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# Plastics, the circular economy and Europe's environment — A priority for action

European Environment Agency

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# Acknowledgements

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Plastic items and products surround us every day © Pixabay

# Summary

**Plastics play an essential role in modern society, but also lead to significant impacts on the environment and climate. Reducing such impacts while retaining the usefulness of plastics requires a shift towards a more circular and sustainable plastics system. This report tells the story of plastics, and their effect on the environment and climate, and looks at their place in a European circular economy.**

Plastics comprise a range of materials, each with its own unique characteristics, properties and applications — 99 % of plastics are made from carbon from fossil fuels (CIEL, 2019). The consumption and production of plastics have grown exponentially since the 1950s, with the resulting products (including packaging, kitchenware, electronics, textiles, car components and furniture) constituting an important part of everyday life. Plastics are light, cheap, durable and can be made in an infinite number of variations, and the plastics industry contributes to growth and job creation.

Plastic packaging is the largest sector of the plastics industry, representing almost 40 % of total plastic consumption. Among other things, plastics provide new transport solutions for the logistics sector, and they are important for improving hygiene in healthcare (e.g. in virus protection) and for reducing food waste by keeping food fresh for longer. Plastics are also used in cars and aeroplanes, reducing weight and improving fuel efficiency, in synthetic fibres in clothing and other textiles, and in furniture and kitchenware.

In recent years, plastic has been subject to increased focus and attention from an environmental perspective. Being lightweight and durable are two key strengths of plastic, but this also means that plastic spreads easily and can persist in the environment for many years. Plastic waste can now be found in our parks, on our beaches, at the bottom of the oceans and seas, on top of mountains and even inside our bodies. The leakage of plastics into the environment poses a significant problem for current and future generations, and there are significant gaps in our knowledge about the kind of effects that this exposure can have. The potential magnitude of impacts on the environment and human health varies a lot depending on the type of plastics and the chemical additives they contain. The negative effects of plastics go beyond littering and leakage: 7 % of crude oil output is used to make plastics, a proportion set to grow rapidly as consumption of plastics is expected to double in the coming 20 years (EC, 2020). The energy and fossil feedstock used to produce and transport plastics and manage plastic waste creates a large and growing carbon footprint.

Today, plastics are too often used as single use products, then discarded, then too often littered. The current linear models of production and consumption of plastics are failing nature and our economy at the same time, which is why we need a circular plastics economy. Reducing the environmental and climate impacts of plastics, while retaining the usefulness of plastics in society, requires making the systems of plastic consumption and production more circular, resource efficient and sustainable, thereby enabling longer use, reuse and recycling. Adequate policies and the scaling of circular business models can, together with changes in the behaviour of producers and consumers, enable a more circular and sustainable plastics system.

This report introduces the wide family of plastics and briefly explores the main challenges involved in transitioning towards a circular plastics economy. It shows that, although the production, use and trade of plastics continue to grow, significant differences exist between Europe and other regions of the world. Furthermore, it explains the environmental and climate impacts that occur across the life cycle of plastics, including the leakage of plastics into natural environments and the growing demand for oil and emissions of greenhouse gases. Finally, it shows that an increasing number of EU initiatives are already in place to address some of these issues, but that more coordination and scaling up is needed. Three pathways (smarter use; increased circularity; and use of renewable raw materials and decarbonisation) are discussed, which together can help ensure the continued longer term move towards a sustainable and circular plastics system.

# About plastics and the circular economy

**Plastics are a large family of different materials, each with its own unique characteristics, properties and applications. To address the environmental and climate challenges associated with the production, use and disposal of these various types of plastics, a circular economy offers a promising strategy for a more sustainable plastics system in which materials and products never become waste.**

## Plastics: one name, many types

Plastics are composed of polymers (large molecules comprising many repeated subunits called monomers) combined with chemical additives. A common feature of plastics is that, depending on which chemical additives are used, they can be easily turned into many different forms during production. Chemical additives may, for instance, improve the flexibility of plastics or reduce their flammability.

Despite their distinct composition, all plastics are based on carbon. Whereas fossil-based plastics use carbon derived from oil and natural gas (petrochemicals), bio-based plastics use carbon derived from renewable materials, such as agricultural products, cellulose and even carbon dioxide ($CO_2$). Plastics, whether derived from oil or sugar, for example, can have identical properties.

Plastics can also be divided into different types according to what they are made of (Figure 1), whether they are natural or synthetic, whether they can be remoulded or not, and how they can be recycled without causing contamination.

## A more circular plastics economy

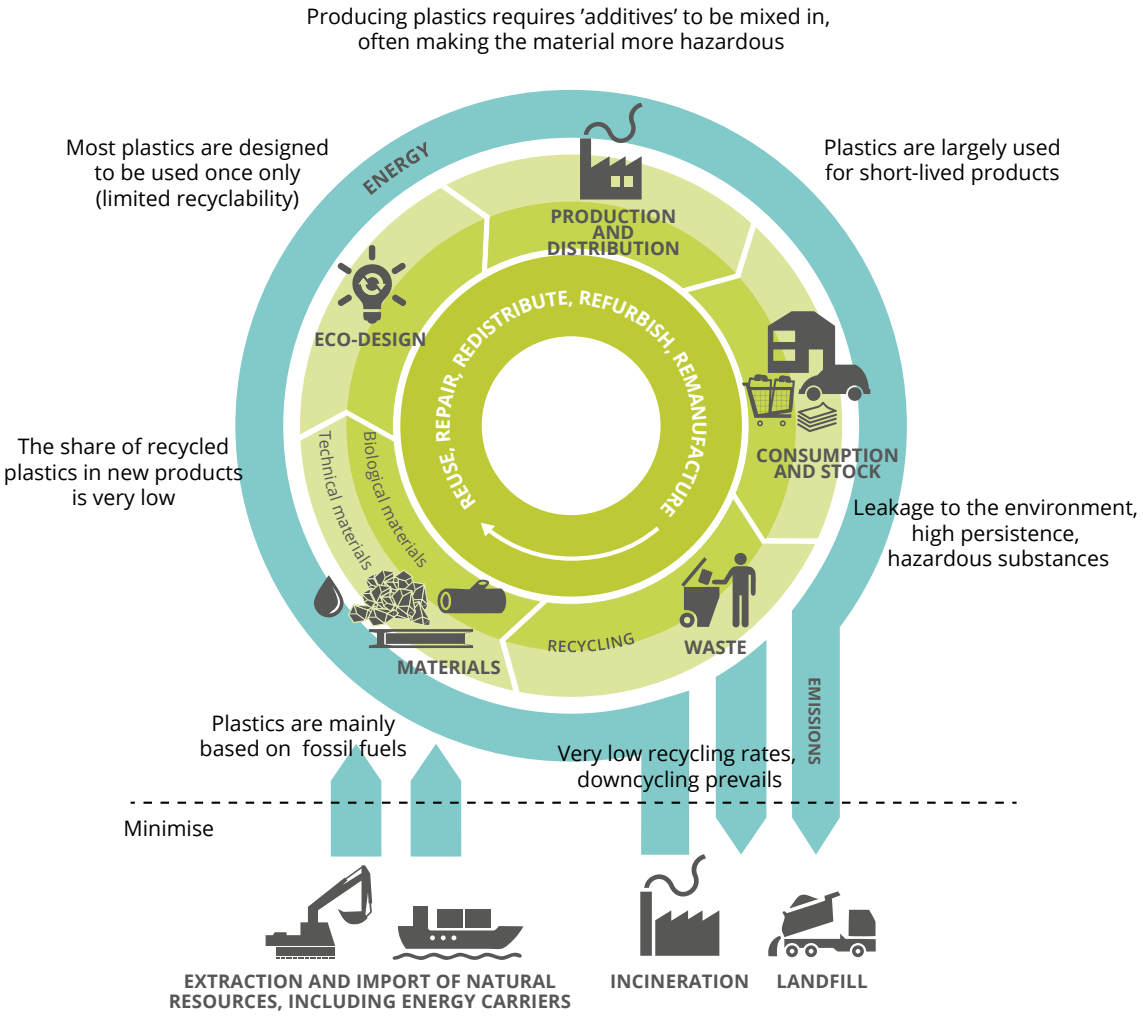
A more circular plastics economy seeks to minimise the need for virgin material and energy in the production of plastics while ensuring that environmental pressures linked to resource extraction, production, consumption and waste are reduced. By improving design, adopting higher quality plastics, and encouraging and enabling reuse, repair, remanufacturing and recycling, a circular plastics economy aims to retain the value and utility of products within the economy for as long as possible to ensure that plastics never become waste (EEA, 2016; Ellen MacArthur Foundation, 2016). This is as opposed to the current linear system of plastic production and use (dominated by low-value, low-cost and short-life plastics) in which all phases of the value chain consume finite resources and cause environmental impacts. Figure 2 shows the current challenges in achieving a shift from a linear plastics economy to a circular plastics economy.

**Figure 1. Seven common types of plastics, with symbols and applications**

| Types of plastics | Symbol | Applications |
|---|---|---|
| Polyethylene terephthalate (PET) |  | Beverage bottles, medicine jars, rope, clothing and carpet fibre |
| High-density polyethylene (HDPE) |  | Containers for milk, motor oil, shampoos and conditioners, soap bottles, detergents and bleaches |
| Polyvinyl chloride (PVC) |  | All kinds of pipes and tiles |
| Low-density polyethylene (LDPE) |  | Cling-film, sandwich bags, squeezable bottles and plastic grocery bags |
| Polypropylene (PP) |  | Lunch boxes, margarine containers, yogurt pots, syrup bottles, prescription bottles, plastic bottle caps and plastic cups |
| Polystyrene (PS) |  | Disposable coffee cups, plastic food boxes, plastic cutlery and packing foam |
| Polyethylene (PE)<br>Acrylonitrile butadiene styrene (ABS)<br>Polyamide (PA) or nylons<br>Polybutylene terephthalate (PBT) |  | Baby bottles, compact discs and medical storage containers |

**Source:** IVL and EEA.

**Figure 2. Challenges in shifting from a linear to a circular plastics system**




**Source:** Adapted from EEA (2019b).

## Plastics and COVID-19

The coronavirus disease 2019 (COVID-19) pandemic has caused significant changes in the production, consumption and wastage of plastics.

The pandemic led to a sudden surge in global demand for personal protective equipment, such as masks, gloves, gowns and bottled hand sanitiser. During early efforts to stop the spread of the virus, the World Health Organization estimated that 89 million medical masks per month were required globally, together with 76 million examination gloves and 1.6 million sets of goggles (WHO, 2020).

As a result of lockdown measures across most of Europe, coupled with stringent hygiene requirements, COVID-19 has had a significant effect on the consumption of single-use plastic packaging and products such as plastic cutlery. As most restaurants in Europe were closed for on-site dining, many shifted to offering takeaway and delivery services using single-use plastic containers. Several large coffee retailers stopped allowing customers to bring refillable containers, using disposable cups in their place. Meanwhile, online shopping outlets have seen a surge in demand, with many products packed in single-use plastic.

Although disposable plastic products have played an important role in preventing the spread of COVID-19, the upsurge in demand for these items may challenge EU efforts in the shorter term to curb plastic pollution and move towards a more sustainable and circular plastics system. The production, consumption and disposal of additional single-use plastics will have led to greater impacts on the environment and climate than otherwise, such as increased air pollution and greenhouse gas emissions, waste generation and the risk of littering. In cases where the cleanliness of multiple use products cannot be guaranteed, single use products may be preferred, but without undermining or delaying the objectives and rules of the Single Use Plastics Directive.

In addition to the direct effects stemming from increased demand for single-use plastics, other factors related to the pandemic are important to note. Reduced economic activity has seen sharp falls in global oil prices. In turn, this has made it significantly cheaper for manufacturers to produce plastic goods from virgin, fossil-based materials than to use recycled plastic materials. The economic viability of the European and global plastics recycling market is presently under significant pressure. Lower market demand for recycled plastics has also complicated the efforts of many of Europe's municipalities to manage their waste practices sustainably, and less desirable waste disposal options are being used for significant quantities of plastic waste.

# The consumption, production and trade of plastics

**With an exponential increase in the production and consumption of these versatile and cheap materials ever since the 1950s, plastics have become an integral part of modern society. However, significant differences in the demand for, production of and trade in plastics exist between Europe and other regions of the world.**

## Plastic consumption and use

Global plastic use has increased very rapidly, from almost zero around 1950 to 359 million tonnes worldwide in 2018. Plastic use in Europe alone was 61.8 million tonnes in 2018, but it seems to have stabilised somewhat, while its use in other parts of the world is still increasing rapidly (PlasticsEurope, 2019).

The global average use of plastics is 45 kg per person per year. Western Europe (Europe excluding central Europe and the Commonwealth of Independent States) uses three times as much — around 136 kg per person (Plastics Insight, 2016).

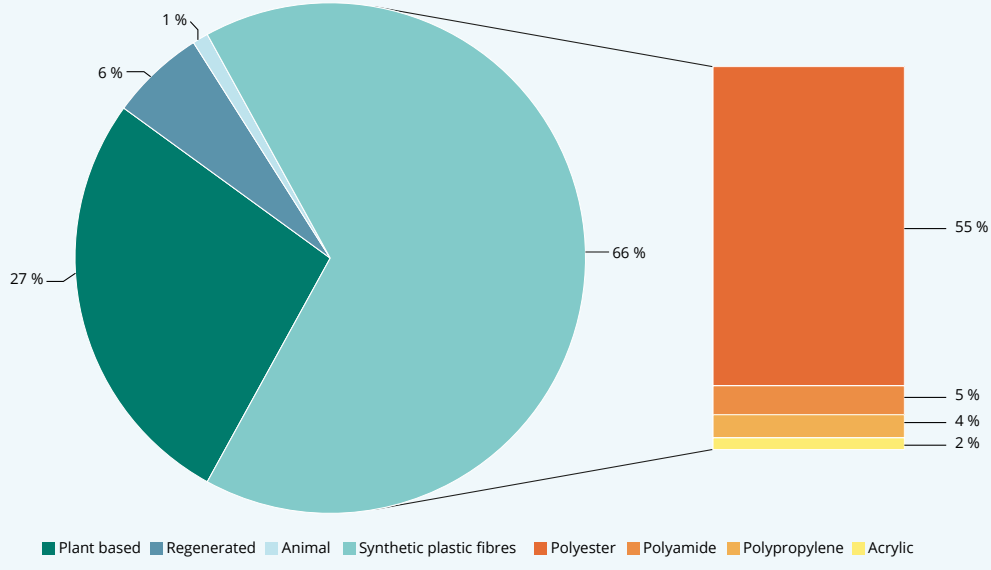
The three largest end-use plastic markets are (1) packaging, (2) building and construction, and (3) the automotive industry, accounting for almost 70 % of all plastics used in Europe. The single largest end-use market for plastics is packaging, which constitutes almost 40 % of European demand. Although synthetic textile fibres are also made from plastics, they are not included in the official statistics for plastics.

## Box 1. Plastics for textiles

A significant proportion of plastics goes into synthetic fibres, such as polyester and nylon, used for textiles. Plastic fibres are used for clothing, as well as furniture upholstery, carpets and other applications. Although this is one of the largest end-use markets, textile fibres are usually not included in the statistics for plastics. Synthetic fibres constitute the largest share of all textile fibres used today. Almost two thirds of all textile fibres are synthetic, and one third are plant based (mainly cotton), regenerated fibres (mainly viscose) or animal fibres (mainly wool).

Whereas the production of natural fibres has grown slowly over the past 30 years, the use of synthetic fibres has grown rapidly. Over the past 25 years, synthetic fibres have become the most common type of fibre for textiles, and production amounts to around 65 million tonnes per year. Synthetic fibres are dominated by polyester, which is almost always the same as the plastic which is known as polyethylene terephthalate (PET) when used for water bottles or packaging. However, other plastics are also used for textiles — see Figure 3. More details on textiles and their environmental impact can be found in a recent EEA briefing and underpinning report (EEA, 2019c; ETC/WMGE, 2019).

### Figure 3. Distribution of global textile fibre production by type




**Source:** Based on data from Sandin et al. (2019).

## Box 2. Plastics for building and construction

The second largest application of plastics (after packaging) is also one of the most invisible. The building and construction industry is responsible for 20 % of plastic use in Europe. Plastic pipes are used to supply water and remove sewage, as well as for cables and other technical installations. Plastic membranes are used as moisture-proof layers in walls and ceilings. Plastic window frames and profiles have become popular, as they are energy efficient and do not require paint; plastic insulation is used extensively. Plastic flooring is common, especially in public buildings (Agarwal and Gupta, 2017).

The building and construction sector has special requirements (including for durability and strength) for the plastics it uses. The most commonly used plastic is polyvinyl chloride (PVC), accounting for 43 % of plastic used in the sector. In fact, 69 % of all PVC produced is used in building and construction (Häkkinen et al., 2019).

Whereas plastics for packaging are designed and produced for a lifetime of weeks or months, plastics intended for building and construction are designed for a lifetime of decades. This introduces significant challenges when it comes to recycling. Since the plastics from buildings that we want to recycle today are often 30-50 years old, they contain substances that are no longer permitted. This means that new plastic products must be designed today to be recyclable in 30-50 years' time.

Plastic water and sewage pipes used in building and construction © Pixabay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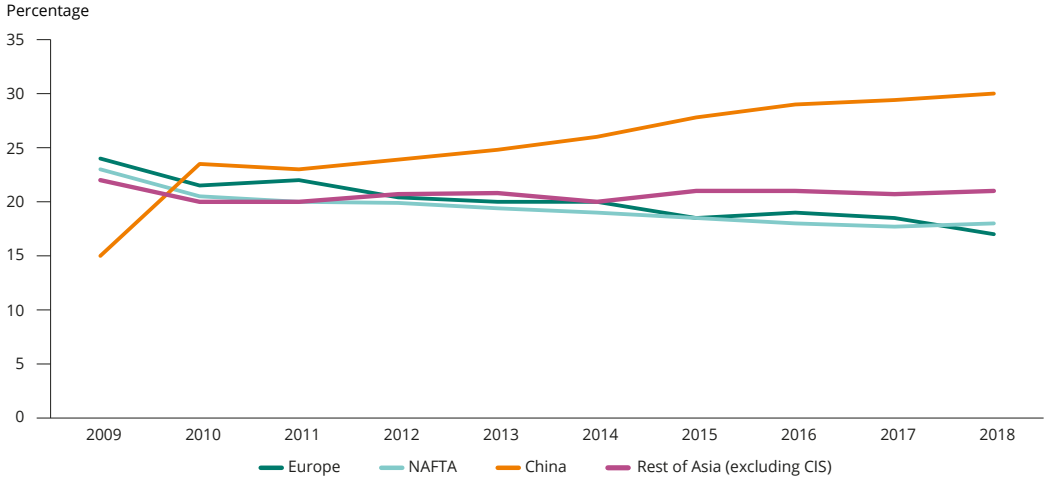
## Production of plastics

With its numerous uses and growing supply and demand since the 1950s, the plastic sector has become a very large industry. It employs over 1.6 million people in Europe — including in raw material producers, plastic converters, recyclers and machinery manufacturers — and had an annual turnover in 2018 of EUR 360 billion (PlasticsEurope, 2019).

Global production of plastics has been growing at an average rate of 4.6 % per year over the past decade (PlasticsEurope, 2019). The geographical distribution of plastics production around the world has changed considerably in that time, as shown in Figure 4. Although production in the 28 EU Member States as of 1 July 2013 (EU-28), and in Norway and Switzerland, has only increased by about 1.2 % per year, production elsewhere has grown, leading to a falling market share for European plastics production from about 24 % to 17 %. The growth has primarily been in China, which has doubled its share of the global market from 15 % to 30 %. North America has also lost some of its market share, but less so than Europe because of recent US investments in production based on shale gas.

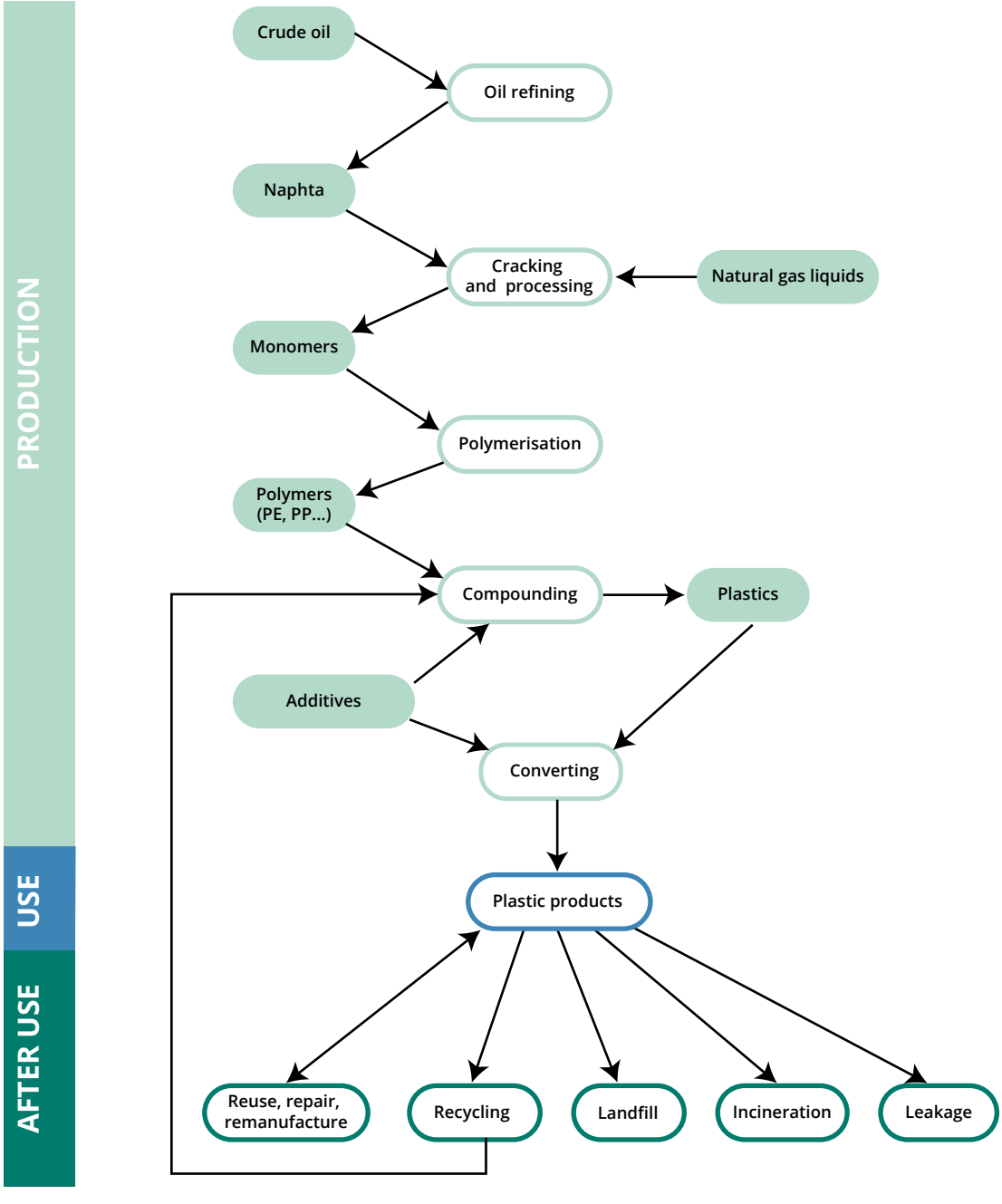
**Figure 4. Share of global plastics production in regions with the largest output**




**Note:** Europe, EU28, Norway and Switzerland; CIS, Commonwealth of Independent States; NAFTA, North American Free Trade Agreement.

**Source:** Based on data from Plastics Europe (2010-2019).

**Figure 5. The value chain for plastics**




**Source:** Adapted from Nielsen and Bauer (2019).

Plastics and chemical production has seen faster growth than other markets for oil in recent years, some of which are expected to decline as electric transport gains share from fossil fuel-based propulsion. This has resulted in increased interest in plastics from oil companies, which are investing in plastics and chemicals firms, and production capacity.

The value chain for plastic is long and complicated. As shown in Figure 5, crude oil fractions, such as naphtha and natural gas liquids, are cracked to produce monomers — the building block molecules for polymers. During the polymerisation stage, the monomers are linked together to form larger molecules called polymers. The polymers are then mixed with various chemical additives that give the plastic its desired properties. This is done during a process called compounding. After compounding, the plastic material is used by a converter to produce the final plastic products, such as bottles, water pipes and interior panels for cars. Although approximately one third of these products is collected for recycling in Europe once they become waste, the majority is leaked into the environment, incinerated or landfilled. Only a small fraction is circulated for reuse, repair and remanufacturing (PlasticsEurope, 2019).

The production of primary plastics is dominated by large multinationals in the petrochemical industry. Many of them are subsidiaries to or partially owned by large oil firms, some of which are controlled by national governments. Production usually takes place in large industrial clusters in which oil refineries, steam crackers, polymerisation units and other chemical production facilities are co-located. Some of the world's largest chemical clusters are found in various parts of Europe, such as the areas around Rotterdam (the Netherlands), Düsseldorf (Germany), Antwerp (Belgium), Lyon (France) and Cheshire (United Kingdom) (Ketels, 2007).

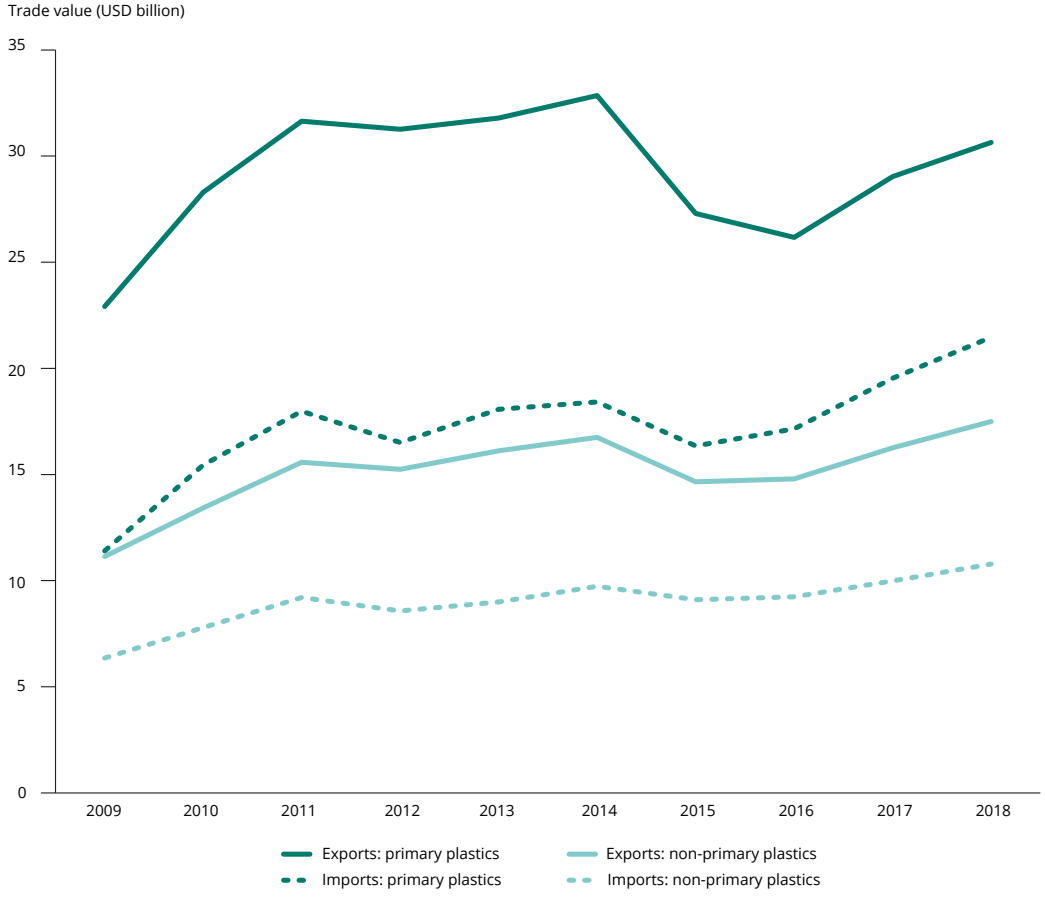
In contrast, the downstream plastics industry, namely plastic compounders (adding chemical additives) and converters (converting into specific products), are mostly smaller firms distributed throughout Europe and other regions of the world.

## The plastics trade

Plastics are traded globally, and Europe imports and exports large amounts of both primary and non-primary plastics every year. Primary plastics are the plastic materials themselves, such as pure polymer granulates and compounded plastics. Non-primary plastics are plastic components for later assembly, such as car interior panels, and finished products, for example tubes and bags, as well as products containing plastics, such as electronics, furniture and cars.

The EU has a trade surplus in both primary and non-primary plastics, meaning that the value of the exports for both categories is larger than the value of the imports, as shown in Figure 6. Europe had a positive trade balance of EUR 15 billion in 2018 (PlasticsEurope, 2019).

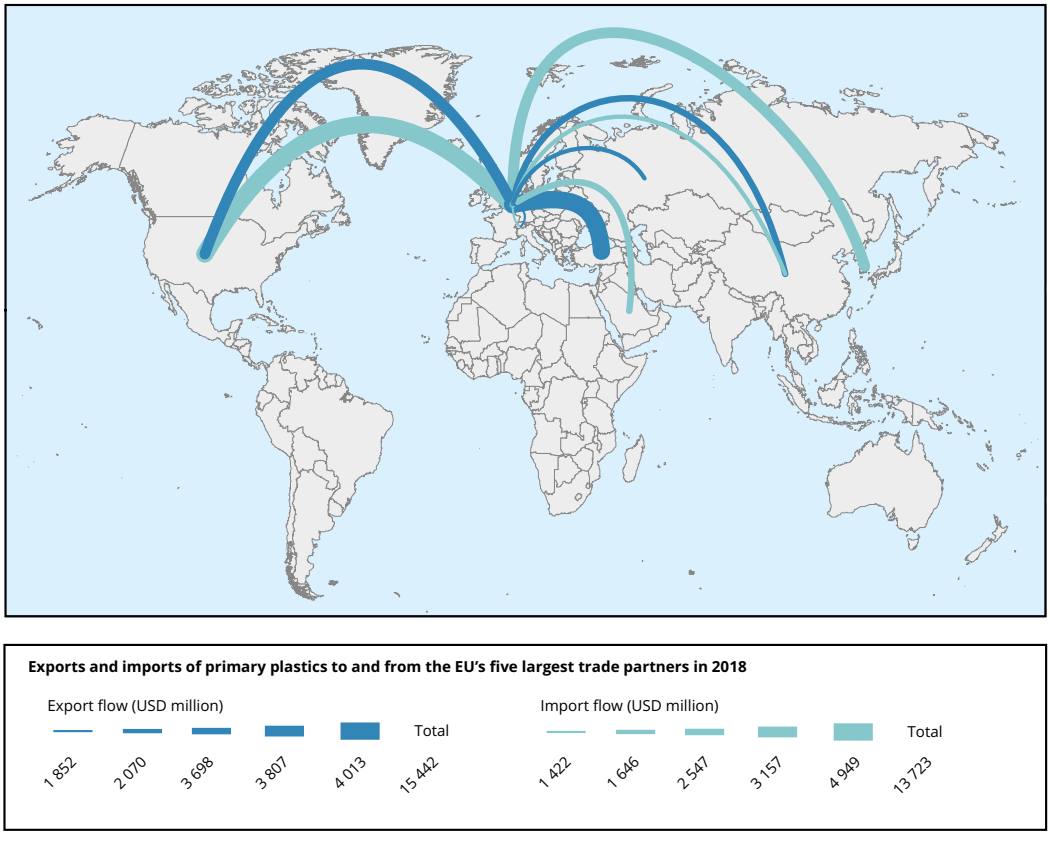
**Figure 6. EU imports and exports of primary and non-primary plastics, 2009-2018 (EU-28)**




**Source:** Based on data from UN Comtrade (2019a).

Map 1 shows the EU-28's trade flows in primary plastics with its most important trade partners in 2018. The top five trade partners represent about 50 % of EU plastic exports and approximately 65 % of imports in each category. The EU's strongest trade partner in terms of plastics is the United States.

## Map 1. EU-28 exports and imports of primary plastics to and from the EU's five largest trade partners in 2018




**Source:** Based on data from UN Comtrade (2019a).

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### Box 3. Polyethylene and its trade

Polyethylene (PE) is the most commonly used plastic worldwide, especially for packaging in the form of bottles or film, as well as for pipes and cable insulation. About 100 million tonnes of PE are produced every year.

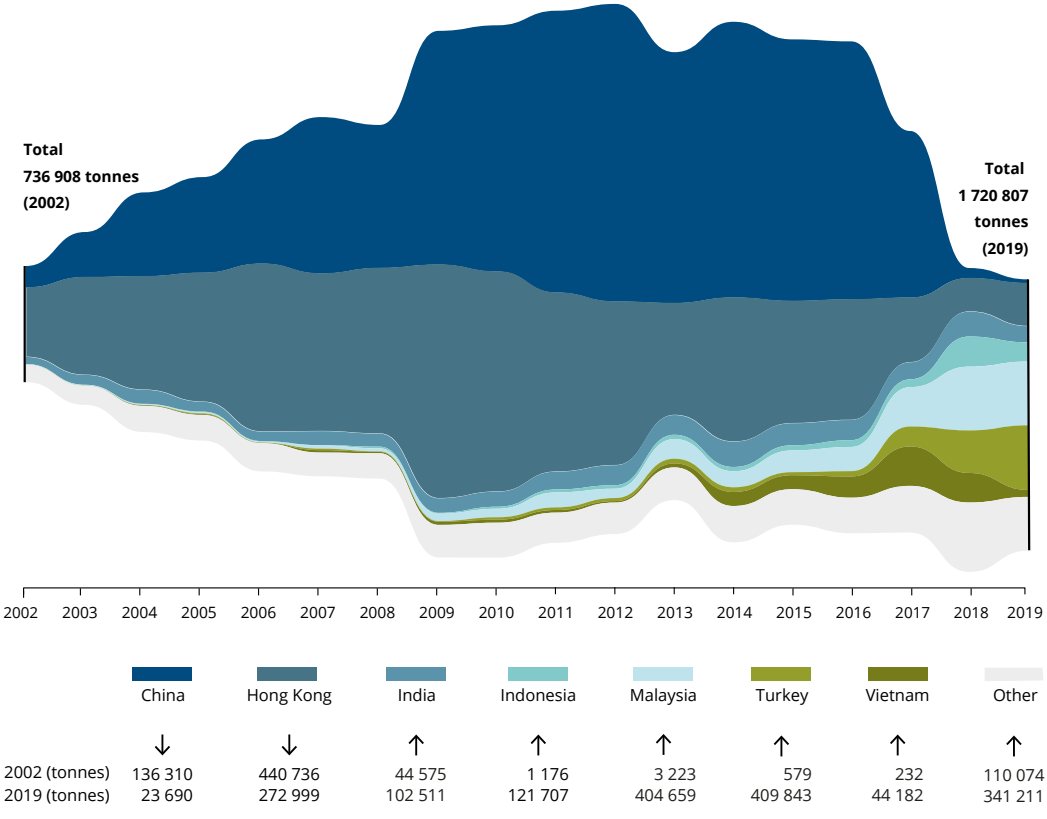
A significant amount of PE is traded worldwide. Saudi Arabia and the United States are significantly larger exporters than most others, and the EU countries Belgium, Germany and the Netherlands are also large exporters. China is by far the largest importer, as the massive manufacturing industry in China demands considerable volumes of plastics. Of the EU countries, Germany, Belgium, Italy and France are those with the largest imports.

## The trade in plastic waste

Following policy requirements to collect certain waste streams separately as well as demands for plastic waste for reuse and recycling, more plastic waste became visible and available during the 1990s, leading to rapid growth in international trade in plastic waste.

The EU-28 represents the largest source of export of plastic waste, accounting for around one third of all exports of plastic waste from 1988 to 2016 (Brooks et al., 2018). Most of this waste was previously exported to China and Hong Kong, as can be seen in Figure 7.

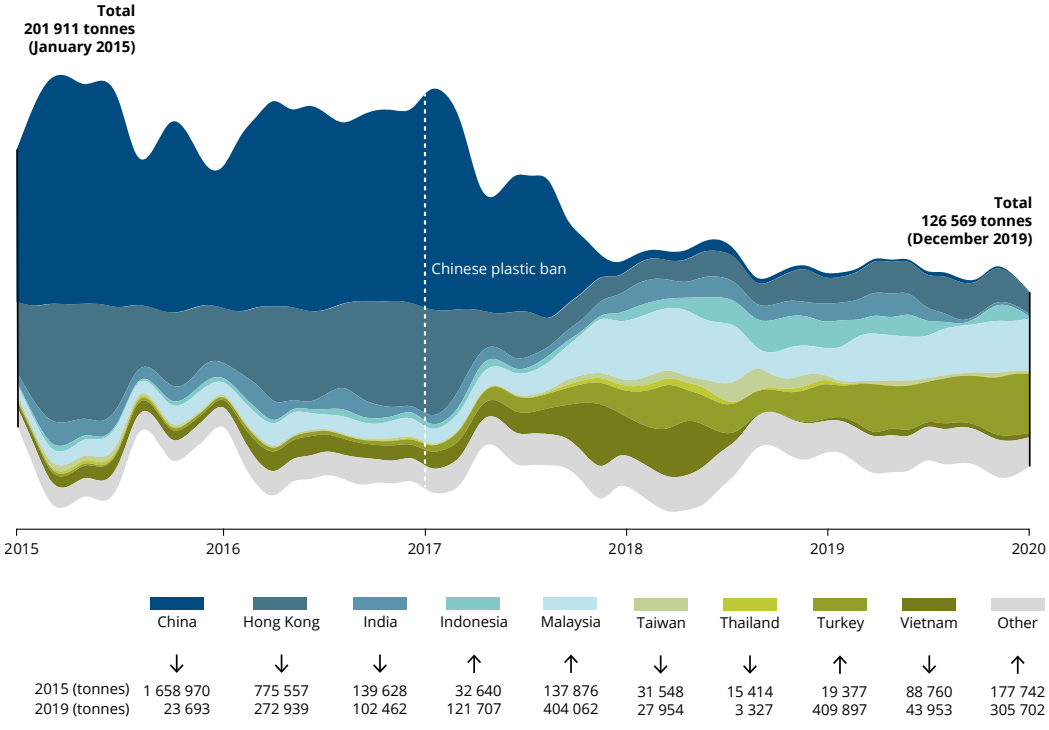
**Figure 7. EU-28 plastic waste exports, 2002-2018**




**Source:** Based on data from UN Comtrade (2019b).

The quantities and patterns of exported plastic waste have shifted, following an initial temporary Chinese restriction in 2013 and then new regulations in China banning the import of non-industrial plastic waste in 2017. European plastic waste exports have halved and at the same time been re-routed to other countries in South East Asia, such as Vietnam, Thailand and Malaysia — see Figure 8.

**Figure 8. EU-28 exports of plastic waste by receiving country, tonnes per month, January 2015 - December 2019**




**Source:** Reproduced from EEA (2019d).

The export of plastic waste from the EU is likely to decrease and possibly halt in the coming years. In the short term, this may lead to more landfilling and incineration.

In the longer term, it is an opportunity to improve capacities for reusing and recycling plastic waste within the EU (EEA, 2019d).

 Offshore oil rigs, pictured here in the North Sea, are used to extract oil © Pixabay

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