, The Telegraph, 13th April 2019
- ⁴⁸ The Beeswax Wrap Co. www.beeswaxwraps.co.uk/ Accessed May 2019.
- ⁴⁹ Cupffee crispy drinking, www.cupffee.me/ Accessed May 2019.
- ⁵⁰ Rahimi, AliReza, and Jeannette M. Garcia. Chemical recycling of waste plastics for new materials production. Nature Reviews Chemistry 1,6, 0046, 2017
- ⁵¹ Tesco starts trial to recycle 'unrecyclable' plastic packaging. Packaging News, 2nd April 2019
- ⁵² Eastman in the Circular Economy. Accessed May 2019.
- ⁵³ Personal communication University College London, Plastic Waste Innovation Hub, March 2019.
- ⁵⁴ Hedayati, A et al, A. Chemical recycling of consumer-grade black plastic into electrically conductive carbon nanotubes, C 2019, 5, 32; doi:10.3390/c5020032
- ⁵⁵ Biobased materials used in food contact applications: workshop hosted by the Food and Environment Research Agency (FERA). Thursday 11th April 2019, Institute of Minerals and Mining.
- ⁵⁶ Packaging waste: producer responsibilities, 9th May 2014
- ⁵⁷ National Audit Office Report: The Packaging Recycling Obligations, July 2018
- ⁵⁸ Plastic bottles: Turning Back the Plastic Tide. House of Commons Environmental Audit Committee, December 2017
- ⁵⁹ Food contact material applications: regulations and guidance, European Food Safety Authority
- ⁶⁰ A framework for greater consistency in household recycling in England, WRAP, September 2016
- ⁶¹ Statement: The Local Authority Recycling Advisory Committee (LARAC): LARAC responds to Consistency Consultation, 15 May 2019
- ⁶² Plastic Packaging Tax, Consultation Document, HM Treasury, February 2019
- ⁶³ Statement, British Plastics Federation, October 2018
- ⁶⁴ Consultation on introducing a Deposit Return Scheme in England, Wales and Northern Ireland, Department for Environment, Food and Rural Affairs, February 2019
- ⁶⁵ Scotland's bottle return scheme deposit to be set at 20p, BBC News, May 2019
- ⁶⁶ Institute of Economic Affairs study: A load of rubbish? Introducing a Deposit Return Scheme to the UK, 14th April 2019
- ⁶⁷ Consultation on reforming the UK packaging producer responsibility system, Department for Environment, Food and Rural Affairs, February 2019
- ⁶⁸ Foodservice Packaging Association, personal correspondence May 2019.
- ⁶⁹ New plastic research projects announced, UK Research and Innovation (UKRI) Press Release, 18th December 2018
- ⁷⁰ Food scraps could be turned into environmentally friendly plastic packaging Press Release, Department for Business, Energy and Industrial Strategy, December 2018
- ⁷¹ Accelerating the future of the fiber cup, NextGen Cup Consortium
- ⁷² Veolia, evidence session: Implications of the Waste Strategy for Local Authorities, Housing, Communities and Local Government Committee, Monday 20th May 2019, Portcullis House, Westminster.
- ⁷³ Statement: The Local Authority Recycling Advisory Committee (LARAC): LARAC response to DRS Consultation, 17 May 2019
- ⁷⁴ Statement, Foodservice Packaging Association, May 2019
- ⁷⁵ Statement, British Plastics Federation, May 2019
- ⁷⁶ WRAP, The UK Plastics Pact, Accessed May 2019
- ⁷⁷ Jambeck, Jenna R., et al. Plastic waste inputs from land into the ocean. Science 347,6223, 768-71, 2015
- ⁷⁸ UK Government rallies Commonwealth to unite on marine waste, Press release, GOV.UK, 18th April 2018
- ⁷⁹ Commonwealth unites to end scourge of plastic, Press Release, GOV.UK, 15th April 2018
- ⁸⁰ Alliance to End Plastic Waste, Accessed May 2019
- ⁸¹ The Africa Plastics Recycling Alliance – Waste and Opportunity, Diageo, 26th March 2019.
- ⁸² Plastic waste, Marine Plastics Litter and Microplastics, Overview, Basel Convention, Accessed May 2019
- ⁸³ Catch Plastics, Accessed May 2019
- ⁸⁴ The Ocean Cleanup, Accessed May 2019