
PLASTICS
A GUIDEBOOK FOR
THE BOOK CHAIN PROJECT
PUBLISHERS
BOOK
CHAIN
PROJECT

INTRODUCTION

The first man-made plastic was made publicly available in the UK in 1856. Throughout the 1930s and 40s, new types of plastic were synthesised. By the 1950s, polyethylene terephthalate (PET), polyethylene (PE) and polystyrene (PS) were all made in mass production. Since then, over 8.3 billion tons of plastic have been produced worldwide[1].

Most plastic today is made from fossil fuel-based building blocks, ethane and propane, derived from refining crude oil and natural gas[2].

A great advantage – and now, it seems, a curse - of plastic is its resistance and endurance to wear and tear. A plastic bottle, for example, will take roughly 450 years to degrade[3]. This incredible longevity made plastic the material of choice, transforming retail, food, and many other industries.

But now the adverse effects of plastic's long-life are coming in to sharp focus, with attention from regulators and the public centred on single-use plastics, which make up 40% of all plastic waste[4]. It is estimated that 12 million tonnes of plastic enter our oceans every year[5]. If this rate continues, there will be more plastic than fish in the world's oceans by 2050[6].

Consumers are calling on legislators and business to reduce single-use plastics, especially in packaging. Business responded by signing the UK Plastics Pact; a collaboration of the plastic value chain, the UK government, and non-governmental organisations (NGOs). The Pact sets four targets to reach by 2025[7]:

- 100% of plastic packaging is reusable, recyclable or compostable
- 70% of plastic packaging is effectively recycled or composted
- Eliminate single-use packaging
- 30% average recycled content across all plastic packaging

The UK Government has plans to tax non-recycled plastic packaging by 2022[8] to spur progress towards these targets. The EU has similar measures to make all plastic packaging recyclable by 2030[9] and is aiming for a complete ban on single-use plastic by 2021. Early in 2018, the EU has also adopted a new plastics strategy that is aiming for better design of plastic products, boost recycled content, increase plastic recycling rates and curb plastic waste[10].

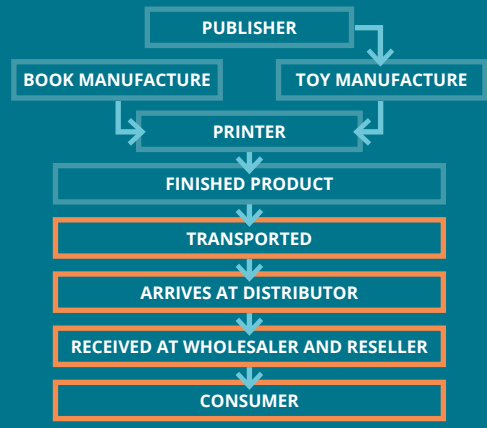
A plastic bottle will take roughly 450 years to degrade

1 http://advances.sciencemag.org/content/3/7/e1700782.full
2 http://advances.sciencemag.org/content/3/7/e1700782
3 https://www.postconsumers.com/2011/10/31/how-long-does-it-take-a-plastic-bottle-to-biodegrade/
4 https://wedocs.unep.org/bitstream/handle/20.500.11822/25496/singleUsePlastic_sustainability.pdf
5 https://friendsoftheearth.uk/plastics
6 https://www.ellenmacarthurfoundation.org/publications/the-new-plastics-economy-rethinking-the-future-of-plastics
7 http://www.wrap.org.uk/content/the-uk-plastics-pact
8 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/752202/Budget_2018_red_web.pdf
9 https://ec.europa.eu/unitedkingdom/news/tackling-plastic-pollution-commission-sets-2030-target-make-all-plastic-packaging-recyclable_en
10 https://www.bbc.co.uk/news/world-europe-45965605 and http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-annex.pdf

WHAT DOES THIS MEAN FOR THE PUBLISHING INDUSTRY?

The issue with plastic is how it is being used. The big focus is on removing single use plastic wherever possible and, when it has to be used, creating a closed loop by using recycled content or ensuring the waste product gets recycled. For the publishing sector, when we're talking about single use plastic it's mostly in the context of packaging, particularly in the later stages of the supply chain (see highlighted steps in diagram, below). However, it's worth noting that toys mounted to the covers of books and children's magazines also risk being labelled as 'single use' if they're not made to last.

In keeping with the aims of the Book Chain Project, we've produced this guide to help our publishers make informed decisions around the design, purchasing and production of their books, magazines and journals. It shares an overview of the situation today, looks at some of the common misconceptions, charts the new developments in this area, and presents good practice from other sectors. We conclude with five specific recommendations to will help our publishers to make the right decisions, innovate, and use plastic responsibly.



*Note that some toys included with books/magazines risk being labelled 'single use' if they are not made to last

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PLASTICS

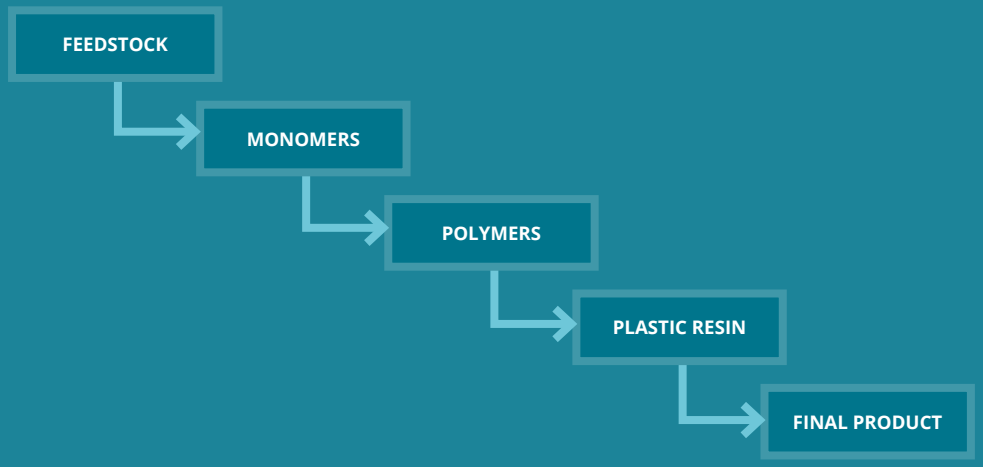
HOW PLASTICS ARE MADE

Plastics begin with a feedstock, most commonly a fossil fuel like crude oil, which is a complex mix of different chemicals. A series of processes break down these feedstocks into simple chemicals called monomers, which are selectively recombined with additives and colourants to help achieve the properties of a desired plastic. This process of recombination, called polymerisation, results in a plastic resin, otherwise called raw plastic, which is delivered to manufacturers either as a powder or pellets.

This general process is outlined in the diagram below, but importantly each plastic can be produced from one or more different feedstocks. As mentioned above, most plastics we are familiar with are derived from crude oil; however a growing awareness of fossil fuel depletion and the environmental impacts associated with extracting such products is leading to the emergence of so-called 'bioplastics'.

The term 'bioplastic' is incredibly broad and can be used to denote one of a few different things. The term is used either:

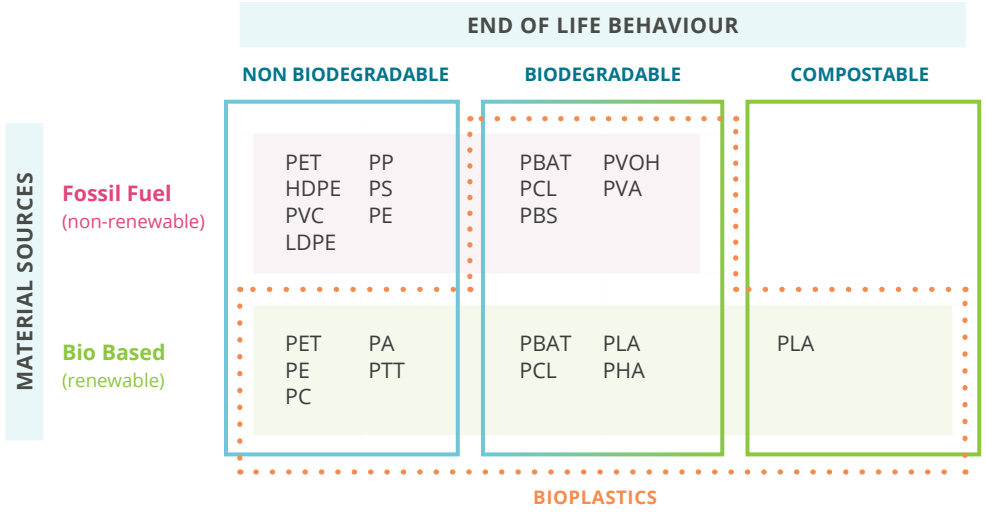
- to show that a plastic is made from a bio-based feedstock that can be grown as a crop such as starch or cellulose derived from sugarcane (for the purpose of this guide, we will refer to these as bio-based plastics), or
- it is used to describe the end-of-life properties of a plastic and whether or not it is biodegradable.



SOURCE MATERIAL

Fossil-fuel based plastics are the most commonly used plastics because of their various favourable properties, such as durability, strength and low density. Fossil-fuel based plastics are often non-biodegradable; however, there are many biodegradable fossil-fuel based plastics too, which are sometimes referred to as 'bioplastics'.

Bio-based plastics can behave exactly like their non-renewable counterparts, but are derived from biological sources such as corn, potatoes, and wood pulp, rather than from crude oil. Not only can bio-based plastics be made to have the same properties as fossil-fuel based plastics with the same chemical structure (which is why there are sometimes bio and non-bio versions of the same plastic e.g. PET and bio-PET), they can also have properties which fossil-fuel based plastics cannot, such as compostability.



A common misconception on bio-based plastics

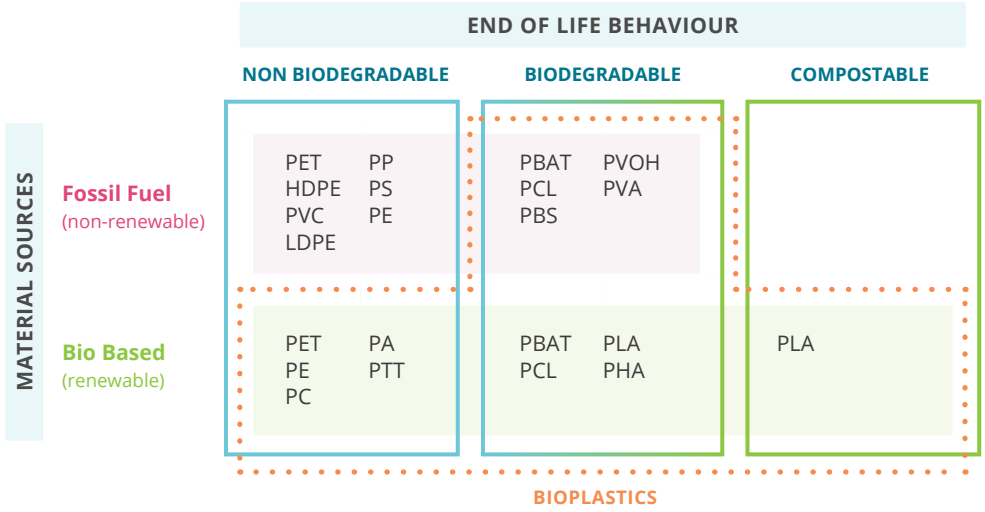
THEY ARE NOT PLASTICS!

- This is not true. Bio-based polymers can be chemically identical to fossil fuel-based plastics and mimic the same physical properties.
- The term 'bio' in bio-based plastics does not mean that the plastic is necessarily biodegradable! It refers to the nature of the material used to make the plastic and does not necessarily dictate how this plastic will behave at the end of its life.
- Plastics often referred to as 'bioplastics' cover all plastics made from bio-based materials as well as plastics that are fossil-fuel based and biodegradable, such as PBAT (see diagram, above).

END OF LIFE BEHAVIOUR

Both fossil-fuel based and bio-based plastics can be designed to behave in two different ways. They can either be non-biodegradable or biodegradable. Some biodegradable plastics can also be compostable (see diagram, right).

Technically all plastics, even fossil-fuel based plastics, degrade to some degree, particularly under controlled conditions. However not all plastics are biodegradable. All plastics, if exposed to light and water, will degrade over a period of time, however in the case of most fossil-fuel based plastics this process can take hundreds of years and release harmful chemicals to the environment. A plastic is considered biodegradable if this process can be aided by biological processes, typically through the action of microorganisms. However, not all biodegradable plastics will decompose under the conditions found in a backyard compost heap, but instead need to be processed in a specialist bioreactor, requiring a different waste management system to regular food waste.



A common misconception on bio-based plastics

THEY ARE ALWAYS BIODEGRADABLE!

- This is not true. Not all bio-based plastics are biodegradable or compostable – some are non-biodegradable. Some bio-based plastics are non-biodegradable because they will last for years and can release harmful chemicals into the environment.
- Not all biodegradable plastics are bio-based plastics – some are fossil-fuel-based plastics.

BIODEGRADABLE PLASTICS AND THE PROBLEM OF MARINE PLASTIC POLLUTION

The main benefit of biodegradable plastic is that it can eventually break down completely. Yet, few natural environments can bring about this process completely or in a reasonable time frame, especially marine environments. Most biodegradable plastics will only fully break down in industrial composting facilities which use specially controlled conditions to aid the decomposition process. This means that if disposed of incorrectly, biodegradable plastics can persist in the environment long enough to cause harm to nature. There is also evidence which suggests that people are more likely to litter if they know a product is biodegradable, meaning that biodegradable plastic items are more likely to become pollution than non-biodegradable ones[11]. The culmination of these issues has led the United Nations to the conclusion that an increased use of biodegradable plastics will not improve the plastic pollution problem as it affects the marine environment, both in terms of the sheer amount of plastic and its chemical impact[12].

Unless the use of biodegradable plastics is matched with increased consumer awareness, product collection, and industrial treatment, biodegradable plastics should be seen as similar to non-biodegradable plastics, with all the associated negative environment impacts.

There is evidence which suggests that people are more likely to litter if they know a product is biodegradable, meaning that biodegradable plastic items are more likely to become pollution than non-biodegradable ones

[11] http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20study.pdf via https://europa.eu/capacity4dev/unep/document/biodegradable-plastics-and-marine-litter-misconceptions-concerns-and-impacts-marine-environ

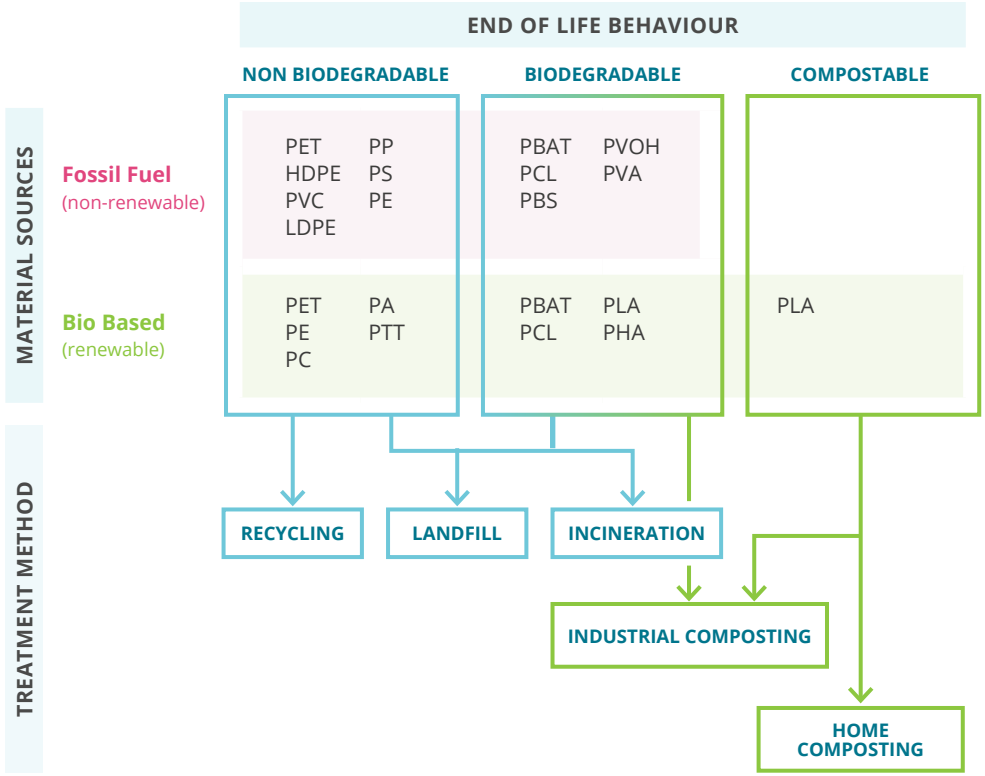
[12] https://europa.eu/capacity4dev/unep/document/biodegradable-plastics-and-marine-litter-misconceptions-concerns-and-impacts-marine-environ

SUITABILITY FOR RECYCLABILITY

There is a strong misconception around the materials used to make plastics and how this impacts their end of life treatment. Most consumers may know that bio-based plastics are made from plant matter for instance, but they might not know that only non-biodegradable plastics can be recycled, or that a landfill does not allow a compostable product to adequately decompose[13].

Non-biodegradable plastics can be recycled only when collected through specific recycling routes. Only about half of non-biodegradable plastics can be recycled – the rest must enter landfill or be incinerated[14]. In 2016, approximately 32% of non-biodegradable plastics were recycled; 38% were incinerated with energy recovery; and 30% entered landfill in the UK. EU-wide, 31.1% were recycled; 41.6% were incinerated with energy recovery; and 27.3% entered landfill in 2016. Globally, the figures are very different: in 2015, 19.5% were recycled; 25.5% incinerated; and 55% entered landfill or were otherwise discarded[15]. Non-biodegradable plastics cannot enter the composting route without risking contaminating the final compost produced[14].

A biodegradable plastic is designed to decompose relatively quickly in the environment. Biodegradable plastics cannot enter other recycling routes without risking contaminating non-biodegradable plastics because of additives to aid the breakdown process. Finally, biodegradable plastics can only be composted when they meet specific composting standards[13].



[13] http://www.wrap.org.uk/sites/files/wrap/Understanding%20plastic%20packaging%20FINAL.pdf
[14] https://ourworldindata.org/grapher/plastic-waste-polymer
[15] https://www.plasticseurope.org/application/files/5715/1717/4180/Plastics_the_facts_2017_FINAL_for_website_one_page.pdf and https://ourworldindata.org/faq-on-plastics#how-much-of-global-plastic-is-recycled

A common misconception on bio-based plastics

THEY ARE ALWAYS RECYCLABLE!

- This is not true. Biodegradable plastics (both fossil-fuel based and bio-based) cannot be recycled using the same treatment method as non-biodegradable plastics.
- Presently in the UK, biodegradable plastics have no kerbside recycling or recovery options.

The biggest barrier to recycling in many countries is the limited presence and capability of recycling infrastructure. In some cases, the processing facilities are just not there. This leads many local areas to specify which types of plastic they treat and which ones they don't, leading to potential confusion when moving between different systems. Once the recyclable waste has been correctly separated and collected, it may be shipped abroad for processing. As at June 2018, the UK only has capacity to recycle 9% of its plastic waste[16].

Composting is one such waste stream which is extremely variable. Many councils in the UK do not collect food waste for composting because they don't have the capacity for industrial composting treatments. Furthermore, the councils that do collect food waste tend to use a process called anaerobic digestion (AD) to turn waste into biogas and a compost-like biomass, which keeps the waste in a sealed container in the absence of oxygen, whereas most biodegradable plastics are designed to decompose in the presence of oxygen. As a result, many industrial composting facilities do not accept biodegradable plastics, instead removing them from the waste stream and disposing of them via landfill or incineration[17].

Products made from a mixture of materials which cannot easily be separated are also hard to process during recycling. Sachets and specially designed bottles of layered plastic and aluminium, used for sauces, dried food and crisps are particularly hard to separate and are currently unrecyclable. Products containing plastic and cardboard laminated or fused together are also tricky. Some companies like Marks and Spencer (M&S) have begun to tackle this by reducing the amount of plastic used. For example, in 2017, M&S redesigned and repackaged their popcorn and crisps into packets which were 37% smaller, but contained the same amount of food, and used fewer, thinner layers of plastic film[18].

[16] www.theguardian.com/environment/2018/jun/14/recycled-plastic-could-supply-three-quarters-of-uk-demand-report-finds
[17] http://www.recyclingwasteworld.co.uk/in-depth-article/whats-the-problem-with-plant-based-packaging/178541/
[18] https://www.theguardian.com/environment/2017/jul/18/ms-slashes-plastic-use-in-food-packaging-to-cut-waste

Even once the recyclable waste has been correctly separated and collected, it may be shipped abroad for processing. As at June 2018, the UK only has capacity to recycle 9% of its plastic waste

THE CHALLENGES OF USING RECYCLED CONTENT

Simply designing a product to be recyclable does not necessarily mean that it won't end up in a landfill site. For recycling facilities to be economically viable there must be a market for the recycled product, and this is not always the case.

One of the main factors limiting the market appeal for recycled plastics is that some recycled plastics are worth more than others. Clear plastic bottles, for instance, are most desirable and fetch a higher price, while coloured plastic gets a lower price as the colour limits its reuse potential. Recycled polystyrene has almost no market and is therefore hardly ever recycled[19]. No market means there is very little use in putting those items in the recycling bin in the first place, as they will end up in landfill anyway.

... the European Commission (EC) will develop, by mid-2019, a specific decision-making methodology to support decisions on the recyclability of waste containing substances of concern.

There are other factors which complicate this cycle. Once the plastic has been melted into pellets and remoulded, the strength of the polymer bonds are often reduced. This makes it harder to recycle again and changes the potential application of the new plastic item. This is why most recycled plastic tends to end up in a select number of (lower quality) products, namely waste bins, bin bags, plant pots, benches etc[20]. Before this century, it was almost impossible for a plastic product to be remoulded and used again for its original purpose, but in 2007, M&S won an award for achieving this milestone, launching the world's first plastic milk bottle made using recycled material[21].

Another complication is the risk of re-introducing "legacy chemicals" into the supply chain when old plastics are recycled. Those legacy chemicals are toxic substances that are now restricted but may be present in products recycled from older materials, thus re-introducing chemicals of concern into the supply chain. This is proving to be a greater challenge for those industries with more stringent restrictions, such as food and toys for example. This is why, as part of the European Union's (EU) actions to tackle hazardous substances in waste, the European Commission (EC) will develop, by mid-2019, a specific decision-making methodology to support decisions on the recyclability of waste containing substances of concern. As the EC is also expecting an increased use of recycled materials in new products, including the use of recycled plastics in food packaging to meet the EU plastic strategy, they are also planning to authorise over one hundred plastic recycling processes that have been considered safe by the European Food Safety Authority[22,23].

Whilst increasing the amount of plastic that is recycled could indeed reduce the demand for virgin plastic, there is a limit to the number of times a plastic product can be recycled. The properties that make plastic so useful all rely on the material's long flexible polymer chains. Yet, each time a plastic is recycled these chains are damaged and get shorter[24], limiting its use and recyclability.

Companies have been tackling these problems for a while. Their stories are useful to understand how manufacturers have overcome these and other barriers, and what new innovative strategies are being developed and applied (see the 'Evian' [p14] and 'Innocent' [p15] case studies) .

19 https://www.bbc.co.uk/news/science-environment-45496884
20 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2873020/
21 https://corporate.marksandspencer.com/media/press-releases/archive/2007/30032007_marksspencerlaunchestheworldsfirstplasticmilkbottleusingrecycledmaterial
22 https://chemicalwatch.com/63228/eu-sets-out-actions-to-tackle-hazardous-substances-in-waste-products
23 https://www.euractiv.com/section/energy-environment/news/is-recycled-plastic-safe-for-food-packaging-eu-seems-to-think-so/
24 https://www.huffingtonpost.co.uk/entry/how-many-times-can-one-plastic-bottle-be-recycled_uk_5bc9b98be4b0d38b58771df3?guccounter=1&guce_referrer_us=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_cs=vCsYCBRDIcseWDaCowpXUg

THE CHALLENGES OF USING BIO-BASED PLASTICS

A recent study from Morgan Stanley Research found that only 1% of global plastics are produced from bio-based materials. On average these are more expensive than the fossil-fuel based equivalent, which means that a bottle made from bio-based plastic could cost as much as 50% more than the fossil-fuel based equivalent[25]. Despite this and according to the industry body European Bioplastics, the demand for bio-based plastic could grow by 20% in the next 3 to 5 years, reflecting the strength of opinion on this issue[26].

As the feedstock used to produce bio-based plastics are usually plant based, they consume CO2 via photosynthesis whilst they grow which reduces the carbon footprint of the product. Bio-based plastics can be designed to be recycled, composted or burnt again for fuel, creating closed resource loops in production which reduces the demand on natural resources, and can help offset the initial cost of the product[27].

However bio-based plastics predominantly lose out in comparison to fossil-fuel based plastics is on the amount of land, water, pesticides and fertilizers they require to grow the feedstock[28]. The use of agricultural material can also introduce a whole new suite of human rights issues, from competition with food, biofuel and feedstock production to land rights conflicts and issues of forced or migrant labour.

Furthermore, the use of biodegradable bio-based plastics, more specifically the end of life treatment of those plastics, can produce methane - an incredibly potent greenhouse gas, when disposed of in landfill sites[29]. Many bio-based plastics need high temperatures and oxygen rich conditions to decompose, but such commercial facilities are not yet mainstream in the UK.

Several businesses, including Lego, Nestle and Danone are presently working to advance this field (see case studies below). These businesses work alongside initiatives that have been developed to ensure the sustainable sourcing of plant feedstock for bioplastic production. Here are a few examples of those initiatives:

- **Bioplastics Feedstock Alliance (BFA)**[30]: Overseen by World Wide Fund for Nature (WWF) and set up by a group of global brands. It aims to tackle the issues involved in sourcing raw materials for bio-based plastic production.
- **Chain of Custody (COC)**: There have been some successes in applying a chain of custody to bio-based plastics, in a similar way to how wood pulp in books is managed and tracked throughout its supply chain. For example, a company called Corbion managed to successfully apply the first COC to a bio-based plastic material in 2017: PLA made from sugarcane[31].
- **Existing raw material standards**: Some raw materials already have industry specific standards and certifications to encourage sustainably managed supply chains. Sugarcane, for instance, already has its own individual standard, administered by the non-profit Bonsucro, which allows the end products to be certified as sustainably sourced much like the Forest Stewardship Council (FSC) for wood pulp[32].

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25 https://www.morganstanley.com/ideas/bioplastics-single-use-plastic?cid=230047639:431712533:108823932#
26 https://www.britishplastics.co.uk/materials/bioplastics-expected-to-see-20-percent-growth-over-next-five/
27 http://www.bpf.co.uk/press/oil_consumption.aspx and https://www.ellenmacarthurfoundation.org/publications/the-new-plastics-economy-rethinking-the-future-of-plastics
28 https://www.researchgate.net/publication/233135576_Bioplastics_and_Petroleum-based_Plastics_Strengths_and_Weaknesses
29 http://content.time.com/time/magazine/article/0,9171,1983894,00.html
30 http://bioplasticfeedstockalliance.org/who-we-are/
31 https://www.bio.org/sites/default/files/0230PM-Derek Atkinson.pdf
32 https://www.bonsucro.com/what-is-bonsucro/

case study 1

LEGO

Lego has committed to stop the production of fossil-based plastic blocks by 2030. This year, they released their first line of bio-based plastic products: 25 different little Lego trees and leaves which are made from plant-based polyethene (PE)[33]. Plant-based PE has a much lower carbon footprint than the conventional plastic, because as the plant feedstock grows it fixes CO_2 from the atmosphere into sugars. But sugarcane farming, one of the main sources of this bio-based plastic feedstock, has a range of environmental concerns, including excessive water use, soil erosion, and deforestation[34].

Lego has taken significant steps to ensure that their plant-based PE is sourced responsibly by partnering with WWF and joining the BFA to secure sustainable raw materials for its products, which were certified by third parties using established global standards for sugarcane sourcing. Lego are careful to note, however, that this will not make the blocks biodegradable. Because the bio-based PE polymers are technically the same as the fossil-fuel based polymers, they too will be non-biodegradable but still are recyclable[35].

The bio-PE material is still not strong enough to be used in the regular Lego blocks. Lego have therefore invested 1bn Danish Krone in their own Sustainable Materials Center to research sustainable alternatives for their full range of products[33].

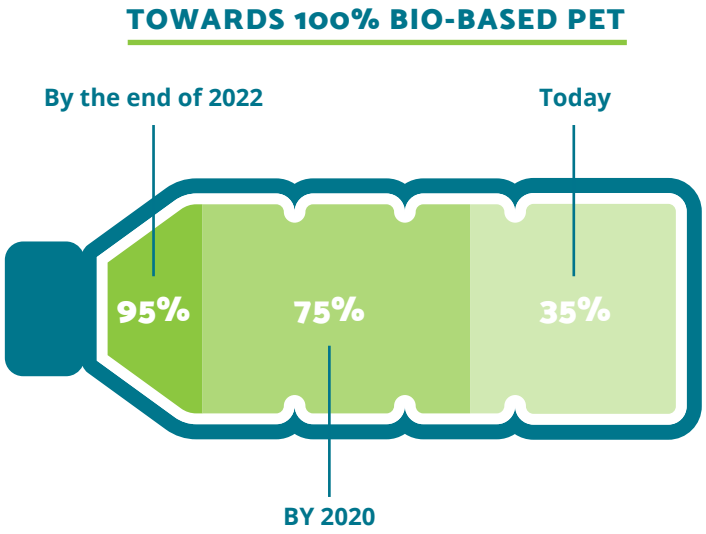
Image © Lego. Source: Lego, news room, 2018. https://goo.gl/7LfBM8

[33] https://www.lego.com/en-us/aboutus/news-room/2018/march/pfp
[34] https://www.worldwildlife.org/industries/sugarcane
[35] https://www.bbc.co.uk/news/business-43383607

case study 2

NESTLÉ / DANONE

A collaboration between Nestlé, Danone and a US start-up Origin Materials created the NaturALL Bottle Alliance in 2017. They are working together to pioneer a 100% bio-based PET material for their water bottles, made from biomass feedstock, namely recycled cardboard and sawdust. At the moment, the maximum use of bio-based material in a PET product has been 30%, so a 100% renewable and recyclable plant-based PET is a breakthrough[36]. Using wood-based material also removes the issues of channelling edible material towards plastic production rather than food production, but then brings into question the sourcing of the wood fibre and its potential impact on deforestation. This new innovation will be rolled out in 2020 and will be made available to the food and beverage industry.[37]



Source: Nestlé Waters. https://goo.gl/xZZgLL

[36] https://www.nestle.com/media/news/naturall-bottle-alliance-welcomes-pepsico (case study Nestle&Danone)
[37] https://www.nestleusa.com/media/pressreleases/nestle-waters-launch-alliance-naturall-bio-based-bottles (case study Nestle&Danone)

OUR RECOMMENDED ACTIONS

1. REDUCE THE USE OF PLASTICS

Plastic has caused serious problems for our natural environment, marine life and our human health. The first step in tackling plastic pollution is to reduce the amount we use, with the main target at the moment being packaging and 'single-use' plastic products.

Some of the first pieces of legislation aimed at tackling this have been outright bans on certain plastics, for example the EU ban on use of single-use plastic items by 2021 and the zero avoidable plastic waste in the UK by 2050. These have been quickly adopted by businesses[9,38]. Closely following these bans, we've seen the European Commission set a target to make all plastic packaging recyclable by 2030, which triggered over 20 public consultations on plastic from the UK Government and many new laws being introduced[11,9]. Finally, as previously mentioned, many businesses are signing up to the UK Plastic Pact and committing to their four targets around plastic packaging[8].

With this in mind, step one in your plastic journey should be to:

- Understand your plastic supply chain: Where are plastics being used? What are they sourced from? What are their end of life behaviours? How much plastics are being used?
- Identify which plastics are avoidable and which ones are not.
- Reduce where possible the use of plastics.

The first step in tackling plastic pollution is to reduce the amount we use, with the main target at the moment being packaging and 'single-use' plastic products.

[38] http://ec.europa.eu/environment/circular-economy/pdf/single-use_plastics_proposal.pdf

case study 3

M&S

In January 2019, M&S announced it was to start selling many fruit and vegetables without any plastic packaging, as part of its aim to remove over 1,000 tons of plastic packaging from its business by Spring 2019. They have replaced plastic packaging for many items of produce with traditional paper bags, and are selling more delicate items like soft fruits and berries in compostable punnets[39].

[39] https://corporate.marksandspencer.com/media/press-releases/5c2f8d617880b21084450f5e/m-and-s-trials-plastic-free-produce-as-it-accelerates-plastic-reduction-plan

Image source: https://corporate.marksandspencer.com/media/multimedia-library

2. USE MORE RECYCLABLE PLASTICS

One might argue that using biodegradable plastics is much better than using recyclable plastics. In concept this might be true, however, due to the lack of proper communication around the use and disposal of biodegradable plastics to end consumers, and due to the lack of infrastructure offered by governments to collect and treat such plastics, there is a concern that biodegradable products might do more harm than good. With a clear lack of customer awareness and infrastructure, the likelihood of biodegradable plastics contaminating recycling routes or ending up in landfill is currently very high.

On the other hand, if a plastic can be recycled, it extends the useful life of the product – even if it is single-use. Recycling brings into the mix the possibility of re-use and closed-loop plastic production. This is why step two in your plastic journey should be to use more recyclable plastics. To do this, you need to know which plastic material can be recycled and whether the infrastructure to process this material is in place or not, because this is not guaranteed.

If more manufacturers increase their use of recycled materials, such as recycled PET (rPET), we could expect to see investment in recycling infrastructure to try and meet these demands.

Recycling brings into the mix the possibility of re-use and closed-loop plastic production.

case study 4

EVIAN

Evian has committed to make all its plastic water bottles from 100% recycled plastic by 2025. They also want to start using their own bottles as the feedstock, thereby creating a closed-loop system. Through a collaboration with Loop Industries, Evian has developed a technology that takes all forms of PET waste, including their own bottles, and transforms it into the high-quality plastic needed to make new bottles[40]. So far, they have reached 25% rPET content.

They are also investing heavily in the end of life of their bottles to ensure they are being recycled and that they are closing the loop. They have partnered with Citeo and major non-alcoholic beverage industry players and retailers to help educate consumers on the importance of recycling and are working to increase the deployment of local collection facilities to help achieve their goals of a circular economy[41].

[40] https://uk.reuters.com/article/us-danone-evian-plastic/danones-evian-vows-to-use-100-percent-recycled-plastic-in-bottles-by-2025-idUKKBN1F70RZ
[41] https://circular.evian.eco/the-loop/citeo

Image: https://circular.evian.eco/pages/7zMJ3xU2k0ga46e6uwAuig

3. USE MORE RECYCLED CONTENT

Increasing the percentage of recycled plastic used in products and packaging creates a closed-loop in plastic production as it encourages more plastic to be recycled. It also means less virgin plastic, meaning less fossil fuels and energy used, and a lower carbon footprint[42].

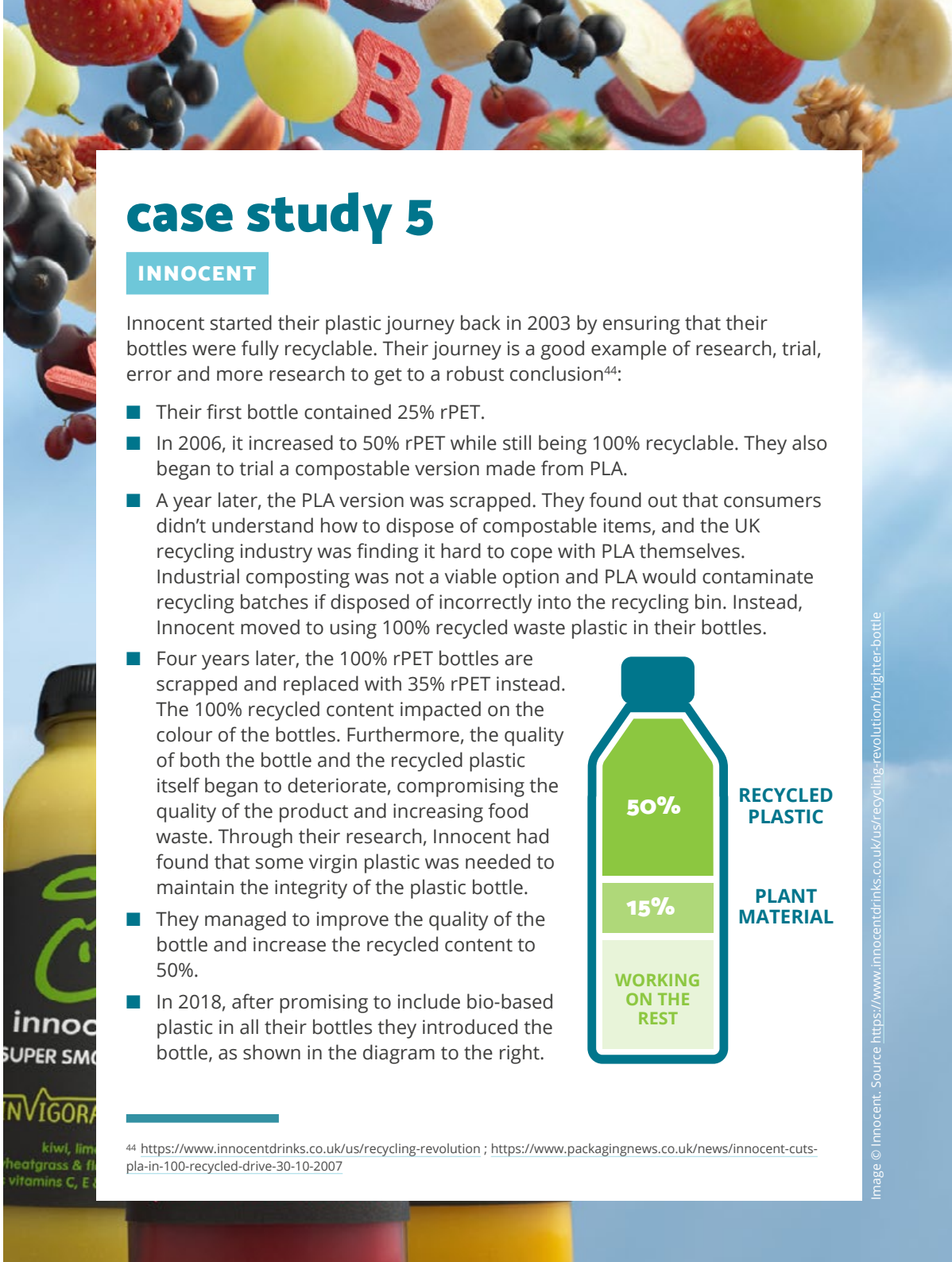
Both the UK and the EU are expecting an increase in the use of recycled material in new products to meet their recently established targets. Today, with consumers expecting clear actions from businesses on plastics and with governments introducing new legislation to encourage the use of recycled content (see example, below), we are expecting more industries to include this as part of their overall plastic strategy. It is therefore not surprising that to meet these demands the European Commission are exploring ways of supporting this emerging market[43].

With this in mind, step three of your plastic journey should be to use more recycled content whenever possible. Even with the challenges that come with this approach, many businesses are expected to introduce more recycled content in packaging.

IN THE UK 2018/19 BUDGET, THE GOVERNMENT ANNOUNCED THAT IT WILL INTRODUCE A TAX ON PRODUCED OR IMPORTED PLASTIC PACKAGING. SUBJECT TO CONSULTATION, THIS WILL APPLY TO ALL PLASTIC PACKAGING THAT DOES NOT INCLUDE AT LEAST 30% RECYCLED CONTENT.

HM Treasury October 2018.

[42] https://www.thisisplastics.com/environment/the-potential-of-recycled-plastics/
[43] http://ec.europa.eu/environment/circular-economy/pdf/plastics-strategy-brochure.pdf



case study 5

INNOCENT

Innocent started their plastic journey back in 2003 by ensuring that their bottles were fully recyclable. Their journey is a good example of research, trial, error and more research to get to a robust conclusion[44]:

- Their first bottle contained 25% rPET.
- In 2006, it increased to 50% rPET while still being 100% recyclable. They also began to trial a compostable version made from PLA.
- A year later, the PLA version was scrapped. They found out that consumers didn't understand how to dispose of compostable items, and the UK recycling industry was finding it hard to cope with PLA themselves. Industrial composting was not a viable option and PLA would contaminate recycling batches if disposed of incorrectly into the recycling bin. Instead, Innocent moved to using 100% recycled waste plastic in their bottles.
- Four years later, the 100% rPET bottles are scrapped and replaced with 35% rPET instead. The 100% recycled content impacted on the colour of the bottles. Furthermore, the quality of both the bottle and the recycled plastic itself began to deteriorate, compromising the quality of the product and increasing food waste. Through their research, Innocent had found that some virgin plastic was needed to maintain the integrity of the plastic bottle.
- They managed to improve the quality of the bottle and increase the recycled content to 50%.
- In 2018, after promising to include bio-based plastic in all their bottles they introduced the bottle, as shown in the diagram to the right.

[44] https://www.innocentdrinks.co.uk/us/recycling-revolution ; https://www.packagingnews.co.uk/news/innocent-cuts-pla-in-100-recycled-drive-30-10-2007

Image © Innocent. Source https://www.innocentdrinks.co.uk/us/recycling-revolution/brighter-bottle

4. PRODUCT DESIGN: THE EASY WINS

Colourings, additives and mixtures of other materials prevent plastics from being recycled economically[45]. There is very low demand for recycled coloured plastics as they cannot be dyed as easily as clear or white plastics, meaning that many recycling centres treat dark and black plastics as contaminants, and separate them out for landfill.

There is no one-size-fits-all approach here – companies are having to alter their own products to align with recycling infrastructure or take control of the recycling process themselves (see the Walkers take-back scheme case study on the right). Issues with design can be to do with colours or mixtures of materials. As mentioned previously, some coloured plastics do not fetch a high price when recycled, as their colour is locked in and not widely desirable. Colours are also an issue with the current state of recycling technology – black plastics, for example, cannot be recognised and sorted by the machines, limiting their recyclability.

Mixtures of different materials that cannot easily be separated, also make it hard to recycle. Sachets and specially designed bottles of layered plastic and aluminium used for sauces, dried food and crisps are particularly hard to separate and are currently unrecyclable. Plastic and cardboard mixed in laminated products, or simply melded together in design, are also tricky. Some companies like M&S have begun to tackle this by first reducing the amount of plastic used. For example, M&S redesigned and repackaged their popcorn and crisps into packets which were 37% smaller, but had the same amount of food in, and used fewer, thinner layers of plastic film[46].

So, where possible, products should be designed for disassembly, for example plastic or carboard labels should easily separated from a plastic bottle, and colours should be plain (e.g. clear plastic or beige not black). Simple solutions that have begun appearing include making plastic film labels easily removable from their respective bottles or packets and making cardboard sleeves easily removable from plastic trays.

Image: © M&S

M&S redesigned and repackaged their popcorn and crisps into packets which were 37% smaller, but had the same amount of food in, and used fewer, thinner layers of plastic film.

[45] https://sustainablebrands.com/read/waste-not/the-many-challenges-of-plastic-recycling
[46] https://www.theguardian.com/environment/2017/jul/18/ms-slashes-plastic-use-in-food-packaging-to-cut-waste

case study 6

LIDL / MORRISONS

Many food retailers who use black trays have been struggling with this issue, but in many cases this issue can be solved simply by changing the colour of the plastic used. Lidl phased out black plastic trays from their fruit and vegetable range in September 2018 and replaced them with fully recyclable clear plastics, following a pledge by the company to reduce own brand plastic packaging by 20% by 2020[47]. Morrisons have introduced similar measures, vowing to replace all black plastic trays for meat and fish with alternative colours by the end of 2019[48].

Image: © Lidl

case study 7

WALKERS

Walkers has partnered with recycling technology firm TerraCycle to repurpose its crisp packets into benches, watering cans and waste bins. This will be the UK's first nationwide recycling scheme for crisp packets and all brands will be accepted[49,50].

[47] https://www.thegrocer.co.uk/home/topics/environment/lidl-to-remove-black-plastic-from-fruit-and-veg-lines/571906.article
[48] https://my.morrisons.com/uk-plastics-pact/
[49] https://www.bbc.co.uk/news/uk-england-leicestershire-45759712
[50] https://www.terracycle.co.uk/en-GB/zero_waste_boxes/candy-and-snack-wrappers

5. MOVE TO ALTERNATIVE MATERIALS

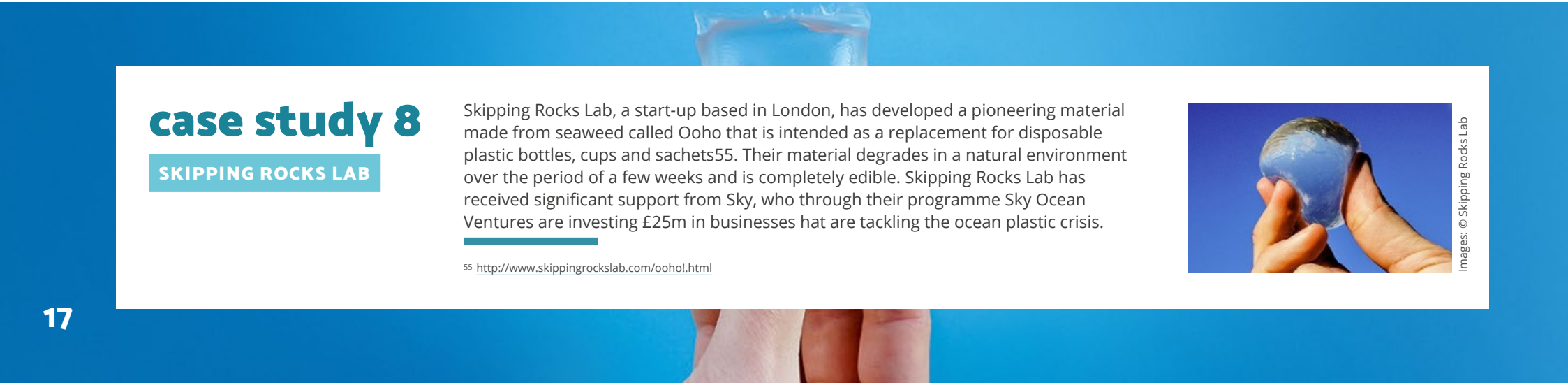
Momentum to move away from plastic has grown so much recently that materials that were once replaced by plastic are coming back into fashion, namely paper, cardboard and glass. New materials are also being created, mostly from plant material such as mushrooms, seaweed and bamboo. One of the main positive effects of re-introducing some of these materials is that they are not only more biodegradable, but their recycling infrastructure is far more established (e.g. paper, glass and metal).

But there was a reason we moved to plastic in the first place: it was a superior material to its predecessors! The issues with these materials are still present, namely their cost and how much energy and water are involved in their production. Those alternative materials can be more energy intensive. Both paper and cotton have far higher environmental impacts – largely due to their extraction and production (e.g. toxic pollution of land and water, resource depletion and deforestation). Truth be told, when you compare materials from a whole lifecycle perspective, plastic often comes out favourably. A study by the Environment Agency shows that to have a lower carbon footprint than a single-use plastic carrier bag, a paper bag needs to be reused 3 times and a cotton bag would need to be used 131 times[51].

Realising this, start-ups and Research and Development (R&D) teams have invested heavily in creating innovative new materials to mimic the characteristics of conventional plastics: ideally without the energy or environmental costs of the alternatives currently available. This was the aim of the most recent Circular Materials Innovation Challenge run by the Ellen MacArthur Foundation – to come up with new materials to replace plastic packaging, specifically sachets used for sauces and fresh coffee which are too hard to recycle at present.

Today, the market for these products remains niche, but there is more and more collaborative ventures sprouting up. Perhaps one of the most notable and widely used examples is mushroom packaging from Ecovative - a replacement for polystyrene made from mycelium (fungi) which is biodegradable and compostable. It is currently being use as a packaging material by Ikea and Dell, but its use is expanding into building materials and clothing[52]. Ikea is also supplementing the use of this material with an increased use of paper and cardboard, which they roll up and fold to provide a layer of support much like expanded polystyrene foam[53], a technique which has been adopted by many other retailers. Sky is an example of a company which has used the innovative seaweed material for their binbags, as well as making a return to previously used materials such as cork and laminated cardboard to replace polystyrene[54].

51 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291023/scho0711buan-e-e.pdf
52 http://www.ecovativedesign.com/
53 https://www.ikea.com/ms/en_KR/this-is-ikea/ikea-highlights/Flat-packs/index.html
54 https://news.sky.com/story/sky-invests-in-biodegradable-plastic-bottles-and-edible-condiments-sachets-11448353



case study 8

SKIPPING ROCKS LAB

Skipping Rocks Lab, a start-up based in London, has developed a pioneering material made from seaweed called Ooho that is intended as a replacement for disposable plastic bottles, cups and sachets55. Their material degrades in a natural environment over the period of a few weeks and is completely edible. Skipping Rocks Lab has received significant support from Sky, who through their programme Sky Ocean Ventures are investing £25m in businesses hat are tackling the ocean plastic crisis.

55 http://www.skippingrockslab.com/ooho!.html

Images: © Skipping Rocks Lab

APPENDIX
DIFFERENT TYPES OF PLASTIC

TRADITIONAL FOSSIL FUEL-BASED NON-BIODEGRADABLE PLASTICS AND THEIR RECYCLABILITY

SYMBOL	POLYMER	COMMON USES	PROPERTIES	RECYCLABLE? *	POTENTIAL SUBSTITUTES**
1 PETE	Polyethylene Terephthalate (PET/PETE)	Plastic bottles for water/ soft drinks/oils	Clear, strong, lightweight	**Yes.** Widely recycled in household/ industrial waste	*Polylactic acid (PLA)* *Bio-based PET*
2 HDPE	High-density polyethylene (HDPE)	Milk containers, cleaning agents, shampoo/bleach bottles	Stiff, hardwearing, hard to break down in sunlight	**Yes.** Widely recycled in household/ industrial waste	*Polybutyrate adipate terephthalate (PBAT),* *Polylactic acid (PLA)* *Polyhydroxy-alkanoates (PHA) and (PHB)* *Bio-based PE*
3 PVC	Polyvinyl chloride (PVC)	Piping, flooring, insulation, roof sheeting	Can be ridged or soft via plasticizers, used in construction, healthcare, electronics	**Not often recyclable in household waste due to chemical properties.**	
4 LDPE	Low-density polyethylene (LDPE)	Plastic bags, food wrapping, lamination for cardboard containers	Light-weight, low cost, versatile	**Not often recyclable in household waste.** Failure under stress makes it hard to recycle, but some plastic bags are recycled industrially to produce low-grade bags	*Polybutyrate adipate terephthalate (PBAT)* *Polylactic acid (PLA)* *Polyhydroxy-alkanoates (PHA) and (PHB)* *Bio-based PE*
5 PP	Polypropylene (PP)	Bottle lids, food tubs, some medical appliances	Tough and resistant. Effective barrier against water and chemicals	**Not often recyclable in household waste at present** – though potential to do so if infrastructure improves. Some recycled industrially.	*Polybutylene succinate (PBS)* *Polyhydroxy-alkanoates (PHA) and (PHB)* *Polylactic acid (PLA)*
6 PS	Polystyrene (PS)	Food takeaway containers, plastic cutlery	Lightweight, but structurally weak	**Not recyclable in household waste.** Some commercial recycling under way, but limited.	*Polylactic acid (PLA)*
7 OTHER	Covers an array of other fossil fuel based plastics, including acrylic, polycarbonate (PC)	Water cooler bottles, baby cups etc. Mixed plastic products fit into this category.	Diverse.	**Not recyclable in household waste** (Commercial recycling limited too - mixed materials risk contamination)	*Bio-based PC*

*Based on UK practices. Local recycling capacity differs by country/region.
**This is not an exhaustive list. The intention is to demonstrate what substitutes are available – this is not to suggest that the traditional non-biodegradable fossil fuel-based plastic should be substituted for one of these alternatives. [56, 57]

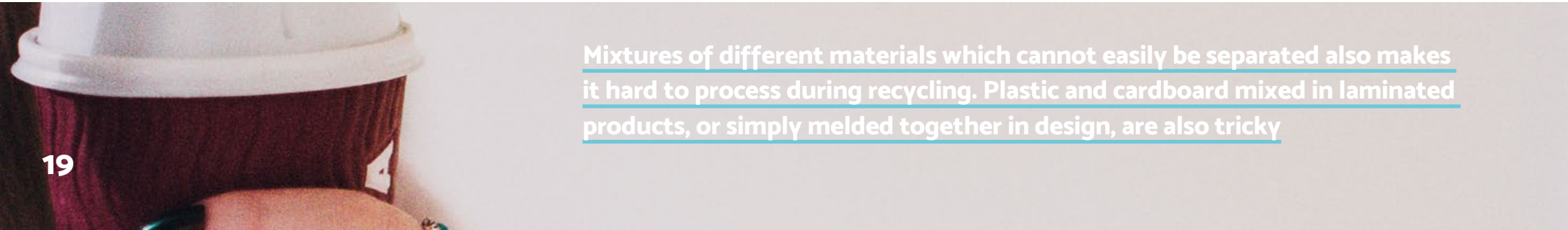
[56] https://ourworldindata.org/wp-content/uploads/2018/07/Plastics-by-polymer-type-01.png
[57] http://news.bbc.co.uk/1/hi/magazine/7516859.stm

SUBSTITUTES FOR FOSSIL FUEL-BASED NON-BIODEGRADABLE PLASTICS AND THEIR APPLICATION

NAME	FOSSIL FUEL-BASED	BIO-BASED	BIODEGRADABLE	NON-BIODEGRADABLE	APPLICATIONS	SUBSTITUTE FOR
Polybutyrate adipate terephthalate (PBAT)	✓		✓		Plastic bags, wrapping films, disposal dishes/cups	HDPE LDPE
Polybutylene succinate (PBS)	✓		✓		Films/bags/boxes for food and cosmetic packaging	PP
Polycaprolactone (PCL)	✓		✓		Bio-medical equipment	
Polyvinyl alcohol (PVOH, PVA)	✓		✓		Textiles, coatings	
Bio-based Polyethylene terephthalate (PET)		✓		✓	Bottles	PET
Bio-based Polyethylene (PE)		✓		✓	Carrier bags, films, bottles	HDPE LDPE
Bio-polycarbonate		✓		✓	Electronics, Automotive	PC
Polyhydroxy-alkanoates (PHA) and (PHB)		✓	✓		Plastic tubs, bottles	PP HDPE LDPE
Polylactic acid (PLA)		✓	✓		Diverse, process dependent	PET HDPE LDPE PP PS

[58]

[58] http://www.bioplastics.guide/



Mixtures of different materials which cannot easily be separated also makes it hard to process during recycling. Plastic and cardboard mixed in laminated products, or simply melded together in design, are also tricky

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