The future potential economic impacts of a bio-plastics industry in the UK

A report for the Bio-based and Biodegradable Industries Association (BBIA)

October 2015

Cebr

Disclaimer

Authorship and acknowledgements

This report has been produced by Cebr, an independent economics and business research consultancy established in 1992. The study that led to this report was led by Oliver Hogan (Cebr Director) and the other contributors to the report and study include Rajini Jayasuriya (Economist), Shruti Uppala (Economist), Laura Holdgate (Senior Economist) and Nina Skero (Economist). The views expressed herein are those of the authors only and are based upon independent research by them.

The report does not necessarily reflect the views of the BBIA.

London, October 2015

Contents

Executive Summary

Bio-plastics have the potential to become an integral part of the UK economy. Not only can they fulfil the functional requirements that modern day society demands from plastic products, but their use contributes to the development of a more efficient, smart, and sustainable future. In addition, at a time when innovation is crucial to the future vitality of the UK economy, the findings of this study reveal the potential that a domestic bio-plastics sector holds for the UK. Through this report, Cebr finds that the motivation for developing a domestic bio-plastics sector, above all, lies with the range of economic opportunities that a UK bio-plastics sector can offer, as much as it does with the opportunities to improve the country's resource efficiency and sustainability.

This report details the findings of research undertaken by the Centre for Economics and Business Research (Cebr) on behalf of the Bio-based and Biodegradable Industries Association (BBIA). The objective of this study is to understand the current and potential future economic contribution of the bio-plastics industry to the UK economy. In doing so, this research aims to increase awareness of the importance of the bio-plastics industry and the role it plays in generating economic growth.

With the UK bio-plastics sector still in its infancy, and the potential economic contribution of the industry to the national economy still unexplored, the results presented by this study are the first of its kind.

Drivers of the demand for bio-plastics

Presently in the UK, supportive regulation and legislation has encouraged more environmentally sustainable business practices and consumer behaviour. For example, the Government's drive towards achieving a 'zero waste' economy, through reducing waste and increasing recycling, has fostered an increased consciousness of resource efficiency. This awareness has indirectly promoted the use of bio-plastic products.

Due to their biodegradability in the right applications, bio-plastics can help divert organic waste from disposal so avoiding the additional costs of Landfill Tax. This can act as an incentive to businesses and municipalities to use bio-plastics, instead of conventional plastics.

In addition, initiatives to reduce food and packaging waste have fostered research and innovation into more carbon neutral forms of plastics. Already, advances in the technical properties and functionality of bio-plastics have increased their attractiveness and the extent to which they can substitute for conventional plastics.

Macroeconomic impacts of a UK bio-plastics sector

Based on the current annual domestic demand for bio-plastic products of 4,000 tonnes, Cebr estimates that in 2014 the gross output impact of the bio-plastics sector amounted to £103.4 million, of which £43.4 million the direct output contribution to the UK economy. This supports roughly 1,000 jobs and adds £50.5 million of gross value added (GVA) to the economy (including direct and multiplier impacts). In addition, Cebr estimates that the bio-plastics sector paid about £28.2 million in gross employee compensation in 2014, making a substantial contribution to aggregate household incomes in the UK (see Table 1).

Table 1: Current macroeconomic impacts of the UK bio-plastics sector

	Output (£m)	GVA (£m)	Jobs (FTEs)	Income (IfE £m)
Direct contribution	43.4	21.9	542	12.4
Aggregate contribution	103.4	50.5	1,045	28.2

Source: Cebr analysis

Given the right conditions, in particular a proper legislative and commercial framework that would enable the development of a UK bio-plastics sector, the industry expects domestic production of bio-plastics to reach 120 thousand tonnes. If this is achieved, Cebr predicts that the gross output impacts of the bio-plastics sector will amount to £4.2 billion. From this, approximately 35,000 jobs are expected to be supported, and roughly £1.92 billion of gross value added is predicted to be contributed to the UK economy. Further, we estimate that the bio-plastics sector will pay around £1.01 billion in gross employment compensation (see Table 2).

Table 2: Potential future macroeconomic impacts of the UK bio-plastics sector

	Output (£m)	GVA (£m)	Jobs (FTEs)	Income (IfE £m)
Direct contribution	1,756.4	764.6	14,403	389.6
Aggregate contribution	4,199.9	1,906.2	35,447	1,013.2

Source: Cebr analysis

Capitalising on the opportunity for UK plc

Bio-plastics are often promoted by the range of environmental and functional benefits they offer over conventional plastics. However, in addition to meeting the UK's environmental targets, the findings of this study reveal that a domestic bio-plastics industry also has the potential to meet the country's economic goals. But for the UK to fully capitalise on the potential opportunities, a technological, legislative and commercial environment conducive to the development of a domestic bio-plastics industry should be in place. To achieve this, the UK can learn from the examples set by Europe, the USA and Asia.

- Currently, the UK is missing a public procurement approach, similar to the US's BioPreferred Programme. Public sector support would help develop the UK bio-plastics industry from its infancy, and encourage private sector investment.

- Political support is crucial, and the UK government should do more to incorporate the economic potential of the bio-plastics sector into the country's wider growth strategy. The EU's "Europe 2020" is an example of how contribution of their bio-plastics industry can be integrated into the region's strategy for achieving sustainable economic growth.

- The bio-plastics industry should be set within the context of the wider economy. In addition to creating bio-plastic products, the industry could enhance the UK's agricultural, chemical and manufacturing sectors, thus supporting the nation's farmers and creating new value chains.
- Legislative support, such as the ban on traditional shopping carrier bags introduced in Italy, can also contribute to the commercialisation of bio-plastics. This approach has also recently been taken by France and Hawaii. The UK government should recognise that initiatives that aim to achieve other targets, such as the objective of reducing littering, are an opportunity to bring wide-reaching policy benefits. For example, bio-plastic carrier bags do not only play a role in waste minimisation and reduced littering but encourage increased food waste collection and improve organic recycling resulting in enhanced soil structure and quality.
- The commercialisation of bio-plastics production is imperative if the industry is to achieve economies of scale and production efficiencies, which can be translated into lower cost bio-plastic products for consumers and businesses.
- The full potential of a bio-plastics industry in the UK will only be released if society is aware of the value of sustainability. Bio-plastics suppliers should be able to signal the value of their products, and consumers should understand what bio-plastic products mean to society in practical terms, to the economy, and to the environment. Unambiguous standards and labelling will be crucial to achieving this. The UK could follow the example set by the Thai Bio-plastics Industry Associations (TBIA), which created a memorandum of understanding (MOU) with a range of global institutions to cooperate in the development of harmonised certification and labelling programmes.

In summary, a UK bio-plastics sector has the potential to simultaneously:

- Increase economic output
- Provide jobs
- Drive research and innovation
- Promote the efficient use of resources
- Contribute to sustainable economic growth
- Reverse the depletion and deterioration of our natural capital

In combination, these benefits highlight the opportunity that a domestic bio-plastics sector in the UK offers. An integrated approach, involving progressive policy initiatives, a robust and stable economic environment, and an environmentally conscious society, will be vital to realising the potential future growth in the bio-plastics sector and capitalising on this opportunity for UK plc in the way other countries are doing.

1 Introduction

This is a report by Centre for Economics and Business Research (Cebr), on behalf of the Bio-based and Biodegradable Industries Association (BBIA), on the current and potential future economic contribution of bio-plastics to the UK economy.

1.1 Purpose and objectives

The purpose of the study that culminated in this report was to develop an up-to-date picture of the contribution of bio-plastics to the national economy. It was commissioned to increase awareness of the importance of bio-plastics and the role they can play in generating economic growth. With the UK bio-plastics sector still in its infancy, and the potential economic contribution of the industry to the national economy still unexplored, the results presented in this report are the first of their kind.

The overall aim for the research was to develop a clear, robust and evidence-based understanding of the contribution that bio-plastics make to the economy and to gather essential insight into the nature of that contribution. The study involved interpreting the policy environment currently surrounding bio-plastics, with the objective of understanding how the impact of bio-plastics is likely to develop in the future.

Our analysis considers the direct contribution of the producers and suppliers of bio-plastics, measured by macroeconomic indicators such as gross value added (GVA[1]), gross output (or turnover), employment and household incomes. However, we also examine the indirect contributions made by the bio-plastics industry to the wider economy, for example through the additional jobs supported indirectly in the industry's supply chain or in the wider economy as a result of direct and indirect bio-plastics employees spending their wages and salaries in the wider economy.

1.2 What are bio-plastics?

Bio-plastics are a group of products, often comprising of a range of compounds with differing properties and applications. According to European Bio-plastics[2], a plastic material is defined as a bio-plastic if it is either bio-based, biodegradable or both. A bio-based material or product is (at least partly) derived from biomass (e.g. from corn, sugarcane, trees, algae etc.), whereas biodegradable implies that micro-organisms that are present in the environment can convert the material into natural substances (i.e. water, carbon dioxide or compost) without polluting the environment. This definition is illustrated in Figure 1 below.

There are a number of key distinctions between conventional fossil-based plastics and bio-plastics. Conventional plastics (or petro-plastics) are derived from petrochemicals, which are obtained from fossil

---

[1] That is, the value of what is produced less the value of the intermediate goods and services used as inputs to produce it. GVA is also commonly known as income from production and is distributed in three directions – to employees, to shareholders and to government. GVA is linked as a measurement to GDP, both being measures of economic output. That relationship is (GVA + Taxes on products - Subsidies on products = GDP). Because taxes and subsidies on individual product categories are only available at the whole economy level (rather than at the sectoral or regional level), GVA tends to be used for measuring things like gross regional domestic product and other measures of economic output of entities that are smaller than the whole economy, like the bio-plastics sector. GVA must be distinguished from turnover measures, which capture the entire value of sales. By contrast, GVA captures the value added to a set of inputs by a firm on their journey from raw materials to finished consumer products. Thus the value added of a firm that uses oil imports to make plastics is equal to the price that it sells the plastic for minus the cost of the oil it uses as inputs. Similarly the value added of a manufacturer that uses that plastic to make a bus shelter is equal to the price that it sells the bus shelter for minus the cost of the plastic it uses as an input. The concept of added value enables the avoidance of double counting when estimating the size of an economy.

[2] European Bio-plastics, Factsheet, January 2015

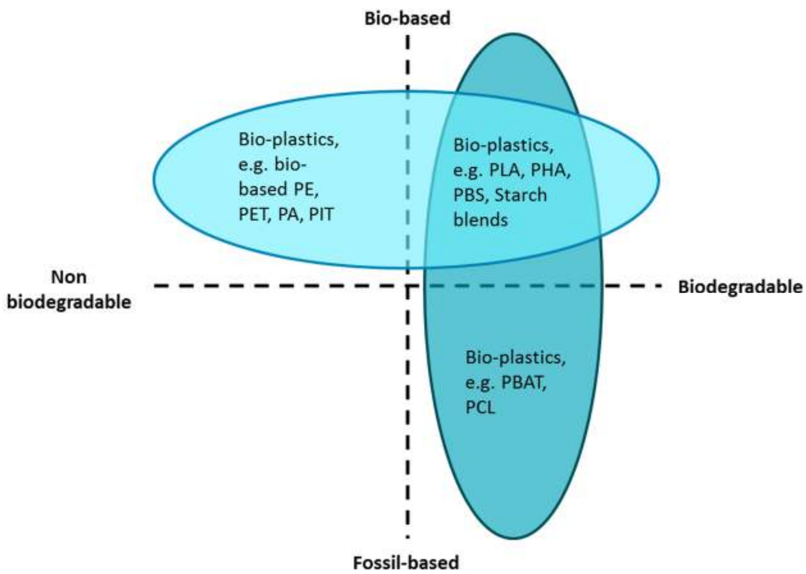
fuels such as crude oil, coal or natural gas, whereas bio-plastics are produced from bio-based polymers or biodegradable polymers.

Bio-based polymers are produced from mainly renewable resources, and their use can reduce our dependency upon the finite reserves of fossil fuel stocks. Biodegradable polymers are defined as materials whose physical and chemical properties undergo deterioration and completely degrade when exposed to microorganisms, into carbon dioxide (as in aerobic processes), methane (as in anaerobic processes) and water (used in aerobic and anaerobic processes).[3] This property can help reduce the amount of waste requiring disposal by enabling increased diversion to organic recycling. In comparison, conventional plastics are fossil-based and non-biodegradable and, thus, fall into the bottom left quadrant in Figure 1 below.

Bio-plastics can be biodegradable or non-biodegradable and may also be bio-based or fossil fuel-based. Thus, it is possible to have a biodegradable fossil fuel-based bio-plastic and a non-biodegradable bio-based bio-plastic. These properties can cause confusion when distinguishing between different forms of bio-plastics.

Products that are both bio-based and biodegradable are also defined as bio-plastics and the scope of this study is confined to this category. This is represented visually as the overlap between the blue and teal oval in the top right hand quadrant of Figure 1. Throughout the rest of the report, where we refer to ‘bio-plastics’ we mean this restricted segment of the market, unless otherwise stated.

Figure 1: Defining bio-plastics[4]



Source: European Bio-plastics Factsheet (2015)

[3] Babu, O’Connor and Seeram (2013), “Current progress on bio-based polymers and their future trends”

[4] Description of bio-plastics acronyms used throughout in Figure 1 and throughout report: polyethylene (PE), polyethylene terephthalate (PET), polyamide (PA), polyimide terephthalate (PIT), polyactic acid (PLA), polybutylene succinate (PBS), polyhydroxyalkanoates (PHAs), polybutyrate (PBAT), polycaprolactone (PCL).

1.3 Overview of approach and methods

The approach to the study involved, first, developing a clear picture of the current international bio-plastics landscape, examining the demands for and uses of bio-plastics, the structure of the value chain, recent developments in the global industry and the future outlook. This provides a useful basis against which to compare and contrast the situation in the UK. Secondly, therefore, was the requirement for a similar understanding of the UK landscape facing the bio-plastics sector, including the structure of the industry, the policy environment, and recent developments in the devolved nations of Wales, Scotland, and Northern Ireland. Both of these elements involved a review of relevant literature.

Another important element was a data gathering exercise. This was understandably tricky given the infancy of the industry in the UK, including of its industry association (the BBIA). However, we did receive best estimates of the current size and sources of the demands for bio-plastics in the UK and of the extent to which those demands are satisfied through imports or domestic production. We also received best estimates of average prices, margins and intermediate input demands. This facilitated a clear understanding of all levels of the value chain in terms of pounds and pence, which is vital for economic modelling purposes.

Data from the Annual Business Survey (ABS) was used to understand the broader industries of which the various levels of the bio-plastics value chain form part. The ABS discloses economic indicators, including revenues, costs of production and value-added across hundreds of disaggregated industries (on the basis of the Standard Industrial Classification or SIC framework). This, in turn, provided useful guidance in terms of how to approach the modelling phase.

We estimate the direct and multiplier impacts of the bio-plastics industry using supply-use and input-output modelling. These models draw on the most detailed representation of the ONS' national accounts – the supply-use tables. For the purposes of this report, the supply-use and input-output models effectively trace the economic footprint of the various bio-plastic sub-sectors (as identified in the value chain) through their supply chain relationships with other sectors. The demands placed on them by the sub-sectors of interest lead to production, the need for jobs to be filled and the generation of value added contributions to GDP in those sectors. Further production, value generation and employment are generated when the direct and indirect employees of the bio-plastics sub-sectors spend their earnings in the wider economy on the goods and services consumed by households.

Cebr also requested BBIA members to produce a best estimate of the potential size of domestic production of bio-plastics under the assumption that the policy environment was conducive to the investment that would be required in either constructing new plant or converting existing plant used in the production of traditional plastics over to bio-plastics production. Cebr has used these estimates to produce an outlook for the future economic contributions and impacts of the bio-plastics sector in the UK.

1.4 Structure of the report

The report is structured as follows:

- Section 2 describes how bio-plastics are used, presents the forces driving the demand for them and illustrates the global policy environment surrounding bio-plastics today.
- Section 3 provides an overview of the present structure of the UK bio-plastics industry and the policy environment that currently exists.

- Section 4 assesses the direct contributions to and multiplier impacts of the bio-plastics industry on the UK economy today and in the future. This is considered in terms of GVA, employment, and employee compensation.
- Section 5 considers the opportunity to the UK economy of a domestic bio-plastics sector, and highlights the technological, legislative, and commercial determinants that could shape the industry.

2 Context and background

This section begins by assessing the factors that are driving the demand for bio-plastic products. We then highlight the various types of bio-plastics that exist in the current market, before moving on to examining the structure of the bio-plastics value chain. Following this, we examine the current global bio-plastics market and the existing policy environment that has aided its development. Finally, we investigate how the market may develop in the future.

2.1 Demand for and uses of bio-plastics

What are the factors driving the demand for bio-plastics?

The European bio-plastics market is estimated to be growing at more than 20% per year.[5] The key drivers for this high rate of growth can be categorised into internal and external bio-plastics industry factors. In terms of internal drivers, organisations within the bio-plastics industry are achieving advances relating to the technical properties and functionality of bio-plastics. This has been encouraged by policy initiatives aimed at supporting innovation, research and development, such as through funding and grants. As bio-plastic products become increasingly attractive to consumers, there is potential for cost reduction through economies of scale, which further aids the development of additional sustainable and new recycling options.

The influences of external factors are also increasing. Consumer preferences for environmentally sustainable materials, the improved performance of bio-plastic resins[6] relative to traditional plastics and the introduction of commodity plastics produced from bio-based sources have been crucial in driving market demand. Other attractive features of bio-plastics that are encouraging their use include:

- Due to finite oil supplies, energy security is an increasingly high priority for the governments of countries across the world, including the UK. Any measure that reduces the nation's reliance on, and increases the conservation of, fossil fuel reserves such as oil and natural gas are seen as preferable. The use of bio-plastics is such a measure, as the raw materials required to produce the resins are generally starch based components such as vegetable fats, oils or corn starch. As conventional plastics rely on fossil fuels, the use of bio-plastics reduces the dependency on fossil fuels that arises with the production of conventional plastics. However, the substitutability between bio-plastics and conventional plastics is highly dependent on the relative price of fossil fuel-based products. Current low crude oil prices are typically unfavourable for bio-plastic products, the relative price of which usually increases as a result.

- Bio-plastics help reduce greenhouse gas emissions, due to both the reduced reliance on fossil fuels in production and the biodegradable nature of the products. When landfilled, organic food and garden waste release methane as it degrades. However, compostable bags made from bio-plastics can help divert more organic waste into organic recycling, where the methane produced can be used as renewable energy and the compost by-product can be used to enhance the soil required for agricultural and horticultural production.

[5] European Bio-plastics, "Market drivers", accessed at: [http://en.european-bioplastics.org/market/market-development/market-drivers/]

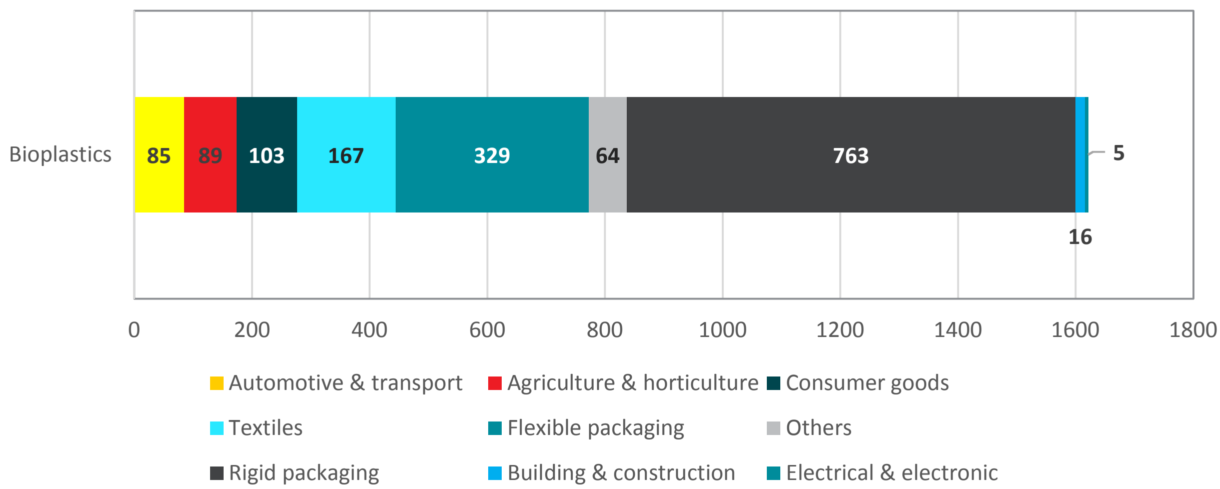
[6] A resin is a solid or highly viscous substance containing polymers. A bio-plastic resin is a substance which is made up of bio-based polymers to create bio-plastics.

Currently, there are a variety of factors that are tempting businesses and consumers away from their use of conventional plastics and towards the use of bio-plastics. As bio-plastics become an increasingly attractive option, the policy framework supporting their use will become ever more important. The current legislative environment is explored in Section 3.2.

How are bio-plastics used?

Global bio-plastics production amounted to 1.62 million tonnes in 2013, of which over two-thirds (1.1 million tonnes) were used in packaging. Figure 2 illustrates that 763 thousand tonnes, (equivalent to 47% of global bio-plastics production) were used for rigid packaging (e.g. beverage bottles or trays) while flexible packaging was the second largest area in which bio-plastic products were used.

Figure 2: Global production capacities of bio-plastics 2013, by market segment (thousand tonnes)



Source: European Bio-plastics 2014

Bio-plastics are also used across a range of areas, such as consumer goods, agriculture and horticulture. Often, these products are promoted for their biodegradable properties and have the potential to streamline the collection of food scraps and garden waste for composting, helping to divert it from disposal in landfills and incinerators. The vast majority of bio-based biodegradable plastic products are typically intended for short life applications such as single-use packaging (e.g. packaging for fresh produce or carrier bags), organic waste collection bags (typically provided by local government or purchased by households from retailers) or food service ware (e.g. bio-plastic utensils, cups, plates etc.).

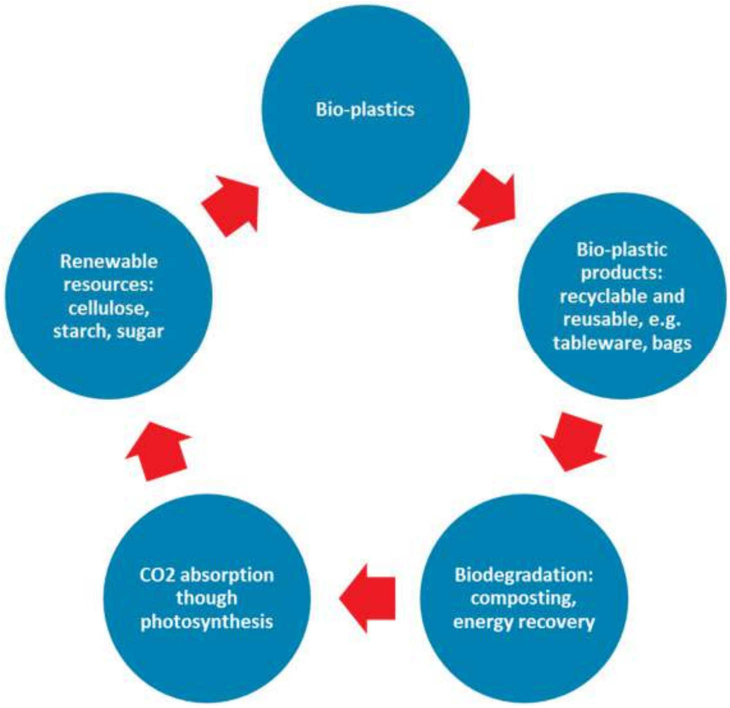
How are bio-plastics recovered?

Although bio-plastic products are often marketed on their recyclable properties, it is their biodegradability and compostability that holds the greatest potential for economic and environmental benefits when compared with conventional plastics. Bio-plastic products' potential is realised when they are utilised within organic waste recycling systems, thus increasing the likelihood of more organic waste recycling and reduced contamination from the conventional non-biodegradable plastics that are not compatible with organic recycling. Organic waste is the single largest municipal waste stream and one of the most environmentally damaging when sent for disposal in landfill.

To capture these benefits and maximise the use of bio-plastics, it is important to dispose of these products in the correct manner. Once a bio-plastic product comes to the end of its useful life, there are several ways in which it can be recovered. These include mechanical recycling, organic recycling (composting and anaerobic digestion) as well as energy from waste options (e.g. gasification and incineration).

Figure **3** illustrates an optimal form of the life-cycle of a bio-plastic product, describing how its disposal and biodegradation leads to the recovery of renewable resources, which are once again used to produce more bio-plastics. This closed loop system exemplifies why bio-plastics are known as sustainable products.

Figure 3: From nature, back to nature: the life cycle of bio-plastics products[7][8]



Source: Corbion, European Bioplastics

Local collection and treatment infrastructure plays a significant role in determining the most suitable recovery option. Currently, there is limited capacity within the UK to recycle post-consumer plastic packaging (film), although there is strong infrastructure for recycling post-consumer rigid packaging such as bottles. However, in recent years, the UK organic recycling industry and associated collection infrastructure has seen significant growth and development, with anecdotal evidence suggesting that these now contribute over 50% of the UK's national recycling infrastructure and service.

2.2 The bio-plastics value chain

The value chain of the bio-plastics industry can, as in any industry, be articulated in terms of the relationships that exist amongst the various players involved in the production of the essential raw

---

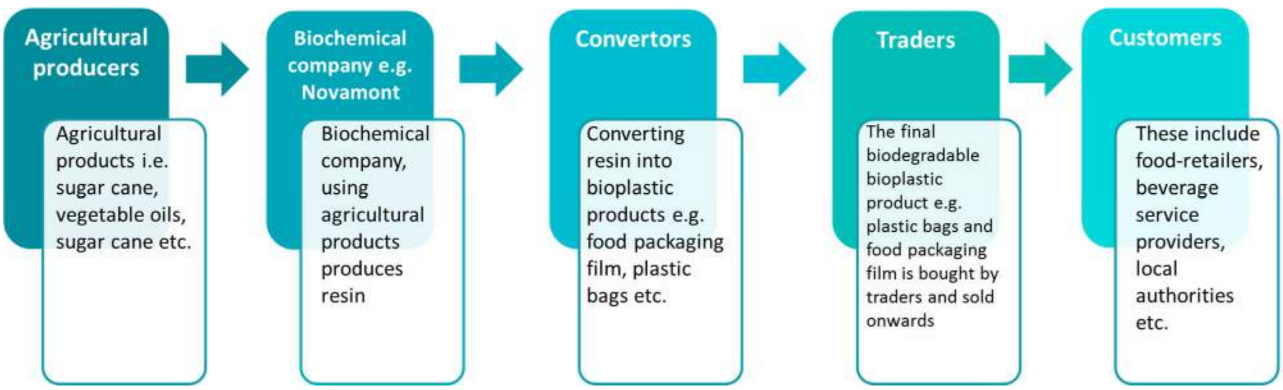
[7] PLA lifecycle, Corbion, accessed at: http://www.corbion.com/bioplastics/about-bioplastics/pla-lifecycle

[8] European Bioplastics, "Life Cycle Economy and Life Cycle Assessment", accessed at: http://en.european-bioplastics.org/environment/lcelca/

materials (biomass in this case), in the manufacturing of the primary and final product and in their distribution and sale to the final end-user. This is illustrated in Figure 4 below.

The first link in the chain is between agriculture and forestry producers of starch, vegetable oil, pulp, sugars and wood cellulose, and the biochemical companies that produce the bio-plastics polymers in primary form. These primary products, usually in the form of resins, are sold to firms that convert these resins into the final product, such as, the plastic film for food packaging, organic waste caddy liners and plastic shopping bags. At this stage, the convertor may sell the product directly to end-users, e.g. food packaging, or to local councils that provide the product to households. Alternatively, they may sell to wholesale traders who might sell the product onto food service businesses or to retailers who sell organic waste caddy liners (when they are not provided by local councils) and various food service items to household consumers.

Figure 4: Bio-plastics industry flowchart



Source: Data from the industry, Cebr analysis

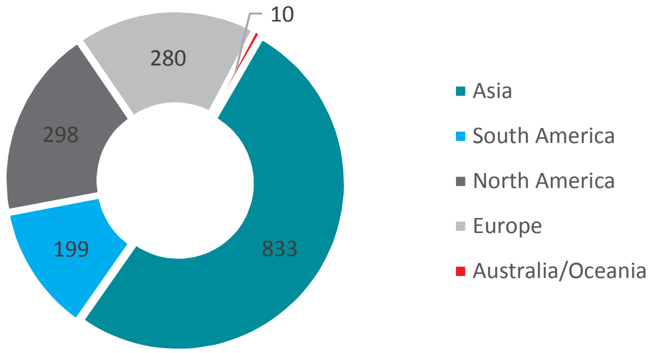
At each stage in the process, value is added through the margins required by the firms undertaking these various activities to cover their costs. Our understanding of the monetary flows in the value chain is set out in Section 3.4 below.

2.3 Recent developments in the global industry

Global overview

The global production capacity of bio-plastics stood at 1.62 million tonnes in 2013, representing less than 1% of aggregate global polymer production. Of this, 833 thousand tonnes, equivalent to 51.4% of the entire global capacity, was produced in Asia. North America and Europe produced similar levels of bio-plastics in the same year, as illustrated in Figure 5 below.

Figure 5: Global production capacity in 2013, by region (thousand tonnes)



Source: European Bio-plastics 2014

Of the 1.62 million tonnes of bio-plastics produced across the world, biodegradable bio-plastics made up 37.6%, whilst the remaining 62.4% of global production capacity was employed to produce bio-based non-biodegradable plastics (top-left quadrant in Figure 1 on page 9). This trend has become increasingly visible, with the number of manufacturers, convertors and end-users producing bio-based, non-biodegradable plastics rising steadily. Bio-based non-biodegradable plastics such as PE and PET, also known as 'drop-in' bio-plastics, are similar to current conventional fossil-based counterparts and only differ by their renewable base. Thus the processing, use, recycling, and recovery follow the same chain as conventional petro-plastics, thereby allowing these bio-plastics to 'drop-in' currently established routes[9].

The largest single market for plastics consumption is packaging, which includes bottles, containers, films and bags. Bio-plastic used for packaging is a further sub-division of the overall packaging industry. A 2013 report by Smithers Pira[10], examining the bio-plastics market for packaging, estimates that in 2013, the bio-plastics share of packaging stood at 0.2%, equivalent to consumption demand of 535 thousand tonnes. To put this in context, all plastics are estimated to represent around 44% of all packaging in 2013. The greatest demand for using bio-plastics in packaging is generated from Europe and North America, which together represent 62% of global demand.

The policy environment in Europe and North America will be critical if these regions are to continue to lead the way in terms of production capacity and demand for bio-plastics. Although few countries have policies that aim to stimulate bio-plastics demand directly, many do have initiatives that intend to optimise resource efficiency and improve sustainability, and as a result, indirectly drive the use of bio-plastics. In the remainder of this section, we provide an overview of the policy environment that currently exists in Europe and the USA, and the extent to which the framework has fostered a bio-plastics industry in those regions.

Europe

The European Commission (EC) has proposed a range of strategies and policies that aim to generate a bio-economy. The initiatives are as much related to developing a more sustainable approach to the use

---

[9] It is worth noting that many bio-based and non biodegradable plastics are created for construction and engineering uses, for example, substituting PVC tubes which are more polluting to make and recycle. Here the characteristic of biodegradability is not desirable as the products must be durable long-term.

[10] Smithers Pira 2013: The Future of Bio-plastics for Packaging to 2023

of resources, as they are about moving Europe's competitive advantage towards science and innovation, and away from commodities trade. Policy recommendations relating to bio-plastics are made through the Ad-Hoc Advisory Group for Bio-based Products, which works through the EC's Lead Market Initiative to stimulate demand for bio-based products.

With European public authorities spending almost 18% of GDP on goods and services a year[11], the Advisory Group has identified public procurement as a key area of policy to drive bio-plastics demand. The Green Public Procurement (GPP) programme was launched in 2008, to provide guidance to Member States on setting, implementing and achieving targets for the purchase of sustainable goods and services. One potential area for increasing the demand for bio-plastics, identified by the Group, was the introduction of criteria that grants preference to bio-based products in tender specifications, through the GPP guidelines. This means that products meeting the minimum level of bio-based content would qualify for preferential selection when public authorities are making purchasing decisions on goods.[12] But, before this can happen, further work on standards for bio-based products is required. In an attempt to achieve this, the European Committee for Standardisation (CEN) was issued Mandate (M491, 492) by the European Commission. The resulting Technical Committee is required to publish a suite of horizontal standards covering terminology, testing, and communication specifications by the end of 2016 and is on track to fulfil the Mandate.

Europe has long recognised the importance of standardisation, labels, and certification in driving the development of the biodegradability of packaging. Labelling in the bio-plastics industry is crucial to enabling consumers to differentiate between bio-plastic products and conventional plastics[13]. Working under Mandate 200, the EC published the first standard for biodegradable and compostable packaging in 2000. This standard, currently one of the most important global standards for bio-plastics, defines the technical specification for compostability of bio-plastic products, with compliance enabling producers to label their products as "biodegradable" or "organically recyclable", thus proving that they are successfully meeting the standard's criteria.[14,15] To date, EN13432:2000 is the only standard for biodegradable packaging that is cited in the European Journal and has undergone three revisions since 2000 all without substantial changes to its criteria illustrating its acceptability over the last two decades..

Robust and unambiguous standards will continue to foster collaboration, innovation and competition in the bio-plastics industry, in addition to easing consumers' lives and increasing awareness. Within the "Carrier Bag Directive" (2015/720/EU[16]), which requires Member States to introduce measures to reduce consumption of single use bags, the European Commission is requested to ask CEN to develop a standard for packaging that is suitable for home composting. It also provides for Member States to promote bags made to this standard to support local bio-waste collection systems.

---

[11] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[12] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[13] European Bioplastics: "Standards, certification and labelling", accessed at: [http://en.european-bio-plastics.org/standards/standardization/]

[14] European Bioplastics: "Standards, certification and labelling", accessed at: [http://en.european-bio-plastics.org/standards/standardization/]

[15] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[16] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32015L0720

In July 2015, the European Parliament approved the Pietikäinen report on resource efficiency and the move towards a circular economy.[17] The text centred on a fundamental shift in European policy, focussing on boosting the economy through resource efficiency, the creation of sustainable jobs and the protection of the environment within a circular economy. Amongst other things, it included a requirement for mandatory bio-waste collection (food and garden waste), increased use of renewable materials and a call for the Commission to assess the feasibility of increasing the use of environmentally friendly food packaging. It also included an assessment of the feasibility of gradually replacing traditional food packaging with bio-based and biodegradable, compostable material in accordance with European standards.

At the Member State-level, Italy became the first country in the EU to ban the distribution of traditional plastic bags, thus allowing for the commercialisation of biodegradable single-use and long-life reusable bags in 2011, while overall bag consumption fell significantly by over 50% [18]. As a result, demand for compostable carrier bags rose markedly during the first half of 2011.[19] In addition, Italy experienced a rise in the quality of composted food waste (less contaminated by plastic waste), with 8% fewer impurities translating into plastic residues in composting sites being reduced by 180,000 tonnes.[20]

Many have used this piece of legislation as evidence of how zero-cost Government intervention can stimulate investment, innovation and growth in the field of bio-plastics, despite the aim of the legislation being to combat littering and waste, rather than supporting the development of a bio-plastics industry. In 2015 France joined Italy in banning all non-biodegradable plastic bags, and from 2017 will require that all fresh produce bags (very thin bags for fruit and vegetables) are home compostable according to a new French standard, consisting of a minimum level of bio-based material. France is also discussing a ban on plastic throw away table ware, while permitting the use of compostable products.

With this type of pioneering legislative activity, it is little surprise that almost a quarter (24%) of worldwide bio-polymer consumption in 2012 stemmed from Europe. Further, the Smithers Pira's 2012[21] report estimates the demand for bio-plastics from Europe to represent 33% of total global demand, greater than other regions such as Asia-Pacific and North America.

Europe is the largest regional market for bio-plastic packaging with 34% of global tonnage consumed in 2013. This is equivalent to 182 thousand tonnes, of which the majority is used for non-food packaging products, as illustrated in Figure 6 below. The favourable consumer and retail attitudes towards sustainable packaging, government policies aimed at packaging waste recycling and well-developed composting infrastructure all support the market.[22] The majority of biopolymer activity is seen in Germany, France, Italy, Belgium, the Netherlands and the UK.

[17] Piteikäinen, S., (2015), "Report on resource efficiency: moving towards a circular economy", accessed at: [http://www.europarl.europa.eu/sides/getDoc.do?type=TA&language=EN&reference=P8-TA-2015-0266]

[18] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[19] Hermann, B., Carus, M., Patel, M. and Blok, K., (2011), "Current policies affecting the market penetration of biomaterials", Biofuels, Bioprod. Bioref, 5:708-719, accessed at: [wileyonlinelibrary.com]

[20] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[21] Smithers Pira (2012), "The Future of Bio-plastics: market forecasts to 2017"

[22] Smithers Pira (2013), "The Future of Bio-plastics for Packaging: market forecasts to 2023"

Milan Case Study: Bioplastics Deliver

Milan is Italy's second largest city. The municipality alone, excluding the larger metropolitan area, has 1.34 million inhabitants, with more than 80% of the households located in high-rise, multi-family buildings.

In 2011, Milan had an overall recycling rate of 35% - made mainly of dry recyclables like paper, glass, plastics and metals collected separately at the kerbside with residual waste being sent to a local energy-from-waste facility. Starting in November 2012, and completed after 18 months, Milan introduced a new kerbside residential food waste collection system. Every household received collection containers and a roll of 25 compostable bags for their kitchen scraps. Once the roll of bags had been used, households can either buy replacement bags from local stores, or use compostable carrier bags.

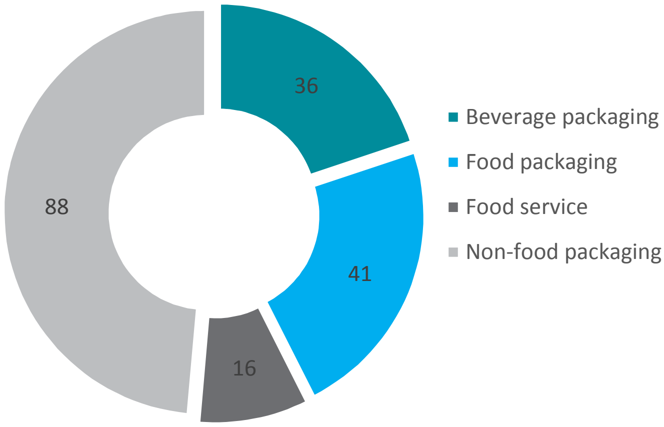
The use of compostable bags is encouraged since Italy banned the use of non-compostable carrier bags. This means that any single-use carrier bags used to dispose of organic household waste in Milan are also suitable for organic recycling at combined anaerobic digestion and composting plant. The purity of the collected feedstock is estimated at around 96%.Today half of the compostable bags used to collect the food waste in Milan are bioplastic carrier bags, the remainder being bioplastic waste bags.

The results achieved place Milan among the best performing cities in Europe in terms of source separation and recycling of municipal waste. To date, the city is collecting an average of 92 kilograms of food waste *per inhabitant* per year, of which about 70% comes from residential sources. To put this in perspective, the UK currently collects on average <50 kilograms of food waste *per household* per year from the 7 million households receiving a similar service. The 2015 projected annualised recycling rate for Milan is 52%. The new approach is also saving in excess of 8,600 tonnes of CO_2 per year.

The bio-plastics industry is also well-established in the Italian economy. There are almost 150 companies, with total sales amounting to €370 million in 2012.[23] The four main bio-plastic products in Italy are shopping bags, organic waste caddy liners, food-grade product packaging and non-food sector plastic applications. A key factor in the success of the bio-plastics industry in Italy is the introduction of policy and regulations that have stimulated the bio-plastic value and supply chains. These are discussed in detail in section 2.4 below.

[23] BioExpo, accessed at: [http://www.bio4expo.com/eng/insights/bio-plastics/italy-and-bio-plastics]

Figure 6: European bio-plastics for packaging demand by segment in 2013, thousand tonnes



Source: Smithers Pira 2013

USA

With energy security a high priority in the USA, government initiatives aimed at fostering the bio-economy are often skewed towards developing bio-mass and bio-fuels. As a result, the Obama Administration has set aside a substantial budget to drive bio-based technological innovation, as outlined in the *National Bioeconomy Blueprint of the United States of America* and the 2015 Budget. The Blueprint outlines the Federal government's efforts to develop a more sustainable economy whilst also generating new industries, increasing productivity and addressing key environmental challenges.[24] Bio-plastics technology is likely to benefit from increased funding towards innovation research as well as improved efforts to develop infrastructure. The US Farm Bill 2008 aims to stimulate the construction and development of bio-based product facilities by providing grants and loan guarantees to refineries, as well as funding for the scaling up of certain types of plant.[25] Further, in his 2015 Budget, President Obama promised $3 million of funding to the Biomass Research and Development programme which is intended to encourage innovation and improve the commercialisation of bio-based products.[26]

The Federal government aims to drive demand for bio-based products through procurement programmes. The Farm Bill also mandates the BioPreferred programme, which advocates the purchase of bio-based products by Federal agencies. To qualify for the BioPreferred programme, a product must meet or exceed the US Department of Agriculture's guidelines on a minimum level of bio-based content.[27] With the opportunity to benefit from preferential status, bio-plastics producers are thus encouraged to develop products that are composed of the minimum levels of bio-based content.

---

[24] Maxon, M. and Robinson, E., (2012) "National Bioeconomy Blueprint Released", The Whitehouse, accessed at [https://www.whitehouse.gov/blog/2012/04/26/national-bioeconomy-blueprint-released]

[25] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[26] Lane, J., (2014), "Benjamins for Biofuels in the 2015 Obama Budget: The Digest's 7-minute guide", Biofuels Digest, accessed at[http://www.biofuelsdigest.com/bdigest/2014/03/05/benjamins-for-biofuels-in-the-2015-obama-budget-the-digests-7-minute-guide/]

[27] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

A recent report assessing the impact of the bio-based products industry in the USA found that, following the introduction of the Programme in 2002, bio-based products contribute $369 billion to the US economy, with $622 million added by the bio-plastics sub-sector. The entire bio-based products industry is also estimated to support 4 million jobs, with every 1 bio-based product job creating a further 1.64 jobs across the US economy.[28] While these impacts relate to the broader set of bio-based products, they suggest the potential effects that an initiative as simple as a public procurement programme can have for the UK bio-plastics industry.

At the State level, policy initiatives are more fragmented, with certain States being more pioneering in terms of bio-plastics than others. In 2007, San Francisco was the first city in the US to regulate plastic bags by banning non-biodegradable carrier bags at all large supermarkets and chain pharmacies. The use of compostable plastic bags, paper bags or reusable bags was mandated, instead. By 2013 the law was expanded to include restaurants[29] and by 2014 California became the first state in the US to introduce legislation enforcing a state-wide ban on carrier bags at large retail shops. By contrast, the introduction of plastic bag restrictions have stalled in areas such as New York City and Philadelphia, with these jurisdictions opting for recycling programmes instead[30]. As a result, bio-plastics producers are likely to find different States' policy environments in the USA more conducive to bio-plastics production than others.

Arguably due to the USA's unaligned efforts to promote bio-plastics specifically, North America (USA, Canada and Mexico) consumed marginally less than Europe in 2012, making up 23% (equivalent to 59 million tonnes) of global polymer demand. In contrast, the regional demand for bio-plastics is estimated to be almost a third (31%) of total global demand for bio-plastics.[31]

Smithers Pira (2013) estimate North America's bio-plastic consumption for packaging to be 28% of global demand in 2012, 6% lower than what they estimate for Europe. In absolute terms, this is equivalent to 150 thousand tonnes of bio-plastics required for packaging. Almost half of this is estimated to be used for non-food packaging related products, as illustrated in Figure 7.

In terms of production capacity, European Bio-plastics estimates that North America produced 18.4% of entire global production in 2013. This is equivalent to almost 300 thousand tonnes of the total 1.62 million tonne global bio-plastics capacity.[32]

---

[28]Golden, J., Handfield, R., Daystar, J., and McConnell, E., (2015), "An economic impact analysis of the US biobased products industry: a report to the congress of the United States of America"

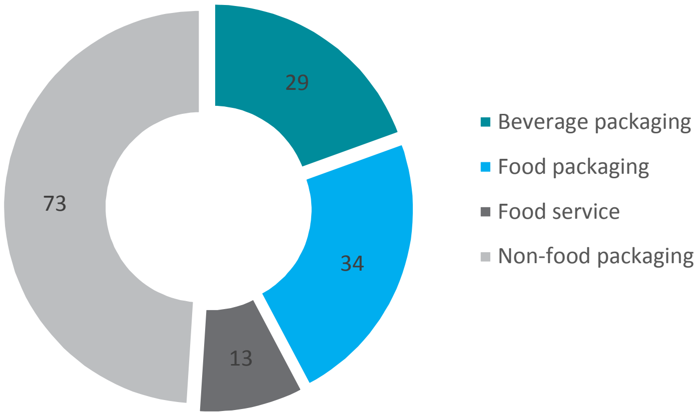
[29] Larsen J., and Venkova, S.,(2014), "Plastic bag bans spreading in the United States", Earth Policy Institute, accessed at[http://www.earth-policy.org/plan_b_updates/2014/update122]

[30] Larsen J., and Venkova, S., (2014), "Plastic bag bans spreading in the United States", Earth Policy Institute, accessed at[http://www.earth-policy.org/plan_b_updates/2014/update122]

[31] Smithers Pira (2012), "The Future of Bio-plastics: market forecasts to 2017"

[32] European Bio-plastics, (2014), "Bio-plastics facts and figures"

Figure 7: North American bio-plastics for packaging demand by segment in 2013, thousand tonnes



Source: Smithers Pira 2013

Asia

Two countries in particular, are catalysing the growth of bio-plastics production in Asia: Thailand and China. The former is achieving this through its comparative advantage in agricultural materials, while the latter does so through the sheer size of its productive capacity and demand potential.

Thailand benefits from natural comparative advantages of low-cost Cassava starch, wheat and sugar cane production, as well as being home to the largest number of plastics processers in South East Asia[33]. The Thai government plans to marry the country's expertise gained from being a major exporter of plastics with its existing strong agricultural base, to become the Asian hub for bio-plastics activity. Several incentive schemes to support investment in the bio-plastics industry have been introduced in recent years, in particular relating to fostering research and innovation, and supporting the construction of bio-plastics production plant.[34] In addition, measures such as reducing import duties for bio-plastic resins that cannot be manufactured in Thailand and improving access to land ownership rights to foster foreign investment have also been introduced by the Thai government to drive private sector investment in the bio-plastics industry.[35]

China is also paving the way for increased bio-plastics production. With the country's ban on free conventional plastic bags in 2008 as well as the encouragement of PLA materials production as part of the 2009 economic stimulus programme, demand for bio-plastics production is expected to increase markedly in China. In addition, the Jilin province in North China has moved a step further by launching a policy to ban conventional plastic bags in certain areas. The upshot of this is expected to be a market demand for 20,000 tonnes of bio-plastic products in this province alone. If other provinces follow suit, China's demand for bio-plastic products would grow rapidly.

With Thailand and China leading the way, Asia accounted for over one-fifth (21%) of global bio-plastics demand for packaging in 2013, equivalent to 113 thousand tonnes (see Figure 8). The largest source of

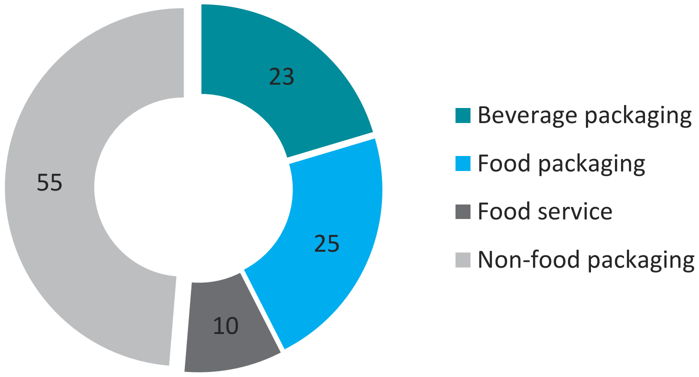
[33] Smithers Pira, (2013), "The Future of Bio-plastics: market forecasts to 2023"

[34] Thailand Board of Investment, (2014), "Thailand's Bio-plastics Industry", accessed at [http://www.boi.go.th/upload/content/AW_BOI-brochure2014-Bioplastics-20140507_51146.pdf]

[35] United Nations ESCAP, (2012), "Low Carbon Green Growth Roadmap for Asia and the Pacific", accessed at [http://www.unescap.org/resources/low-carbon-green-growth-roadmap-asia-and-pacific]

demand was from the beverage packaging sector, with Asia demanding 22% of global beverage packaging (or 23 thousand tonnes).

Figure 8: Asian bio-plastics for packaging demand by segment in 2013, thousand tonnes



Source: Smithers Pira, 2013

2.4 Future outlook for the bio-plastics industry

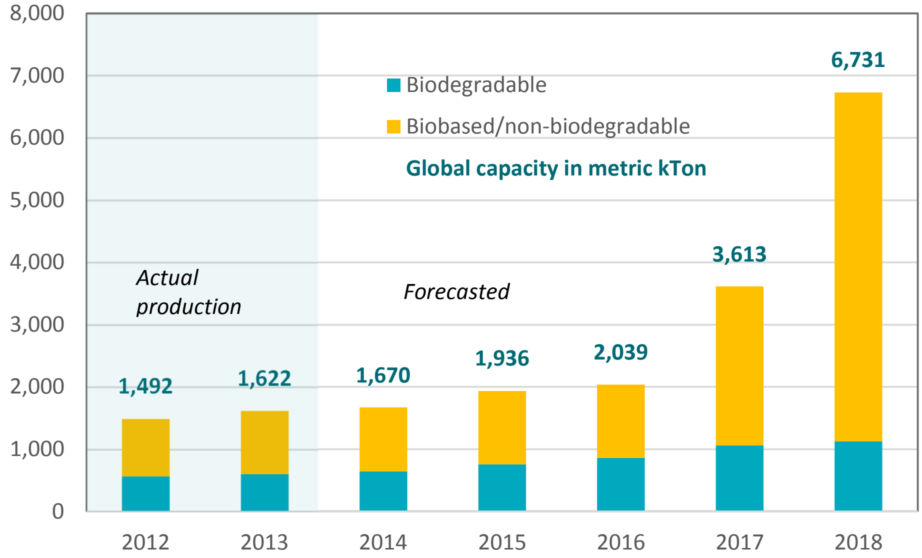
According to Smithers Pira 2012 report, bio-plastics in 2012 accounted for less than 1% of total global plastics production.[36] European Bio-plastics estimates that the annual global production capacity of bio-plastics will increase from its 2013 levels of 1.62 million tonnes to 3.61 million tonnes by 2017. Of this, 1.06 million tonnes (equivalent to 29.3%) is estimated to be the production of biodegradable plastics, with the remaining 2.55 million tonnes (70.7%) estimated to produce bio-based non-biodegradable plastics (Figure 9).

The production capacity of biodegradable bio-plastics is forecasted to increase by 74% by 2017, from its 2013 level. In comparison, bio-based non-biodegradable plastic production is expected to increase by more than one-and-half times (153%) its 2013 level.[37] The bio-based, non-biodegradable bio-plastics group is anticipated to see the strongest growth due to their so-called 'drop-in' solutions.

[36] Smithers Pira (2012), The Future of Bio-plastics 2017

[37] European Bio-plastics, (2014), "Global production capacities of bio-plastics"

Figure 9: Global production capacity of bio-plastics, actual and forecasted values (kilo tonnes) from 2012 to 2018



Source: European Bio-plastics 2014

By 2018, European Bio-plastics predicts a surge in global bio-plastics production, to 6.7 million tonnes. Disaggregating the global production capacity by region, European Bio-plastics anticipates bio-plastic production capacities to grow fastest outside Europe. Asia is forecasted to see its production capacity increase the most and is estimated to be the largest producing region of bio-plastics by 2018, producing 75.8% of global bio-plastics production. This would represent a 24.4% increase in Asian production capacity from its 2013 level.

The vast majority of the currently planned projects are being implemented in Thailand, India and China. By comparison, despite Europe being the frontrunner in terms of research and development, the region is expected to only produce 7.6% of the global bio-plastics supply by 2018, almost 10% lower than its 2013 share of global bio-plastics production (Table 3). European Bio-plastics also advises that regions such as the USA and Asia invest in measurers that encourage and support the infant indigenous industry in its development, which results in faster market development than in Europe.

Table 3: Global production capacities of bio-plastics in 2013 and 2018, percentage produced by region

	2013	2018	Percentage change 2012-2018
Asia	51.4%	75.8%	24.4%
South America	12.3%	12.2%	-0.1%
North America	18.4%	4.3%	-14.1%
Europe	17.3%	7.6%	-9.7%
Australia/Oceania	0.6%	0.1%	-0.5%
Total global production capacity (million tonnes)	**1.62**	**6.73**	**315%**

Source: European Bio-plastics 2014

In terms of consumption demand, the Smithers Pira's 2012 report, '*The Future of Bio-plastics*', estimates that the demand for bio-plastics will increase from 890 thousand tonnes in 2012 to 2.9 million tonnes by

2017. This is equivalent to a compound annual growth rate (CAGR) of 26.9%. This high growth projection is based upon crude oil pricing of about $100/barrel on average over the period, successful installation of announced projects and improvements in regional economies through GDP growth for example. However, the report also notes that if the average price of crude oil were to dip below the $100/barrel mark (with an average crude oil price of $87/barrel - defined as the ‘limited growth’ case[38]), the demand for bio-plastics might only reach 2.16 million tonnes by 2017.

In terms of Europe, the Smithers Pira 2012 report forecasts the region’s bio-plastics consumption to increase from 295 thousand tonnes in 2012 to 830 thousand tonnes in 2017. This is equivalent to a 23.0% CAGR. European demand is expected to be higher than in the US because of the extensive biopolymer compounding (including starch) that is being undertaken in the region. Other key factors driving consumption are the regions’ strong demand for bio renewable consumer and food service end-user products and the highly populated centres that have a strong interest in environmental sustainability. In addition, the legal framework, market conditions and strategies in Europe provide incentives for the use of bio-plastics which help to stimulate the market, as outlined in Section 2.3.

With regard to North America, the demand for bio-plastics is driven by strong industrial end-use segments i.e. packaging, automotive, consumer products, agriculture, medical and others. North America also has the added benefit of housing the largest chemical and polymer companies in the world, which have strong ties to the agricultural sector. Further, the region’s supportive regulation and legislation that encourages more environmentally sustainable business practices and consumer behaviour all contribute to the expectation that demand will rise from 270 thousand tonnes in 2012 to 710 thousand tonnes in 2017.[39]

The 2013 report by Smithers Pira[40] exclusively assesses the impact upon global demand for bio-plastics due to their increasing use in the packaging market. This report has a particular focus upon beverage, food, non-food and foodservice packaging demands. It estimates the global packaging market value in 2013 at $597 billion, forecasting a rise to $828 billion by 2023, equivalent to a compound annual growth rate (CAGR) of 3.3%. With an increasing awareness of and concern for environmental sustainability, the report estimates global bio-plastics demand, in terms of volume, for packaging to reach 535,000 tonnes in 2013. This global demand is anticipated to increase to 9.45 million tonnes by 2023 (representing a CAGR of 33%). The Smithers Pira 2013 report attributes this high growth rate of 33% again to crude oil prices of $100/barrel or higher, successful installation of announced projects and improvements amongst economies such as higher levels of GDP growth. The expectation would be for lower growth in the presence of lower oil prices, as exist today.

Europe and North America are both forecasted to see their demand as a proportion of global demand fall, despite absolute levels of consumption increasing. Both regions are predicted to see their share of demand fall by 8% in 2023 from their 2013 levels, with the expected rise of low-cost shale gas supply driving this trend. As shale gas is another fossil fuel-based alternative to crude oil, a rise in the supply of this will drive the price of crude oil and hence conventional plastics down further. As a result, bio-plastics will become (at least temporarily) relatively more costly. The remaining regions are projected to pick up the West’s share of lost demand, as illustrated in Figure 10. In particular, the region to watch is Asia, with its market share expected to increase to 34% by 2023, from only 21% in 2013.

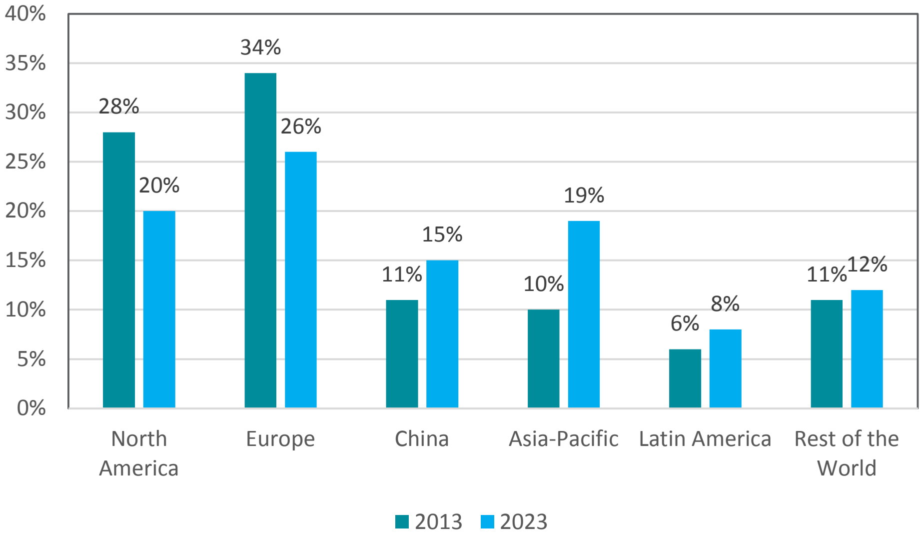
---

[38] Limited growth case by Smithers Pira 2012 report is scenario under which global oil prices average about $87/barrel.

[39] Smithers Pira (2012), “The Future of Bio-plastics: market forecasts to 2017”

[40] Smithers Pira (2013), “The Future of Bio-plastics: market forecasts to 2023”

Figure 10: Global packaging market by region, 2013 and 2023



Source: Smithers Pira 2013

3 The UK bio-plastics market

This section examines the current UK bio-plastics industry and the policy environment that it operates within. We delve further to assess the recent policy and legislative developments in Wales and Scotland that have the potential to encourage the growth of bio-plastics industry in these parts of the UK. Lastly, this section estimates the size of the current and future UK market.

3.1 Current structure of the UK industry

The UK's bio-plastics industrial structure differs from the general structure examined in section 2.2. Since the UK bio-plastics manufacturing industry is still in its infancy, not all components of the industry have been fully established. For example, due to the lack of converting technology in the UK, the resins produced by biochemical firms are converted in Europe. Once the resin has been converted to produce a biodegradable product e.g. plastic bags or food packaging film, a vast proportion of these products are imported from Europe, particularly from convertor companies based in Belgium, Norway, France, Poland, Italy and Germany, through traders into the UK market. The products are sold by traders onto clients in retail, food manufacturing and processing industries, the food and beverage service industries, and local councils across the UK.

Information provided by the industry, including BBIA members, suggests that there exists in the UK at present the demand for 4,000 tonnes of biodegradable bio-plastic finished product. Only 25% (1,000 tonnes) of this is presumed to be manufactured in the UK, whilst the remaining three-quarters are imported from outside the UK.

For food products that require multiple layers of bio-plastic film packaging e.g. coffee, in order to keep the product fresh for longer, strengthen the water barrier etc., a specialist convertor is required. Some of these specialist convertors are located in the UK and provide these products to traders downstream reaching the end-user (food-retailers, local councils etc.).

3.2 The UK policy environment

Current policy and legislative initiatives in the UK are aimed at achieving the Government's policy objective of a 'zero waste economy'. Through this, the Government aims to encourage individuals and businesses to reduce waste and reuse and recycle more. As a result, the variety of programmes, agreements, and legislation which aim to improve the efficient use of resources also have scope to indirectly promote the use of bio-plastic products. Key features of current UK policy are objectives to reduce waste, divert from landfill and increase recycling across the economy.

Reduction of waste

Since 2010, the government-funded Waste and Resources Action Programme (WRAP), has collaborated with businesses from the most resource intensive sectors (the food and drink, clothing and textiles, and the electrical and electronics sectors), as well as individuals, local authorities and trade associations to reduce waste and improve resource efficiency. The Courtauld Commitment, a voluntary deal initiated by WRAP, focuses on helping businesses throughout the food supply chain to improve their packaging design and, as a result, assists households in reducing waste from their groceries.

In addition, the Hospitality and Food Service Agreement sets targets of limiting food and packaging waste by 5% from 2012 levels, and increasing the overall rate of food packaging waste that is being recycled or sent to anaerobic digestion or composting to at least 70% by the end of 2015.[41] Between the Programme's inception and 2015, WRAP's initiatives have had significant success; including reducing waste in England alone by 4 million tonnes and diverting 29 million tonnes of waste away from landfill.

Reduce landfill use

The UK's landfill policies are driven by Directives set by the European Commission (EC). In particular, there are stringent restrictions on the types and amount of waste that can be disposed of in England, Wales, Scotland and Northern Ireland as a result of the Landfill Directive.[42]

Further incentives to divert waste away from landfill are taxation policies. The Landfill Tax, at £82.60 per tonne and set to rise to £84.40 per tonne in 2016, imposes further costs on any business or municipality that disposes of waste in landfill. As bio-plastics are biodegradable, they enable further diversion from landfill of organic waste that is traditionally mixed with non-biodegradable plastic items such as cutlery and food packaging. As a result, the Landfill Tax is likely to be an indirect driver of bio-plastics demand.

Increase recycling

The UK is subject to meeting the targets set by the EC Waste Framework Directive of increasing the household recycling rate to 50% by 2020. As a result, a range of measures have been implemented to encourage households and businesses to recycle more. For example, improved waste collection requires households and businesses to separate their collection of paper, plastic, metal and glass waste. As this improves, the need for biodegradable plastic bags will rise to ensure that organic waste can be recycled properly.

As of 5th October 2015, a 5 pence charge on single-use plastic carrier bags has been in place in England, to mirror similar charges already introduced in Wales, Scotland and Northern Ireland. But biodegradable bags are not currently exempted. With demand for single-use carrier bags set to continue, the Government has signalled that there is scope for single-use bags to be made from biodegradable materials and thus to be exempted from the charge.

3.3 Developments in Wales, Scotland, and Northern Ireland

Many powers over waste and recycling have been devolved to the respective Scottish and Welsh Governments and the Northern Ireland Assembly, although the objective of achieving a 'zero-waste' economy runs through the initiatives of all three nations.

Wales currently has the highest recycling rate out of all the devolved nations, recycling 54% of municipal waste in 2013 and 2014.[43] Wales was also the first of the UK nations to enforce a charge on plastic bags. Wales introduced a minimum charge of 5 pence per single-use carrier bag in 2011 while Scotland followed suit in 2014. In Wales the charge has led to a 79% decrease in plastic bags taken in the first three years of the charge's implementation, although numbers have been slowly increasing after a dramatic initial fall.[44] Meanwhile, reports from Scotland show that carrier bag use has plummeted by

[41] DEFRA, (2015), "2010 to 2015 government policy: waste and recycling", accessed at [https://www.gov.uk/government/publications/2010-to-2015-government-policy-waste-and-recycling/2010-to-2015-government-policy-waste-and-recycling]

[42] Law and Your Environment, (n.d.), "UK Waste Policy", accessed at [http://www.environmentlaw.org.uk/rte.asp?id=82]

[43] "Government policy", Lets Recycle, accessed at [http://www.letsrecycle.com/councils/government-policy/]

[44] http://www.wrap.org.uk/2015_carrier_bag_figures

80%.[45] In Scotland and Wales retailers are encouraged to donate the profits from the sale of single-use bags to good causes. In Northern Ireland, a levy applies to all new carrier bags with a retail price below £0.20. This is regardless of whether they are single use or reusable and a minimum of £0.05 must be charged. Proceeds from the levy go to the Department of the Environment, and in its first year (2013/14), £3.4 million of the proceeds were spent on more than 250 projects delivered by the Northern Ireland Environment Link (NIEL) Challenge Fund.

However, these nations are currently missing explicit exemptions for bio-degradable or bio-based bags, due to the legislation's focus on reducing littering instead of directly promoting recovery of food waste through use of bio-plastics bags. What is interesting here is the fact that European Bio-plastics policy discourages the use of bio-plastics as a solution to littering.[46] Instead, bio-plastics demand is more likely to be promoted by recycling targets. By 2025, both Wales and Scotland aim to recycle 70% of their waste and to send only 5% to landfill. In addition, the 2013 Delivering Resource Efficiency: Northern Ireland Waste Strategy seeks a recycling target of 60% by 2020 and action on food waste collections. Bio-plastics are likely to play an important role in achieving these targets. The use of bio-plastic organic waste caddy liners have been proven to be an essential part of successful initiatives in the separate collection and recycling of food waste and compostable carrier bags can have this dual purpose- for bringing the shopping home and for delivering food waste to collection.[47]

3.4 Sizing the UK market now and in the future

The situation today

Based on data provided by the industry (including BBIA members), Cebr has established that there is today total demand in the UK for approximately 4,000 tonnes of finished bio-plastic products. Three quarters of this demand is met through supply from abroad (imports), with the remaining 1,000 tonnes being domestically produced in the UK. Table 4 below shows how this total demand breaks down across the relevant subset of bio-plastic products that are of interest for this report.

The 100 tonnes of bio-plastic carrier bags are imported from abroad, whereas the 500 tonnes of food packaging are produced domestically. The data available to us suggests that 500 of the 3,200 tonnes of bio-plastic organic waste caddy liners are domestically produced, with the remainder imported from abroad. Of the aggregate demand for organic waste caddy liners, 50% are sold by retailers to household consumers, 40% are provided or sold by local authorities to households and 10% are B2B sales from the final product producers.[48]

---

[45] Slawson, N., (2015), "Scotland's plastic bag usage down 80% since 5p charge introduced", The Guardian, accessed at [http://www.theguardian.com/environment/2015/apr/17/scotland-plastic-bag-usage-falls-after-5p-charge-introduced]

[46] European Bioplastics, (2013), "Plastic shopping bags", accessed at [http://en.european-bio-plastics.org/EuBP_PositionPaper_Plastic_shopping_bags.pdf]

[47] www.wrap.org.uk/foodwaste

[48] These being the producers of bio-plastic organic waste caddy liners, bio-plastic carrier bags and bio-plastic food packaging and food service products that they then sell on to households, local government, business customers

Table 4: Total UK demand for finished bio-plastic products at present, including a breakdown across the relevant subset of bio-plastic products

	Tonnes
Carrier bags	100
Food packaging	500
Food service (cutlery etc)	200
Organic waste caddy liners	3,200
of which	
Sold by retailers to households	*1,600*
Provided or sold by local authorities	*1,280*
B2B	*320*
Total UK demand for finished bio-plastic products	**4,000**

Source: Data from the industry, including BBIA members

We have also made a range of assumptions on prices based on the data provided by the industry, including BBIA members. These assumptions concern the monetary flows in the value chain, which was explained in Section 2.2 above and are:

- Manufacturers of bio-plastics in primary form (essentially bio-chemical resins) receive €3.50 per kilogram from converters. This €-denominated amount was converted to pounds sterling for modelling purposes.
- The price paid by local authorities for the organic waste caddy liners that they provide to households is €4.50 per kilogram, of which manufacturers still take €3.50 per kilogram, with the remainder for converters and traders (if relevant). Again, these amounts were converted to pounds sterling.
- For organic waste caddy liners sold by retailers to households, the price per kilogram is typically in the range of £18-£24 excluding VAT. We have assumed the midpoint of £21 per kilogram.
- The retail margin is typically 40-50%, so we again assume a midpoint of 45%. The remainder is left for manufacturers, converters and traders.
- For B2B sales of organic waste caddy liners, the price paid by the business customer would be about €6 per kilogram, of which manufacturers would again take €3.50 per kilogram. Converters and traders would charge more than to local authorities, hence the higher price, which is more on a par with what is charged to retailers. These amounts were converted to pounds sterling for modelling purposes.
- The average sale price of bio-plastic cutlery is €3 per kilogram, being the price that a food service business would pay to converters or traders. The primary form bio-plastic is cheaper to produce so manufacturers in this case take about €1.80 per kilogram. Again, these amounts were converted to pounds sterling.
- For the technical films required for food packaging, the products are more specialised and complex. The final sale price is estimated at €6 per kilogram, with manufacturers taking €4 per kilogram. This is greater than the typical €3.50 seen above and reflects the higher costs of production.

The future scenario

Given the right circumstances, in particular a legislative framework that creates the conditions that are conducive to investment in bio-plastics production capacity in the UK,[49] the industry believes that there is scope for domestic production of bio-plastics to reach 120 thousand tonnes. This would break down as follows:

- 40 thousand tonnes of bio-plastic carrier bags (for shopping);
- 40 thousand tonnes of bio-plastic food packaging;
- 20 thousand tonnes of bio-plastic organic waste caddy liners; and
- 20 thousand tonnes of bio-plastic food service products (cutlery etc.).

The industry is also of the view that the cost structure is likely to stay the same so there is unlikely to be any significant changes in prices. We suspect that the prices currently being quoted (and outlined above) are for products produced in facilities that already benefit from scale economies. So, if anything, these prices could even understate what would be required to cover costs in the early days of production and until minimum efficient scale is reached by the industry and the companies operating within it.

How these assumptions are used

The assumptions quantities are multiplied up by prices to establish the turnover in each of three sub-sectors:

- The manufacture of bio-plastics in primary form (such as the bio-chemical resins produced by companies like Novamont);
- The manufacture of finished bio-plastic products;
- The (wholesale) trading and retailing of finished bio-plastic products.

Using information about margins and supply chains (as well as the turnover information), we were able to embed these sub-sectors within our models for estimating impacts by establishing explicit roles for them within the models. The subsequent modelling exercise is what produced the results presented in Section 4 below. The modelling methodology is outlined in the Appendix to this report.

[49] This could take the form of investment in brand new dedicated capacity or conversion of facilities producing traditional plastics to the production of bio-plastics.

4 Macroeconomic impacts of a UK bio-plastics industry

This section sets out our findings on the macroeconomic contributions of the bio-plastics industry,

4.1 Methodological overview

The methodology involved the estimation of the industry's direct impacts as well as its indirect and induced multiplier impacts. We outline the estimated GVA[50] contributions made by the bio-plastics industry to GDP and national employment using the ONS national accounting framework and data, based on which our economic impact models are structured. Other key datasets include the Annual Business Survey, the Business Register and Employment Survey (BRES) and Annual Survey of Hours and Earnings (ASHE).

The findings presented in this section are based on standard modelling tools involving the establishment of an explicit role for the sector(s) or sub-sector(s) of interest. Once this explicit role is established, based on our understanding of the value chain and commercial relationships that are common in the industry, these sectors are embedded within a broader economy-wide multi-sector modelling framework. We have then adapted supply-use models to estimate direct economic impacts and input-output models to produce estimates of the multiplier impacts. This is explained in greater detail in the Appendix to this report.

4.2 Gross output impacts

In this section we examine the contribution of the bio-plastics industry to the UK economy in terms of the output generated by the industries that fall within our definition of the sector. Gross output is essentially the national accounting term for turnover. Whilst there are important differences between the concepts in respect of the treatment of sectors that are heavily taxed or subsidised, they are not especially relevant in the case of bio-plastics.

Table 5 presents the direct gross output contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II output multipliers and the aggregate output contributions given these multiplier impacts.

---

[50] GVA or gross value added is a measure of the value from production and can be thought of as the value of industrial output less intermediate consumption. That is, the value of what is produced less the value of the intermediate goods and services used as inputs to produce it. GVA is also commonly known as income from production and is distributed in three directions – to employees, to shareholders and to government. GVA is linked as a measurement to GDP – both being a measure of economic output. That relationship is (GVA + Taxes on products - Subsidies on products = GDP). Because taxes and subsidies on individual product categories are only available at the whole economy level (rather than at the sectoral or regional level), GVA tends to be used for measuring things like gross regional domestic product and other measures of economic output of entities that are smaller than the whole economy, such as bio-plastics etc. GVA must be distinguished from turnover measures, which capture the entire value of sales. By contrast, GVA captures the value added to a set of inputs by a firm on their journey from raw materials to finished consumer products. Thus the value added of a firm that uses oil imports to make plastics is equal to the price that it sells the plastic for minus the cost of the oil it uses as inputs. Similarly the value added of a manufacturer that uses that plastic to make a bus shelter is equal to the price that it sells the bus shelter for minus the cost of the plastic it uses as an input. The concept of added value enables the avoidance of double counting when estimating the size of an economy or the contribution to it of a particular sector.

Table 5: Direct and multiplier output impacts of the bio-plastics sector, split by sub-sector, 2014

Sub-sector	Direct output contribution (£m)	Type II output multiplier (£ output)	Aggregate output contribution (£m)
Manufacture of bio-plastics in primary forms	2.7	2.63	7.1
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	9.5	2.48	23.7
Wholesale and retail of bio-plastic products (traders and retailers)	31.2	2.33	72.7
Aggregate bio-plastics sector[51]	**43.4**	**N/A**	**103.4**

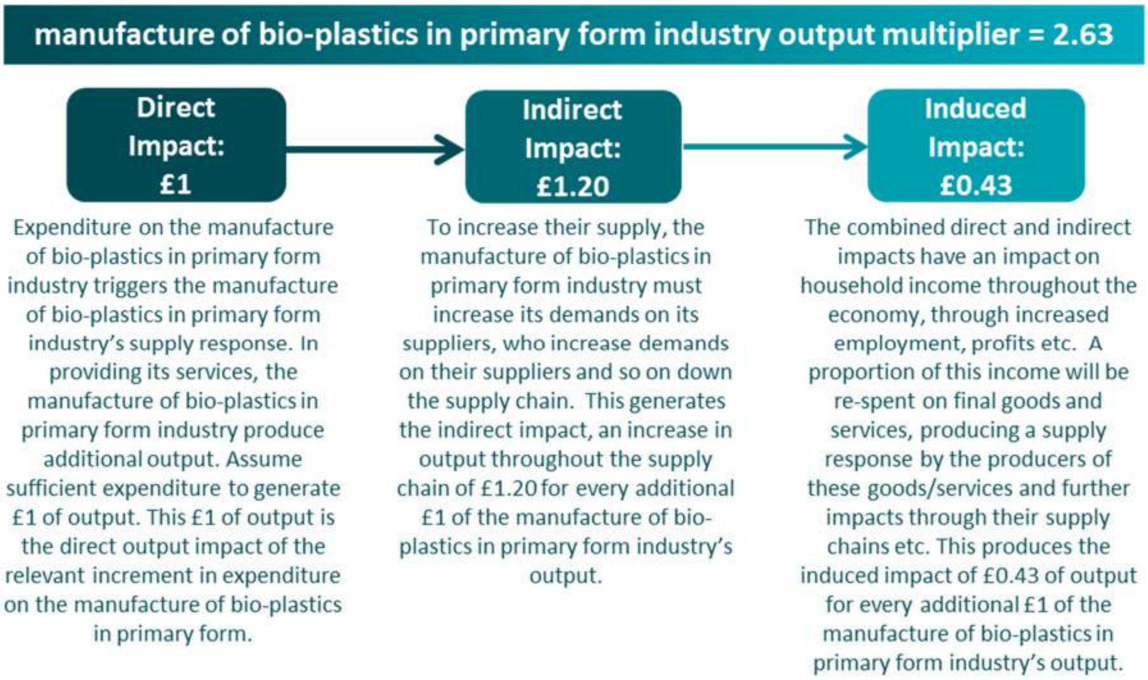
Source: Cebr analysis

In supplying its products, the bio-plastics sector draws upon inputs from several other sectors of the economy. One sub-sector is the manufacture of bio-plastics in primary form, which captures the activities of businesses such as BASF, Bio-Tec, Corbion and Novamont. Our input-output modelling suggests that the gross output multiplier for the manufacture of bio-plastics in primary form is 2.63, as shown in Figure 11. This means that for every £1 increase in this sub-sector's output, the economy-wide increase in output due to direct, indirect and induced impacts is £2.63. The output multipliers for the other two sub-sectors, (manufacture of bio-plastics in final form, and the wholesale and retail of bio-plastic products) work in exactly the same way.

Based on the sub-sector's direct output impact in 2014 of £2.7 million, we estimate that its aggregate output contribution, including direct, indirect and induced impacts, amounted to £7.1 million in the same year, as presented in Table 5. Combined with the direct output impacts of the other two sub-sectors, the direct output contribution of the aggregate bio-plastics sector in 2014 amounted to £43.4 million. With an output multiplier of 2.38, we estimate that the aggregate output contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, totalled approximately £103.4 million in 2014.

[51] The contributions of the various sub-sectors may not sum to the total due to rounding.

Figure 11: The manufacture of bio-plastics in primary form output multiplier



Source: Cebr analysis

4.3 Gross value added impacts

Here we examine the contribution of the bio-plastics sector to the UK economy in terms of the GVA generated by the industries that fall within our definition of the sector. Table 6 presents the direct GVA contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II GVA multiplier and the aggregate GVA contribution given by these multiplier impacts.

Table 6: Direct and multiplier GVA impacts of the bio-plastics sector, split by sub-sector, 2014

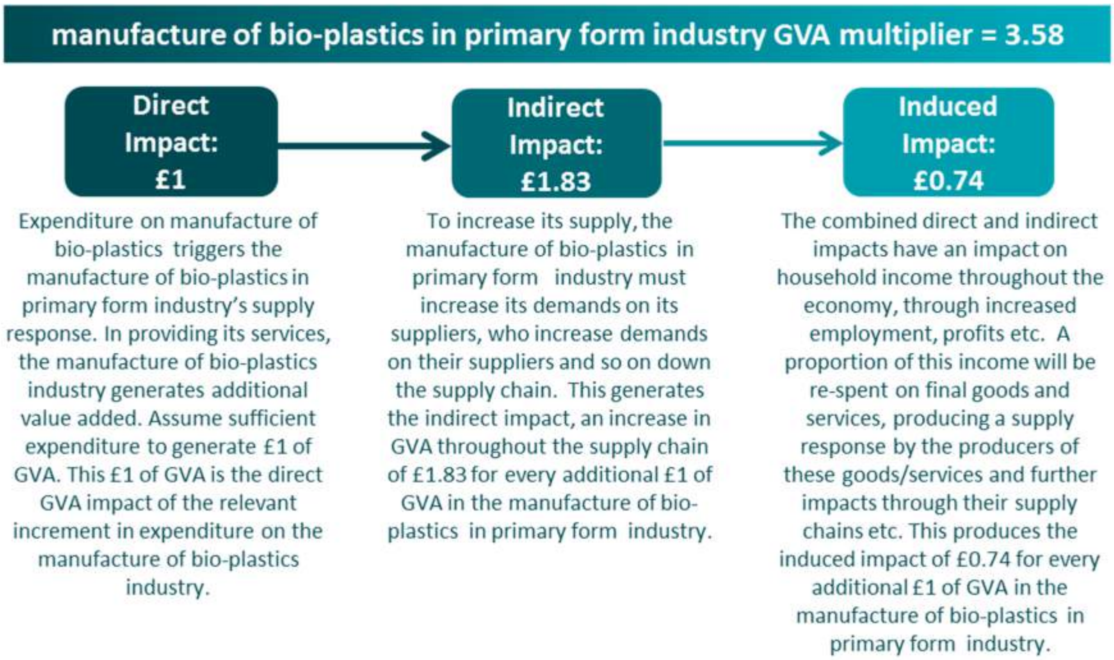
Sub-sector	Direct GVA contribution (£m)	Type II GVA multiplier (£ GVA)	Aggregate GVA contribution (£m)
Manufacture of bio-plastics in primary forms	0.8	3.58	2.8
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	3.1	2.98	9.3
Wholesale and retail of bio-plastic products (traders and retailers)	18.0	2.13	38.4

Sub-sector	Direct GVA contribution (£m)	Type II GVA multiplier (£ GVA)	Aggregate GVA contribution (£m)
Aggregate bio-plastics sector[52]	**21.9**	**N/A**	**50.5**

Source: Cebr analysis

Again, we focus on the manufacture of bio-plastics in primary form industry sub-sector. Our input-output modelling suggests that the manufacture of bio-plastics in primary form has a GVA multiplier of 3.58, as shown in Figure 12. This means that for every £1 of GVA generated by the sub-sector, the economy-wide increase in GVA due to direct, indirect and induced impacts is £3.58.

Figure 12: The manufacture of bio-plastics in primary form industry's GVA multiplier



Source: Cebr analysis

Based on the sub-sector's direct GVA impact in 2014 of £0.8 million, we estimate that its aggregate GVA contribution, including direct, indirect and induced impacts, amounted to £2.8 million in the same year, as presented in Table 6.

Combined with the direct GVA impacts of the other two sub-sectors, the direct GVA contribution of the aggregate bio-plastics sector in 2014 amounted to £21.9 million. With a GVA multiplier of 2.31, we estimate that the aggregate GVA contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, totalled £50.5 million in 2014.

[52] The contributions of the various sub-sectors may not sum to the total due to rounding.

4.4 Employment impacts

This section examines the contribution of the bio-plastics sector to the UK economy in terms of the employment generated by the industries that fall within our definition of the sector. For consistency, it is necessary to model employment multipliers using full-time equivalents (FTEs)[53], rather than numbers of employees. We calculated these employment multipliers based on our input-output modelling of the bio-plastics industry. Table 7 presents the direct employment contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II employment multiplier and the aggregate employment contribution given these multiplier impacts.

Table 7: Direct and multiplier employment impacts of the bio-plastics sector, split by sub-sector, 2014

Sub-sector	Direct employment contribution (FTEs)	Type II employment multiplier	Aggregate employment contribution (FTEs)
Manufacture of bio-plastics in primary forms	4	12.90	46
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	28	4.71	132
Wholesale and retail of bio-plastic products (traders and retailers)	511	1.70	867
Aggregate bio-plastics sector[54]	**542**	**N/A**	**1,045**

Source: Cebr analysis

Our input-output modelling suggests that the manufacture of bio-plastics in primary form comes with an employment multiplier of 12.90, as shown in Figure 13. This means that for every 1 FTE job in the sub-sector's employment, an additional 11.90 FTE jobs are supported in the wider economy, through indirect and induced multiplier impacts. This is a relatively high multiplier but not that unusual, simply reflecting a much greater labour intensity in the supply chain relative to the sector or sub-sector of interest.

The employment multipliers for the other two sub-sectors, (manufacture of bio-plastics in final form, and the wholesale and retail of bio-plastic products) and for the aggregate bio-plastics sector work in exactly the same way.

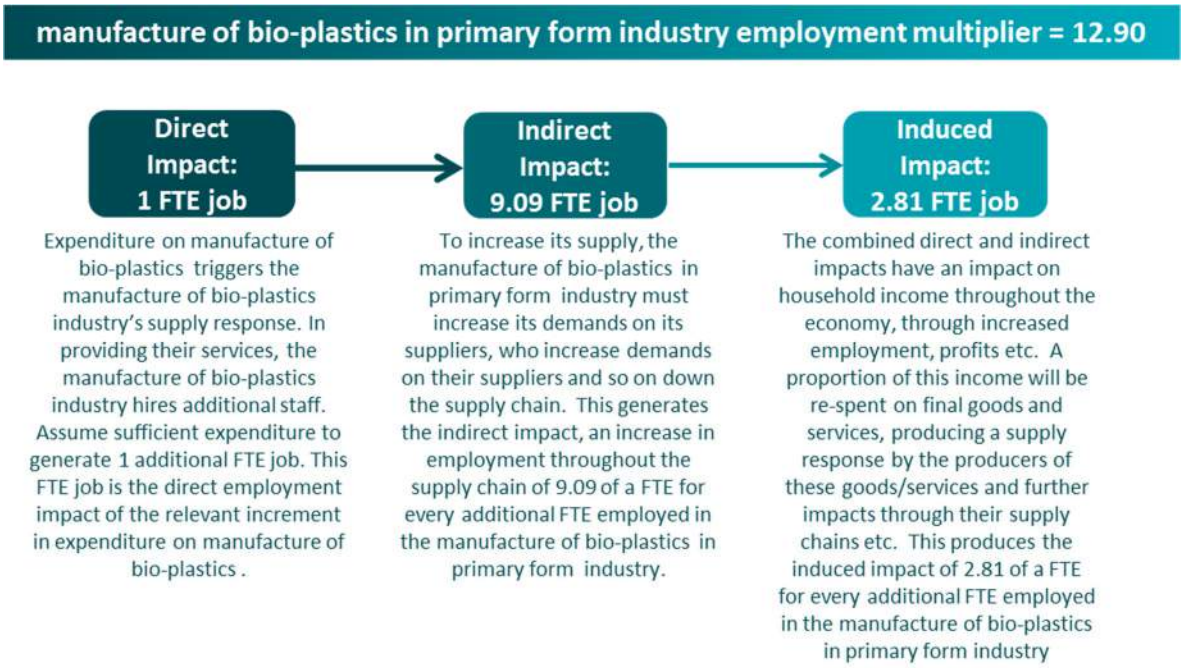
Taking into account the indirect and induced multiplier impacts, the manufacture of bio-plastics in primary form directly employed an estimated 4 FTEs, which is consistent with a total employment impact of 46 FTE jobs in 2014, as presented in Table 7 above. Combined with the direct FTE impacts of the other two sub-sectors, the direct employment contribution of the aggregate bio-plastics sector in 2014 amounted to 542 FTEs. With an employment multiplier of 1.93, we estimate that the aggregate

[53] 1 FTE is equivalent to one employee working full-time hours or two employees working half-hours for instance.

[54] The contributions of the various sub-sectors may not sum to the total due to rounding.

employment contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, totalled approximately 1,045 FTEs in 2014.

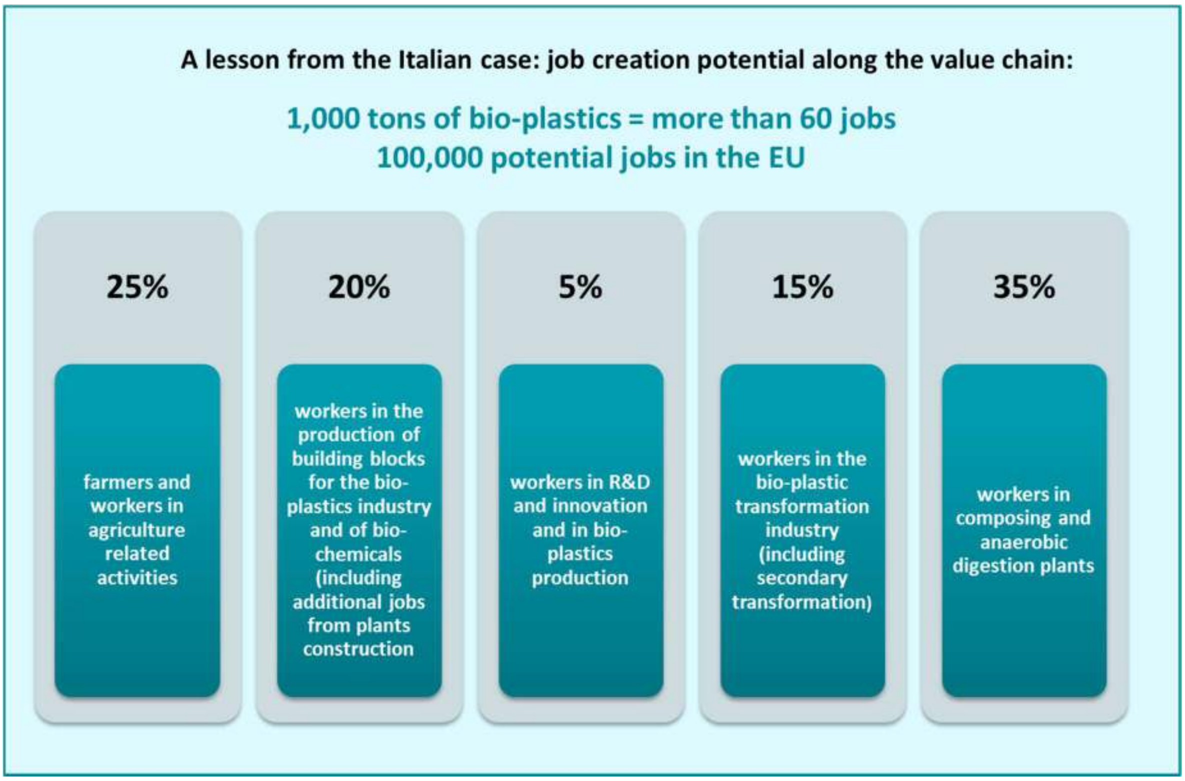
Figure 13: The manufacture of bio-plastics in primary form industry's employment multiplier



Source: Cebr analysis

See Figure 14 below for an illustration, based on the Italian case study, of how jobs are created along the bio-plastics value chain, further illuminating the source of the employment impacts above.

Figure 14: Case study from Italy – job creation along the bioplastics value chain



Source: Novamont[55]

4.5 Employee income impacts

Here we consider impact in terms of income for employees generated by the industries that fall within the sector. Table 8 presents the direct income contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II income multiplier and the aggregate income contribution given these multiplier impacts.

Table 8: Direct and multiplier income impacts of the bio-plastics sector, split by sub-sector, 2014

Sub-sector	Direct income contribution (IfE £m)	Type II income multiplier	Aggregate income contribution (IfE £m)
Manufacture of bio-plastics in primary forms	0.2	5.59	1.3
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	1.1	3.96	4.4

[55] Gregori, G., (2015), "Novamont and its model of circular bioeconomy", Novamont

Sub-sector	Direct income contribution (IfE £m)	Type II income multiplier	Aggregate income contribution (IfE £m)
Wholesale and retail of bio-plastic products (traders and retailers)	11.0	2.04	22.5
Aggregate bio-plastics sector[56]	**12.4**	**N/A**	**28.2**

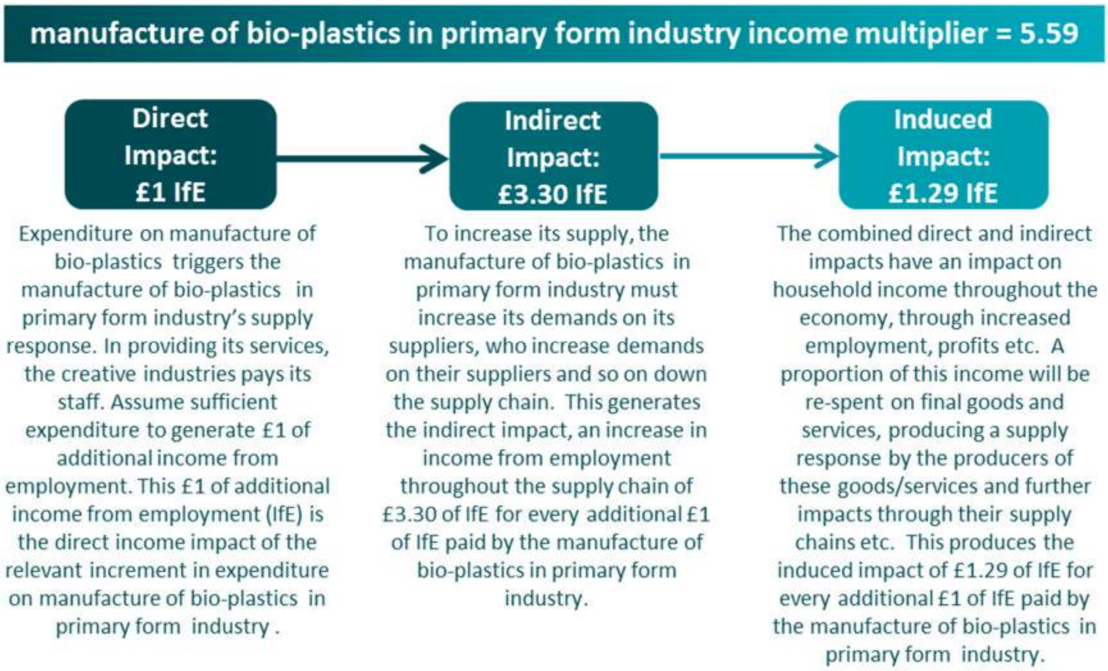
Source: Cebr analysis

As illustrated in Figure 15, our modelling suggests that the manufacture of bio-plastics in primary form has an income multiplier of 5.59. This describes the employee incomes supported in its supply chain and the wider economy through the bio-plastic industries' employee spending impacts.

The sub-sector was estimated to have paid £0.2 million in salaries in 2014. Taking into account the multiplier impacts, we estimate that the sub-sector supports an aggregate £1.3 million in gross employee incomes, as presented in Table 8. Combined with the direct income impacts of the other two sub-sectors, the direct income from employment contribution of the aggregate bio-plastics sector in 2014 amounted to £12.4 million. With an income multiplier of 2.28, we estimate that the aggregate income from employment contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, totalled £28.2 million in 2014.

[56] The contributions of the various sub-sectors may not sum to the total due to rounding.

Figure 15: The manufacture of bio-plastics in primary form industry's income multiplier



Source: Cebr analysis

4.6 Future impacts

This section presents our findings on the potential future contribution of the bio-plastics sector to the UK economy. This is based on the industry expectation that, with a supportive policy environment that is conducive to investment, the sector can achieve a production capacity of 120 thousand tonnes. There is no timetable for reaching this target as such, but our understanding is that, given the potential to convert traditional plastics manufacturing facilities over to the production of bio-plastics, it would likely take somewhere between five and ten years.

We first outline the potential gross output impacts that would arise from reaching this target, before highlighting the potential GVA contribution of the future industry. Following this, we present our estimates of the potential employment contribution of a future domestic bio-plastics sector, and the corresponding employee income impacts.

Gross output impacts

In this sub-section, we examine the potential future contribution of the bio-plastics industry to the UK economy in terms of the output generated by the industries that fall within our definition of the sector.

Table 9 presents the potential future direct output contributions that could be made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II output multipliers and the aggregate output contributions given these multiplier impacts.

Table 9: Potential future direct and multiplier output impacts of the bio-plastics sector, split by sub-sector

Sub-sector	Direct output contribution (£m)	Type II output multiplier (£ output)	Aggregate output contribution (£m)
Manufacture of bio-plastics in primary forms	315	2.63	826
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	793	2.35	1,862
Wholesale and retail of bio-plastic products (traders and retailers)	648	2.33	1,511
Aggregate bio-plastics sector[57]	**1,756**	**N/A**	**4,200**

Source: Cebr analysis

Based on the manufacture of bio-plastics in primary forms industries' direct output impact of £314.5 million, we estimate that its aggregate output contribution, including direct, indirect and induced impacts, will amount to £826.4 million, as presented in Table 9. Combined with the direct output impacts of the other two sub-sectors, the potential direct output contribution of the aggregate bio-plastics sector is predicted to amount to approximately £1.8 billion. With an output multiplier of 2.39, we estimate that the aggregate output contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, could total £4.2 billion.

The only change in multiplier impact between the current and future scenario is recorded for the manufacture of bio-plastics in final form. This has fallen from 2.48 today to 2.35. This is due to the fact that whilst the production of bio-plastics in primary form now takes place domestically (which would boost the multiplier), so also is the conversion (manufacture in final form) also taking place domestically. Whether the net effect is a rise or fall depends on the relative prices and the effect that this has on the value of total input consumed relative to the value of total final output sold.

Gross value added impacts

In this sub-section, we examine the potential future contribution of the bio-plastics industry to the UK economy in terms of the gross value added generated by the sector. Table 10 presents the potential future direct GVA contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II GVA multiplier and the aggregate GVA contribution given these multiplier impacts.

[57] The contributions of the various sub-sectors may not sum to the total due to rounding.

Table 10: Potential future direct and multiplier GVA impacts of the bio-plastics sector, split by sub-sector

Sub-sector	Direct GVA contribution (£m)	Type II GVA multiplier (£ GVA)	Aggregate GVA contribution (£m)
Manufacture of bio-plastics in primary forms	91.9	3.58	328.7
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	298.7	2.61	779.4
Wholesale and retail of bio-plastic products (traders and retailers)	373.9	2.13	798.2
Aggregate bio-plastics sector[58]	**764.6**	**N/A**	**1,906.2**

Source: Cebr analysis

The manufacture of bio-plastics in primary form is expected to contribute a direct GVA impact of £91.9 million, with an aggregate GVA contribution of £328.7 million in the future, as presented in Table 10. Combined with the direct GVA impacts of the other two sub-sectors, the potential future direct GVA contribution of the aggregate bio-plastics sector is predicted to amount to £764.6 million. With an output multiplier of 2.49, we estimate that the aggregate output contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, will total approximately £1.91 billion.

Again, there is a drop in the estimated multiplier for the manufacture of bio-plastics in final form, from 2.98 to 2.61, which can be explained in the same way as for gross output above.

Employment impacts

The future UK bioplastics industry could make a significant contribution to employment and job creation. Table 7 presents the potential future direct employment contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II employment multiplier and the aggregate employment contribution given these multiplier impacts.

Table 11: Potential future direct and multiplier employment impacts of the bio-plastics sector, split by sub-sector

Sub-sector	Direct employment contribution (FTEs)	Type II employment multiplier	Aggregate employment contribution (FTEs)
Manufacture of bio-plastics in primary forms	416	12.90	5,373

[58] The contributions of the various sub-sectors may not sum to the total due to rounding.

Sub-sector	Direct employment contribution (FTEs)	Type II employment multiplier	Aggregate employment contribution (FTEs)
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	3,360	3.59	12,047
Wholesale and retail of bio-plastic products (traders and retailers)	10,627	1.70	18,027
Aggregate bio-plastics sector[59]	**14,403**	**N/A**	**35,447**

Source: Cebr analysis

Based on the manufacture of bio-plastics in primary form's industries' direct employment impact of 400 FTEs, we estimate that its aggregate employment contribution, including direct and multiplier impacts, will amount to 5,400 FTEs in the future, as presented in Table 11. Combined with the direct employment impacts of the other two sub-sectors, the potential future direct employment contribution of the aggregate bio-plastics sector is predicted to amount to 14,400 FTEs. With an output multiplier of 3.59, we estimate that the aggregate employment contribution of the aggregate bio-plastics sector, including direct, indirect and induced impacts, will total 35,400 FTEs.

Employee income impacts

Table 12 presents the potential future direct income contributions made by the bio-plastics industry, split by sub-sector, alongside the corresponding Type II income multiplier and the aggregate income contribution given these multiplier impacts.

Table 12: Potential future direct and multiplier income impacts of the bio-plastics sector

Sub-sector	Direct income contribution (IfE £m)	Type II income multiplier	Aggregate income contribution (IfE £m)
Manufacture of bio-plastics in primary forms	28.0	5.59	156.6
Manufacture of bio-plastics in final form (conversion of bio-plastics in primary form)	131.9	2.94	387.7
Wholesale and retail of bio-plastic products (traders and retailers)	229.7	2.04	468.9

[59] The contributions of the various sub-sectors may not sum to the total due to rounding.

Sub-sector	Direct income contribution (IfE £m)	Type II income multiplier	Aggregate income contribution (IfE £m)
Aggregate bio-plastics sector[60]	**389.6**	**N/A**	**1,013.2**

Source: Cebr analysis

Based on the manufacture of bio-plastics in primary form's industries' direct income impact of £28 million, we estimate that its aggregate income contribution, including direct, indirect and induced impacts, will amount to £156.6 million in the future, as presented in Table 12. Combined with the direct income impacts of the other two sub-sectors, the potential future direct income contribution of the aggregate bio-plastics sector is predicted to amount to £389.6 million. With an employee income multiplier of 2.60, we estimate that the aggregate income contribution of the entire bio-plastics sector, including direct, indirect and induced impacts, will total approximately £1.01 billion.

[60] The contributions of the various sub-sectors may not sum to the total due to rounding.

5 The opportunity for the UK

Bio-plastics are often marketed on the numerous environmental and functional benefits they offer over conventional fossil-based plastics. However, focus on these benefits will only drive the industry forward so far. For the UK bio-plastics market to develop further, the range of opportunities for the industry to contribute to the national economy should be acknowledged. In this section, we outline the components required by the UK to fully capitalise on the opportunities offered by the development of a domestic bio-plastics industry. In particular, we focus on the technological, legislative, and commercial determinants that have the ability to shape the UK industry.

5.1 An enabling policy environment

With an appropriate legislative framework, it is estimated that the UK bio-plastics market will be able to produce 40 thousand tonnes of packaging, 40 thousand tonnes of carrier bags, 20 thousand tonnes organic waste caddy liners and 20 thousand tonnes of tableware.[61] However, the current policy environment surrounding the UK bio-plastics industry is fragmented, with legislation often confusing for consumers and businesses.

The government may first recognise that no one policy will suffice, and instead combinations of direct and indirect policies that complement each other are required to foster the development of a bio-plastics industry in the UK. Direct policies could include schemes that oblige the use of bio-plastic materials in fully biodegradable products. An 'obligation' scheme of this sort could be similar to the Renewable Transport Fuel Obligation (RTOF), which requires fuel companies to supplement petrol and diesel with a certain level of biofuels.[62] In terms of bio-plastics, obliging the use of bio-plastic materials in biodegradable products could drive demand for bio-based biodegradable products over fossil-based biodegradable products. However, whereas the RTOF is based on partial substitution at the individual product level, such a system would not work for bioplastics and would need to be tackled at the category level. For example, if it was mandated that a certain percentage of disposable cutlery was to be biodegradable within a certain time period, organic waste recyclers would not find this acceptable as a proportion of disposable cutlery would be known to be non-compatible with their processes.

Complementary indirect policies should also be considered to ensure the development of a bio-plastics industry. Earlier in October, a 5 pence minimum charge on the use of plastic carrier bags was introduced in England in stores with more than 250 FTEs. However, similar to the devolved nations, England's policy does not mandate the use of bio-plastic carrier bags instead, nor does it require that the remaining plastic carrier bags be made from bio-plastic materials (although this is something being considered for a future date).

The government may recognise that initiatives that aim to achieve other targets, such as the carrier bag tax's stated objective of reducing littering, could also be used to promote the use of bio-plastic products within a circular bio-economy, thus achieving multiple targets and wider benefits simultaneously. Enabling consumers to adopt bio-plastic bags would have a positive impact on food waste collection schemes operating in over 50% of English local authorities that cover 11.5 million households. This would in turn help to reduce the organic waste needing disposal in landfill or incineration, increase organic recycling rates and return more nutrients and essential organic matter back to agricultural soils.

---

[61] Information provided by the industry, including BBIA members.

[62] Barker, M., and Safford, R., (2009), "Industrial uses for crops: markets for bioplastics", HGCA, accessed at [http://cereals.ahdb.org.uk/media/408426/pr450-final-project-report.pdf]

According to the Environment Agency, loss of soil organic matter costs the UK economy £82 million per year[63] and the 2015 Climate Change Committee[64] report highlighted the urgent need for action on soil organic matter as an important contributor to reducing carbon emissions, a point also highlighted by the Renewable Energy Association.[65]

UK policymakers should also do more to lead by example. Currently, the UK is missing a public procurement approach, similar to the USA's BioPreferred Programme and the EU's Green Public Procurement (GPP) framework. With the bio-plastics industry still in its infancy, public sector support could drive the use of bio-plastics products, and encourage or 'crowd-in' private sector investment.

Further, robust and unambiguous standardisation is crucial to developing a strong and well-coordinated industry. Standards and their use are integral to the removal of barriers to the use of bio-plastics in upstream and downstream business, consumer and public procurement markets.[66] With CEN (Comité Européen de Normalisation) mandated to publish a set of standards relating to bio-based products by 2016, the industry should be encouraged to implement these technical specifications. Working to a common standard will also foster collaboration between industrial stakeholders whilst ensuring products on the market which make false green-washing claims around their "biodegradability" are no longer sold. The sharing of ideas and inputs would encourage innovation, competition and growth in the bio-plastics industry. The UK could follow the experience of the Thai Bio-plastics Industry Associations (TBIA), which created a memorandum of understanding (MOU) with a range of global institutions to cooperate in the development of harmonised certification and labelling programmes, as well as collaboration in areas such as technology innovation and market expansion ventures.[67]

5.2 A conducive economic environment

Like any growing market, a robust and stable economic environment will be crucial to the development of an efficient bio-plastics industry. Incentives such as low business rates and ensuring access to capital will encourage investment in infrastructure that the bio-plastics industry in the UK needs to grow further. With UK producers likely to be reliant on overseas suppliers (until a domestic supply chain is fully developed), import constraints such as exchange rate fluctuations and uncertainty[68] will also act as a barrier to the development of the indigenous industry.

Political support is also vital, and policy makers should do more to acknowledge the potential economic benefits that bio-plastics could have on the economy. The EU's "Europe 2020" strategy and the USA's "National Bio-economy Blueprint" are examples of how bio-plastics can be incorporated into a country's growth strategy. Similarly, the UK should recognise the wider economic value of a bio-plastics industry. For example, in addition to creating bio-plastic products, the industry could revive the UK's agricultural sector, thus supporting the nation's farmers and creating new value chains. Likewise, the development of

---

[63] EA (2007), The Total External Environmental Costs and Benefits of Agriculture in the UK.

[64] https://www.theccc.org.uk/publication/reducing-emissions-and-preparing-for-climate-change-2015-progress-report-to-parliament/

[65] "Promoting the benefits of compost and digestate as a tool for mitigating the impacts of climate change in agriculture", accessed at [http://www.organics-recycling.org.uk/uploads/article3078/Compost%20&%20digestate%20and%20climate%20change%20FINAL.pdf]

[66] OECD (2013), "Policies for Bio-plastics in the Context of a Bio-economy", OECD Science, Technology and Industry Policy Papers, No. 10, OECD Publishing, accessed at [http://dx.doi.org/10.1787/5k3xpf9rrw6d-en]

[67] Thailand Board of Investment, (2014), "Thailand's Bio-plastics Industry", accessed at [http://www.boi.go.th/upload/content/AW_BOI-brochure2014-Bioplastics-20140507_51146.pdf]

[68] For example, uncertainty around the outcome of a referendum on the EU, and the possibility of an UK exit is likely to undermine the confidence of domestic and foreign investors.

the industry could make a significant contribution to the Government's *Exporting for Growth* strategy by replacing imported traditional plastic products with domestic production of substitutable bio-plastic products.

5.3 A competitive supply chain

One of the most significant barriers to the development of a bio-plastics industry in the UK is the cost of bio-plastic resin relative to conventional fossil-based plastics. Presently, bio-plastic resins cost at least twice as much as petro-plastic resins, which are strongly linked to crude-oil prices. Currently, with crude oil prices at an all-time low, the cost of producing conventional plastics has been driven down further, to the detriment of bio-plastics production, the relative price of which has increased dramatically as a result. Thus, measures to narrow the price differential between bio-plastic products and conventional plastic products will improve the substitutability and price competitiveness between the two forms of plastic. This will be important in persuading businesses and consumers to use bio-plastics.

The most feasible way of decreasing the cost of bio-plastics is by ensuring the industry develops economies of scale and production efficiencies. However, to date, efficiency gains have been impeded by production capability and land availability.[69] Firstly, the lack of production infrastructure in the UK means that only small scale plants and refineries currently exist. As a result, the volumes needed to harness economies of scale cannot be generated. Consequently, producers and converters are forced to import their feedstock inputs at a higher cost than they would be subjected to if they could source their needs domestically. Barker and Safford (2009) identify how feedstocks for the bio-plastics industry could be sourced from within the UK. They suggest existing grain milling and sugar manufacturing infrastructure in the UK could be used to produce PLA and starch from wheat and grain.[70]

Domestic production of feedstock for bio-plastics is not considered inhibited by the lack of land availability in the UK. Industry estimates that 21,600 hectares of land would be required to grow the feedstocks needed to produce the future projection of 120 thousand tonnes of UK-produced bio-plastics. This is only 0.1% of the total available agricultural land. Achieving an optimal balance between the amount of land devoted to growing feedstock and other land-use priorities is not out of the UK's reach, with Europe setting a feasible example. Europe has moved towards integrating food and non-food activities on the same land to ensure food and feedstock production are not in competition. Further, the reformed Common Agricultural Policy encourages the use of underutilised land and advocates subsidises for farmers producing biomass crops.

Initiatives that support research and innovation into improving crop yields and identifying more efficient methods of producing feedstock could also ensure that economies of scale are reached. Additionally, establishing grants and loans to incentivise manufacturers to scale up bio-plastics production, similar to the £25 million of funding to the UK's bio-fuel industry to build advanced plants, will also contribute to the bio-plastics industry's ability to be price competitive with conventional plastics.

5.4 A sustainable society

The success of a bio-plastics industry in the UK is dependent on consumers increasingly demanding bio-plastic products. Awareness and understanding of what bio-plastic products mean to the general public in practical terms and in terms of the economy and the environment will be crucial in ensuring the full

[69] Barker, M., and Safford, R., (2009), "Industrial uses for crops: markets for bioplastics", HGCA, accessed at [http://cereals.ahdb.org.uk/media/408426/pr450-final-project-report.pdf]
[70] Barker, M., and Safford, R., (2009), "Industrial uses for crops: markets for bioplastics", HGCA, accessed at [http://cereals.ahdb.org.uk/media/408426/pr450-final-project-report.pdf]

potential of a bio-plastics industry in the UK is realised. In addition, if citizens understand and accept the value of bio-plastics products, then it is more likely that the force of public opinion will encourage government to introduce legislation to promote the development of bio-plastics industry.

Currently, the lack of consumer understanding and the difficulty of bio-plastics' producers to signal the value of their product, means consumers' willingness to pay for such products are limited. This was illustrated through the findings of a study by the EC in 2013.[71] The study reported that consumers are not very well informed about the differences between conventional plastic products and bio-plastic products, and often consumers mistakenly believe bio-plastics products are more expensive than and of an inferior quality to conventional plastic products. The report also highlighted that ultimately the purchasing decision is influenced more by price, recognition factors and familiarity with logos than with concerns over the environmental impact of the product. Consequently, measures such as improving production quality and consistency and encouraging clear and unambiguous standards and labelling will promote awareness and understanding among consumers. The success of these initiatives will depend on the government, brand owners and retailers alike.

[71] European Commission (2013), "Attitudes of Europeans towards building the single market of green products", accessed at [http://ec.europa.eu/public_opinion/flash/fl_367_en.pdf]

Appendix: Economic modelling methodology

The model adopts the structure of the economy on which the UK Office for National Statistics (ONS) bases its system of national accounts. Economic activities are broken down according to Standard Industrial Classifications (SIC), the most recent being SIC 2007. This approach facilitates estimation of the size and economic impact of a sector of interest within the framework of the ONS' supply-use tables, the most detailed official record of how sectors of the economy interact with other sectors, with consumers and with international markets in producing the nation's GDP and national income.

The task is to then adapt these tables to assign the sector of interest an explicit role within them. The bio-chemical and bio-plastics industries are very small elements of wider industries at the level of industry aggregation in the supply-use tables (106 industries at the 2-3-digit SIC level. Note that at the 4-digit level, there are hundreds and, at the 5-digit level, thousands of industries). Specifically:

- We assume that bio-chemical resins is a subset of industry "20B: Petrochemicals", which includes (at the 4-digit level) "20.16: Manufacture of plastics in primary form". We have to assume that, despite the broad heading of petrochemicals at the 2-digit level (note that the B in 20B is an ONS construct), that bio-chemicals must be included in the more neutral 20.16. There is not an established sector to justify inclusion separately and it has to be counted somewhere.
- We assume that bio-plastics (the finished products) are a subset of industry "22: Manufacture of rubber and plastic products".
- We also assume that the trading and retailing of bio-plastic products forms part of industries "46: Wholesale trade services, except of motor vehicles and motorcycles" and "47: Retail trade services, except of motor vehicles and motorcycles".

For each of the 106 broad industries (like 20B, 22, 46/47), the supply use tables show gross output (essentially turnover), gross value added, total intermediate consumption and how this breaks down across the 106 product groups that correspond with the 106 industries. The tables also establish equilibrium between demand and supply, in aggregate and at the level of each of the 106 product groups. The tables essentially marry production with supply and demand in the economy and are used to establish consistency between the three measures of GDP (the income approach, the production approach and the expenditure approach).

We use these data on the sectors/products of interest to add columns and rows to the supply-use tables so that these sectors/products now have an explicit role within them. This is how we establish direct impacts - gross output, gross value added (GVA) and employee compensation. The supply-use tables do not deal with jobs, so these are treated separately and integrated with the modelling system at a later point (during the multiplier modelling phase).

Because the supply-use tables balance demand, supply and production in the economy (as in equilibrium), it is important that that balance is maintained when adapting the tables to establish explicit roles for new sectors/products. Data on the newly established sectors/products are therefore subtracted from the wider industries of which they form part in order to bring the system back into balance. Once this is achieved, the adapted supply-use tables can be fed into the next stage - estimation of the multiplier impacts. Our input-output model is based on the Leontief inverse matrix approach and draws on data from ONS input-output tables. These are essentially the supply-use tables taken through a number of transformations to extract net taxes on products and imports from the data so that domestic impacts can be isolated. Our matrix multiplier model is adapted in the same way as the supply-use model, so that they can be linked. The matrix multiplier model is then re-run to produce the multipliers for the newly established sub-sector(s) of interest.

This approach is based on Nobel prize-winning work and is well-established. It is widely accepted so long as additionality is taken into account. This is concerned with the extent to which the impacts measured would not be provided from elsewhere if the sector(s) or sub-sector(s) being measured did not exist. The additionality arguments are strong in this case because you'd be bringing manufacturing back to the UK that, at the moment, does not exist because the relevant products are largely imported. This dovetails with the current government's *Exporting for Growth* strategy. However, whereas the focus is always on boosting exports, reducing imports has precisely the same effect in terms of the impact on economic growth, especially when those imports are replaced by domestically manufactured products.

Therefore, for each of bio-chemical resins, bio-plastics and trading/retailing of bio-plastics, the model produces 2 multipliers for each of 4 indicators. The 4 indicators are gross output (turnover), GVA, incomes (employee compensation) and employment. The two multipliers are the Type I measuring the indirect impact of the sub-sectors of interest through their supply chains and the Type II measuring indirect and the additional induced impact that occurs when employees of the sub-sectors of interest and the employees of their supply chains spend their earnings (wages and salaries) in the wider economy.

It is left to outline what the multipliers say. The most important indicator of impact is GVA (gross value added), and so it makes sense to explain the multipliers using GVA as the example. But first, it is necessary to define GVA. This is the definition that Cebr has developed over a number of years to try to explain the concept as clearly and comprehensively as possible:

GVA or gross value added is a measure of the value from production and can be thought of as the value of industrial output less intermediate consumption. That is, the value of what is produced less the value of the intermediate goods and services used as inputs to produce it. GVA is also commonly known as income from production and is distributed in three directions – to employees, to shareholders and to government. GVA is linked as a measurement to GDP – both being a measure of economic output. That relationship is (GVA + Taxes on products - Subsidies on products = GDP). Because taxes and subsidies on individual product categories are only available at the whole economy level (rather than at the sectoral or regional level), GVA tends to be used for measuring things like gross regional domestic product and other measures of economic output of entities that are smaller than the whole economy, such as bio-plastics etc. GVA must be distinguished from turnover measures, which capture the entire value of sales. By contrast, GVA captures the value added to a set of inputs by a firm on their journey from raw materials to finished consumer products. Thus the value added of a firm that uses oil imports to make plastics is equal to the price that it sells the plastic for minus the cost of the oil it uses as inputs. Similarly the value added of a manufacturer that uses that plastic to make a bus shelter is equal to the price that it sells the bus shelter for minus the cost of the plastic it uses as an input. The concept of added value enables the avoidance of double counting when estimating the size of an economy or the contribution to it of a particular sector.

The Type I GVA multiplier then says that, for every £1 of GVA generated by the sub-sector of interest, say the manufacture of bio-plastics in primary form sub-sector, another £1.83 of GVA is generated indirectly by the supply chain of that sub-sector (where £2.83 is the value of the multiplier minus the £1 of direct impact). The Type II GVA multiplier says that, in addition to the indirect supply chain impact of £2.83, an additional £0.74 of GVA is generated in the wider economy when direct and indirect employees spend their earnings on the goods and services demanded by households. The aggregate multiplier impact is then equivalent to £1+£1.83+£0.74.

The multipliers for the other indicators (output, employee incomes and jobs) are explained in exactly the same way.