EEA Report No 18/2020

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

European Environment Agency

Cover design: Formato Verde
Cover image © iStock.com/Thomas Faull
Publication design: Formato Verde

Luxembourg: Publications Office of the European Union, 2021

ISBN: 978-92-9480-312-2
ISSN: 1977-8449
doi: 10.2800/5847

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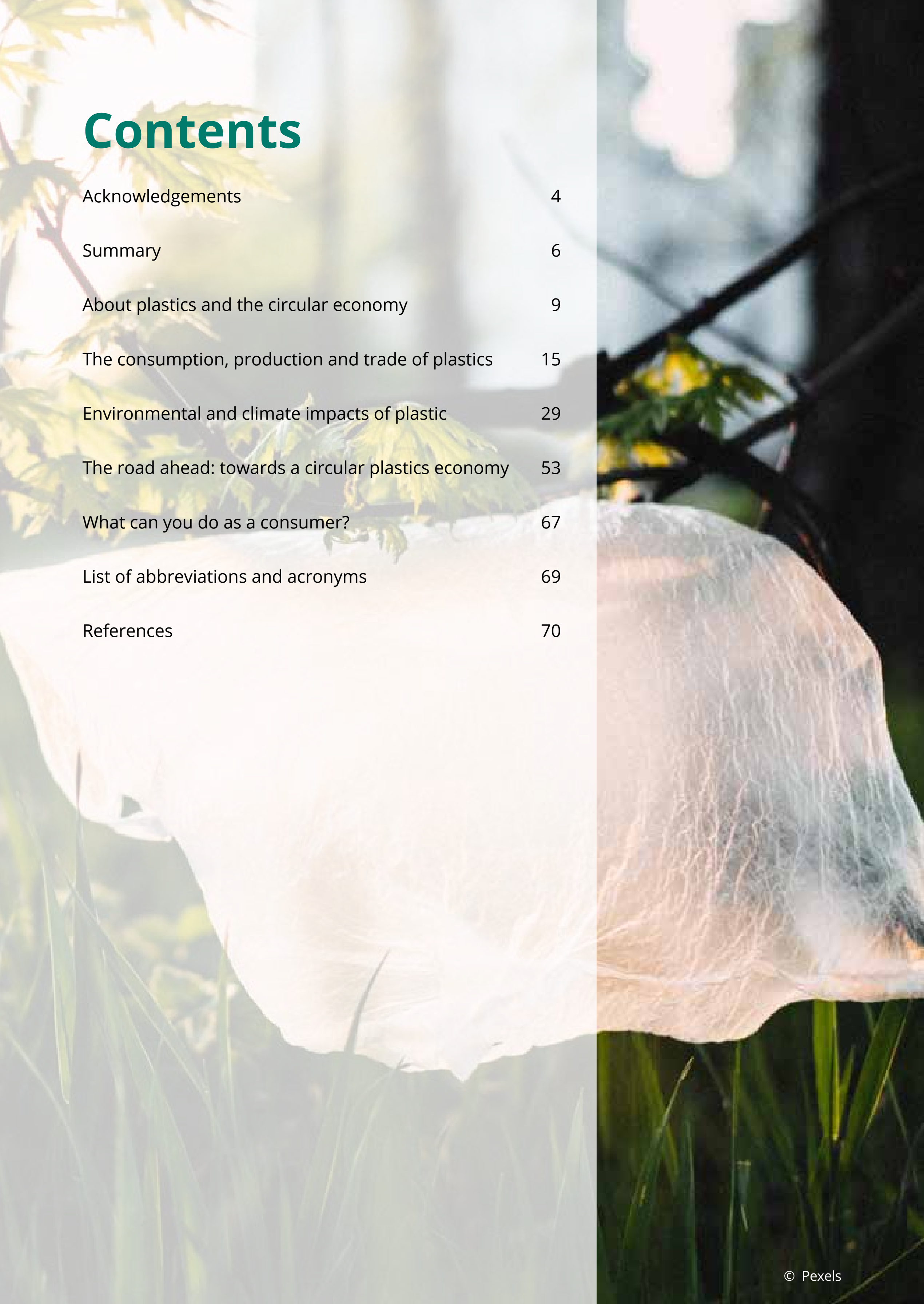

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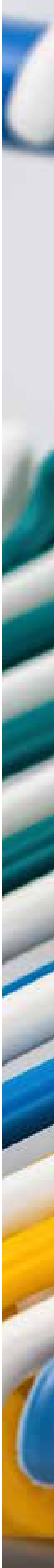
Acknowledgements

Lars Fogh Mortensen and Ida Lippert Tange (both from the EEA) co-authored this report with Åsa Stenmarck, Anna Fråne, Tobias Nielsen, Nils Boberg (all from the IVL Swedish Environmental Research Institute) and Fredric Bauer (Lund University), who prepared a technical report commissioned by the EEA providing underpinning analyses for this report.

Martin Adams and Daniel Montalvo (both from the EEA) provided guidance, comments and strategic oversight in the preparation of this report. James Daniell (from the EEA) led the editing.

The following are thanked for their input during the preparation of the report:

- Ioannis Bakas, Ricardo Fernandez, Almut Reichel, Xenia Trier and Bastian Zeiger (from the EEA);
- Representatives from the European Commission's Directorate-General for Environment.



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.

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Environmental and climate impacts of plastics

Awareness of plastic litter, including its effect on nature (especially the marine environment) and human health, has risen rapidly in recent years. However, litter is just one of the negative environmental impacts that occur throughout the life cycle of plastics, as can be seen in Figure 9. All of these must be addressed to create a circular and sustainable plastics economy. This chapter focuses on impacts occurring throughout the resource extraction, production, consumption and end-of-life phases of plastics. The most significant impacts from each phase are discussed below, recognising that many impacts occur in all phases, but to a varying degree.

Impacts of extracting oil and gas resources for plastics

- If the production and use of plastics continue to increase as projected, the plastic industry will account for 20 % of global oil use by 2050, an increase from today's 7 %.

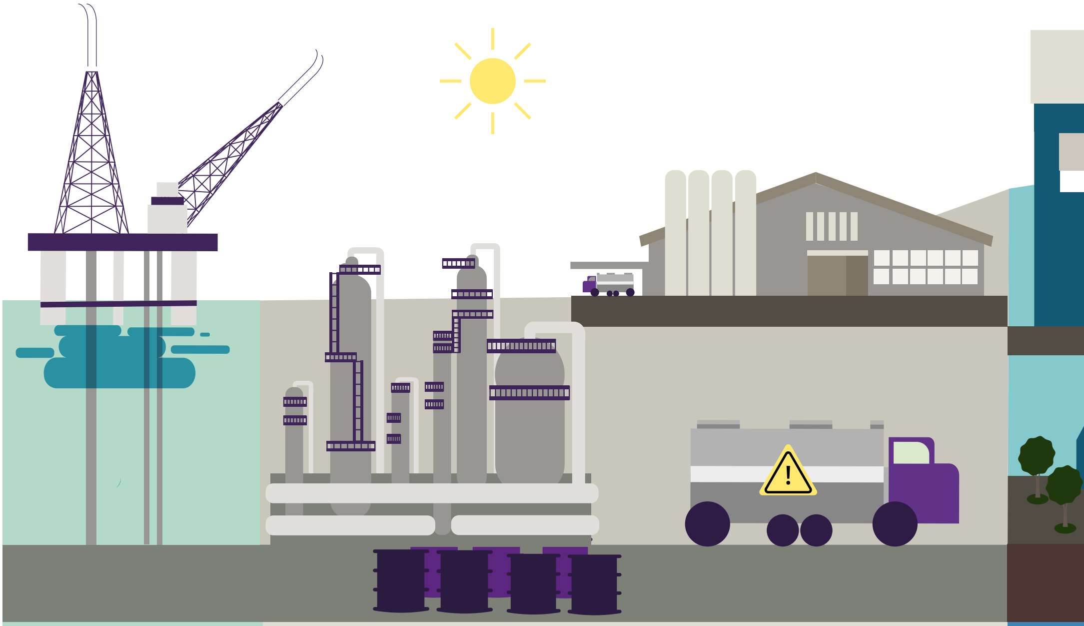
- During the extraction of oil and gas for plastic production, greenhouse gases and multiple pollutants are emitted to the air, and large volumes of waste water containing dispersed oil, hazardous substances and other harmful chemicals are leaked into the environment.

Extraction of oil and gas

The system of consumption and production of plastics implies significant resource use, mainly of fossil fuels, which has implications for the environment and climate. Over 99 % of plastics (CIEL, 2019) are produced from fossil fuel resources, mainly oil and gas. Approximately half of the oil used for plastic is feedstock locked into the plastic products, whereas half is used as fuel in the plastic production process (Ellen MacArthur Foundation, 2016).

If the use of plastics continues to grow as expected, it is projected that the plastics industry will account for 20 % of global oil use by 2050, an increase from today's 7 %. The growth rate of plastic production (3.5-3.8 % per year) is much faster than the growth in demand for oil (0.5 % annually) (Ellen MacArthur Foundation, 2016). Although the vast majority of oil is currently used for fuels, this share is expected to decrease in the coming years as cars and trucks are increasingly electrified, leading to reduced demand for petrol and diesel in developed economies. The International Energy Agency projects that plastics and other petrochemicals will be the largest driver of the growth in the demand for oil up to 2030 (OECD and IEA, 2018).

Figure 9. The environmental impacts across the life cycle of plastics



The life cycle of plastics	EXTRACTION	PRODUCTION
Environmental impacts	• Use of oil and gas • Greenhouse gas emissions and air pollutants • Oil spills	• Use of oil and gas • Greenhouse gas emissions and air pollutants

Source: EEA.

USE

- **Human exposure to toxic substances**

AFTER USE

- **Litter on land and in oceans, seas and freshwater**
- **Greenhouse gas emissions from incineration and landfill**

In the past decade, there has also been a global shift in the choice of feedstocks used to produce plastics. Whereas the main feedstock historically was naphtha, a product derived from oil refining, natural gas liquids are increasingly being used. These are lighter hydrocarbons, mainly ethane and propane, found in natural gas reserves in some regions such as the Middle East and in shale gas reserves in the United States.

Shale gas extraction, in particular, is known to have significant impacts on natural areas, as large areas are used and contaminated in the process. US ethane exports have grown rapidly following the expansion of shale gas production, and since 2016 a significant share of exports goes to Europe (US EIA, 2020). Thus, the EU is increasingly using environmentally damaging shale gas imported from the United States to produce plastics.

Box 4. US shale gas extraction affects European plastics production and use

Shale gas extraction in the United States, which uses hydraulic fracturing ('fracking'; see Figure 10), grew very quickly during the beginning of the 21st century. Shale gas production constituted only 1 % of US domestic natural gas production in 2000; however, in just 10 years the share increased to 20 % (Stevens, 2012). The rapid growth in production led to an oversupply of gas on the North American market. At the same time, technologies were developed for managing liquefied natural gas to enable a global trade in gas, as there has been in oil for decades.

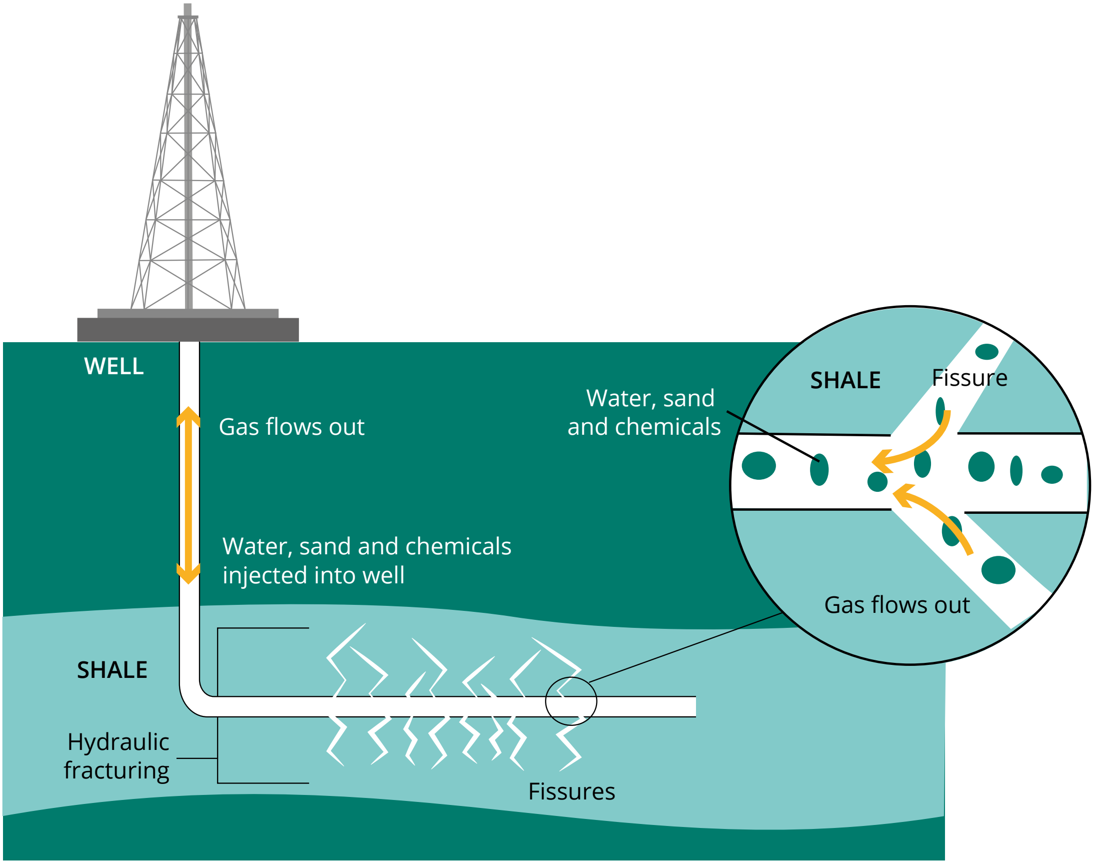
By making use of technologies similar to those developed for liquefied natural gas, a global market for ethane has been established. Several European firms have signed contracts for US ethane, which is being shipped across the Atlantic in large specialised ships. European production of plastics is thus now relying on shale gas products from the United States.

Shale gas extraction and hydraulic fracturing continue to be contentious issues, as they use large volumes of water and chemicals, while issues regarding leakage of potent greenhouse gases and chemicals remain unanswered.

Greenhouse gas emissions and climate change arising from oil and gas extraction

Plastics cause greenhouse gas emissions, mainly due to their current dependence on the fossil fuels oil and gas. Greenhouse gas emissions from plastics start with the extraction of oil and gas, because it requires large amounts of energy. Greenhouse gas emissions are a result of the combustion of natural gas in turbines and diesel in engines to fulfil the energy demands of the drilling machinery and pump and compressor operations (Norwegian Environment Agency, 2020a). Large numbers of trucks emitting greenhouse gases are also needed at the well sites to transport water and waste (CIEL, 2019).

Figure 10. Shale gas extraction through hydraulic fracturing



Note: Horizontal holes are drilled in deep shale layers. Using high pressure water and chemicals, fissures are opened in the shale so that gas is released and can be extracted.

Source: IVL.

In addition to emitting the most common greenhouse gas, CO_2, the extraction of oil and gas is also a significant emitter of methane. Methane emissions occur when natural gas moves through the system, from production to distribution. Examples of activities that may cause methane emissions are intentional venting and unintentional leaks from pipelines and gas engines (US EPA, 2018).

As oil and gas fields get older, the greenhouse gas emissions generally increase, as more energy is needed to clean greater quantities of contaminated water or for injecting more water into the bedrock (Norwegian Environment Agency, 2020b). In some places, onshore oil and gas extraction causes land disturbance and indirect greenhouse gas emissions, as forests and fields are removed to make way for oil fields, and consequently no longer absorb greenhouse gases. Refining crude oil to oil products such as naphtha, still the dominant route for plastics in the EU, consumes large amounts of energy, as does steam cracking (CIEL, 2019).

Pollution of air, water and land arising from oil and gas extraction

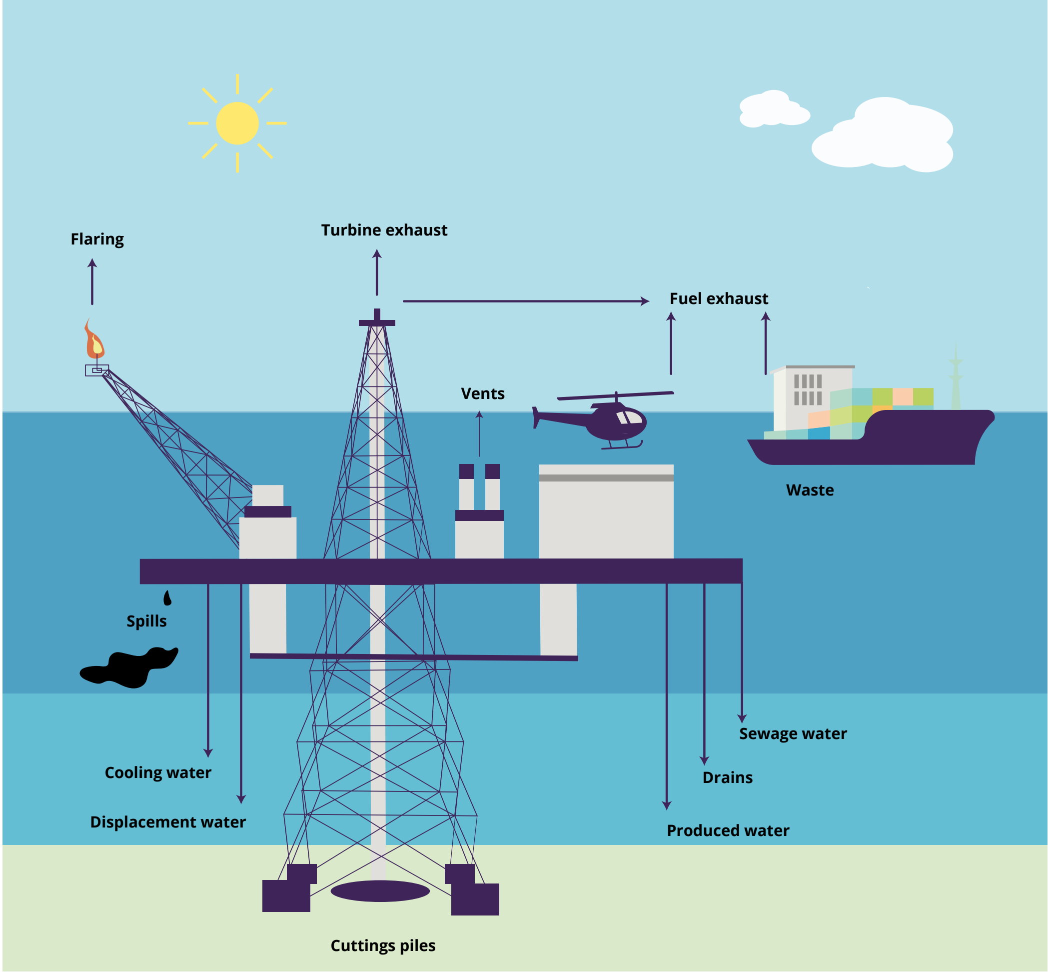
Oil and gas extraction for plastic production emits air pollutants, such as nitrogen oxides (NO_x), sulphur oxides (SO_x), particular matter (PM), volatile organic compounds (VOCs), heavy metals, and a wide range of chlorinated and other toxic organic chemicals (US EPA, 2016). The emissions are mainly a result of fuel combustion in gas turbines and diesel engines that generate energy for drilling operations, treatment of the extracted oil and gas, and transport of oil and gas to reception stations. Flaring or venting excess gases when extracting oil and gas likewise releases toxic chemicals to the atmosphere (CIEL, 2019).

Both onshore and offshore oil and gas extraction result in large amounts of waste water coming from the reservoirs. This is called produced water, and it contains dispersed oil and hazardous substances that occur naturally in the reservoir, such as heavy metals, aromatic hydrocarbons, alkyl phenols and radionuclides. It also contains added process chemicals, some of which are considered harmful in terms of toxicity, bioaccumulation and biodegradation. For example, chemicals are needed when drilling to lubricate and cool the drilling bit (OSPAR, 2017). Although the concentrations of dispersed oil and hazardous substances are generally low in the produced water, the large amounts of water make the quantities relevant. For example, produced water and shipping are the largest emitters of oil into the North Sea. The amount of produced water increases as the oil and gas fields get older (Norwegian Environment Agency, 2020b).

The emissions of oil and toxic chemicals from produced water may have negative impacts on sea animals, but the consequences at ecosystem level are not fully understood (Figure 11). Another environmental risk is oil spill, as this may cause both acute and long-term effects on life at sea. The installation and removal of oil platforms, as well as drilling operations, also affect the local environment, depending on how sensitive the area in question is (Norwegian Environment Agency, 2020b).

Hydraulic fracturing, a technique to improve the flow of the oil or gas from the well, is further associated with risks such as degrading groundwater and surface water quality due to waste fluid disposal, spills of chemicals and the reducing water availability (USGS, 2020). Over 170 fracking chemicals are known to cause health problems such as cancer and damage to the immune system, especially for those living near fracking sites (Heinrich Böll Foundation, 2019).

Figure 11. Emissions to air and water from an oil platform

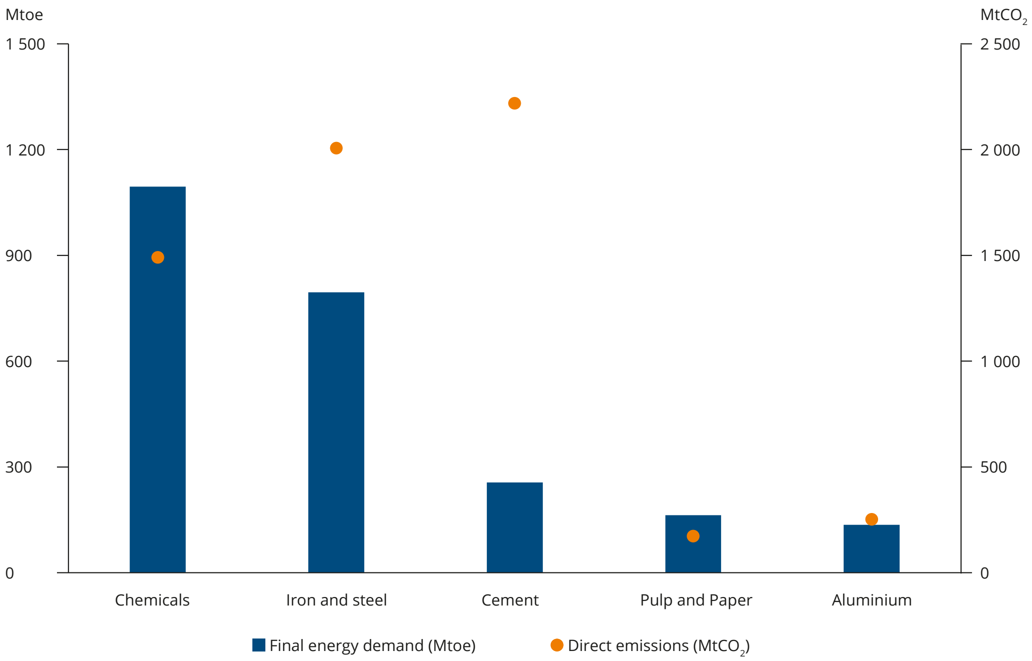


Source: Adapted from OSPAR (2017).

Impacts of plastic production

- Every year, the production of plastics in the EU is responsible for emitting 13.4 million tonnes of CO_2, which is about 20 % of the chemical industry's emissions EU-wide.
- The production of plastics emits substances such as toxic metals and organic compounds, which accumulate in animals and plants and may negatively affect their health.

Figure 12. Global final energy demand and direct CO2 emissions by sector in 2017



Notes: Final energy demand for chemicals includes feedstock, and for iron and steel it includes energy use in blast furnaces and coke ovens. Direct CO_2 emissions includes energy and process emissions in the industry sector; Mtoe, million tonnes of oil equivalent; $MtCO_2$, million tonnes of carbon dioxide.

Source: Reproduced from OECD and IEA (2018).

Greenhouse gas emissions and climate change arising from plastic production

Plastic production is the largest part of the chemical sector, constituting about one third of chemicals production worldwide and about one fifth in Europe (Zheng and Suh, 2019; EEA, 2020a). The chemicals sector is the production sector using the most energy in the world, ahead of the iron and steel, cement, pulp and paper, and aluminium industries, as shown in Figure 12 (OECD and IEA, 2018), and is the third largest source of industrial CO_2 emissions. With about one third of the energy used for plastic production, producing chemicals for plastics has the second largest sectoral energy demand in the world.

In Europe, data from the EEA Greenhouse Gas Inventory shows that annual greenhouse gas emissions related to plastic production in the EU (i.e. the share of direct emissions from petroleum refineries and chemical manufacturing) amount to around 13.4 million tonnes of CO_2, which is about 20 % of the chemicals industry's emissions EU-wide (EEA, 2020a).

Greenhouse gas emissions from plastics production in the EU are, not surprisingly, much higher when emissions over the whole lifecycle are considered i.e. including direct and indirect emissions and upstream activities such as oil extraction and refining/cracking. In this different perspective, greenhouse gas emissions related to the EU plastic value chain for resin production have been estimated to be as high as 132 million tonnes CO_2e in 2018 (ETC/WMGE, forthcoming). Converting these polymers to plastic components and products accounts for an additional 46 million tonnes (ETC/WMGE, 2020).

Pollution of air and water arising from plastic production

NO_x and SO_x are emitted by the plastic polymer manufacturing sector in significant quantities and are well known for their effect as acidifying substances. Acidification may lead to the spread of toxic metals, as it increases the mobility of the metals in the environment. Toxic metals such as lead, cadmium and mercury, as well as toxic organic compounds, are also emitted to air and water during plastic production. These may accumulate in animals and plants and are of concern, mainly because of their undermining health effects. They also persist in the trophic webs, leading to higher concentrations further up the food chain (EEA, 2019a). VOCs in combination with NO_x also participate in the atmosphere's chemistry, leading to various environmental phenomena, the generation of toxic tropospheric ozone being the most important.

Plastics production and waste is also responsible for increased levels of nutrients in water systems, which lead to an ecosystem alteration known as eutrophication. When nutrients increase in a water body, the balance across species changes, fostering increased algal growth. When the algae die, they are degraded in the water body, which causes a reduction in its oxygen concentration and leads to a very significant decrease in biodiversity (EEA, 2019a).

Impacts of plastic consumption, littering and micro-plastics

- When using plastic products in their daily lives, consumers may be exposed to toxic substances through the migration of particles, additives, impurities and degraded chemicals.

- Abundance of plastic litter on land and in oceans, seas and freshwater is one of the most visible aspects of the increasing production and use of plastics. 40 % of plastic items found in European freshwater environments are consumer-related products, such as bottles, food wrappers and cigarette butts.

- Plastic pollution in the environment can have detrimental effects on wildlife, primarily because of entanglement, injuries and ingestion. More research is needed into the effects of micro-plastics, including on marine biota and human health.

Chemical toxicity to humans and nature arising from plastic use

Many negative health impacts including reproductive disorders, behavioural disorders, diabetes and obesity, asthma and cancers have been associated to exposure to various chemicals used in plastics, such as flame retardants, endocrine disrupters and phthalates (HEAL, 2020).

Consumers and users can be exposed to toxicity through the migration of particles, additives, impurities and degraded chemicals, mostly during the first use but also during subsequent uses of plastics. Only limited risk assessments have been performed for chemicals authorised to be used in, for example, food contact plastics, and several materials used in multilayer plastic materials do not have specific legislation that requires authorisation before use.

For single-use plastics, exposure is typically higher than for repeated-use plastics. This is because it is mainly the chemicals that are not bound to the plastic that migrate, and most of the migration happens the first time the plastic is used.

Although additives play an important role in improving the properties of plastics, we know that chemicals used as additives can migrate from macro- and micro-plastics into the environment and lead to human exposure (Hahladakis et al., 2018). For many of the substances used as additives, there are still uncertainties about their hazardous properties and risks to human health and the environment (ECHA, 2019).

The migration of chemicals into nature and humans depends on a number of factors: the type of substance, the concentration of the substance in the plastic, the surface area of the product, and how and where the plastic product is used, for example the temperature (ECHA, 2019). Additives are usually not chemically bound to the plastic structure, so they can potentially migrate/leach from the plastic product into a medium in contact with the product or migrate through the plastic to its surface (Hahladakis et al., 2018).

In nature, environmental factors such as temperature and the availability of microorganisms influence the leaching of chemical substances from plastics (Teuten et al., 2009) including resin pellets, fragments and microscopic plastic fragments, contain organic contaminants, including polychlorinated biphenyls (PCBs. In addition, there are considerable differences between macro- and micro-plastics. Macro-plastics are of key concern for marine animals that may, for example, get tangled in fishing nets or eat plastics. There is less known about the risks of micro- and nano-plastics to humans, animals and the environment. Chemicals from plastics may enter animals directly, if they mistake plastics for food, or indirectly via the food chain. This may result in a higher chemical concentration than that of the source and is common in animals higher up the food pyramid, such as birds and marine mammals. At lower trophic levels, for example plankton, fish, bivalves and molluscs, the major intake of chemicals occurs passively via the surface of the body or via respiratory organs by diffusion (Blastic, 2018).

Plastics in the environment

Plastics end up everywhere in the environment: in air, soil, freshwater, seas, biota and some components of our food. Plastics of various sizes are released into the environment, from large plastic items such as plastic bags and bottles to smaller particles found in textiles and cosmetics or released from car tyres. It has been shown that that plastic waste enters the ocean at a rate of 11 million metric tons per year, harming mariner life and damaging habitats (The Pew Charitable Trusts and SYSTEMIQ, 2020). Over 200.000 tonnes of plastic waste enters the Mediterranean Sea every year, a number that is expected to double if significant measures are not taken (IUCN, 2020).

Larger plastic items in the environment may fragment and degrade into micro-plastics. Recent research estimates that at least 14.4 million tonnes of microplastics have found its way to the bottom of the world's oceans (Barrett et al., 2020). The extent and speed of this fragmentation depends on the type of plastic and the exposure to sunlight, high temperatures, wind and waves. The majority of plastics are not biodegradable in marine conditions but will gradually break down into micro- and nano-plastics through wear and tear and other mechanical action (Velis et al., 2017). In general, knowledge of ecological and health risk of microplastic is surrounded by considerable uncertainly (EC, 2019b).

Plastics on a beach/ © Pixabay

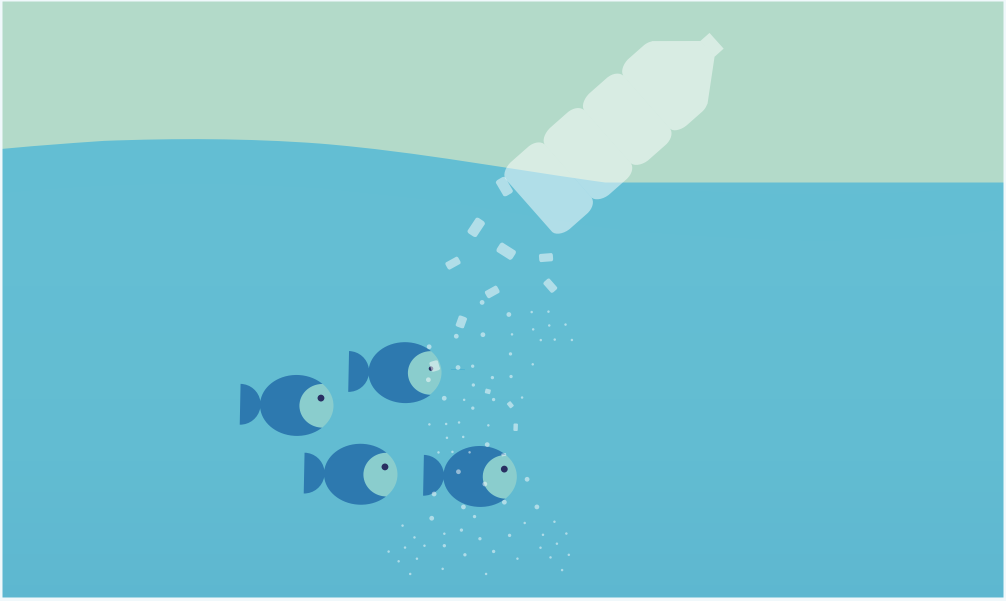
Box 5. Different sizes of plastics in the environment

Plastics in the environment are usually categorised into macro-plastic, micro-plastic and nano-plastic.

Macro-plastics are generally referred to as plastic particles larger than 5 mm. Particles smaller than 5 mm are called micro-plastics, and plastics smaller than 0.1 mm are called nano-plastics. Knowledge about the fate, risks and effects of nano-plastics in the environment is very limited (SAPEA, 2019).

Micro- and nano-plastics can be released either as so-called primary micro-plastics or as secondary micro-plastics. Primary micro-plastics are emitted to the environment in their original shape, for example from washing textiles and as microbeads in cosmetics and personal care products. Micro-plastics can also originate from the fragmentation of macro-plastics (secondary micro-plastics; see Figure 13), for example from the wear and tear of plastic litter or abrasion of car tyres (UNEP, 2018).

Figure 13. The breakdown of a plastic bottle into smaller fragments, eventually ending up as micro- and nano-plastics



Source: IVL.

Figure 14. Sources and pathways of plastics in the environment

Source: EEA.

Seabird nesting on fishing nets ©Pixabay

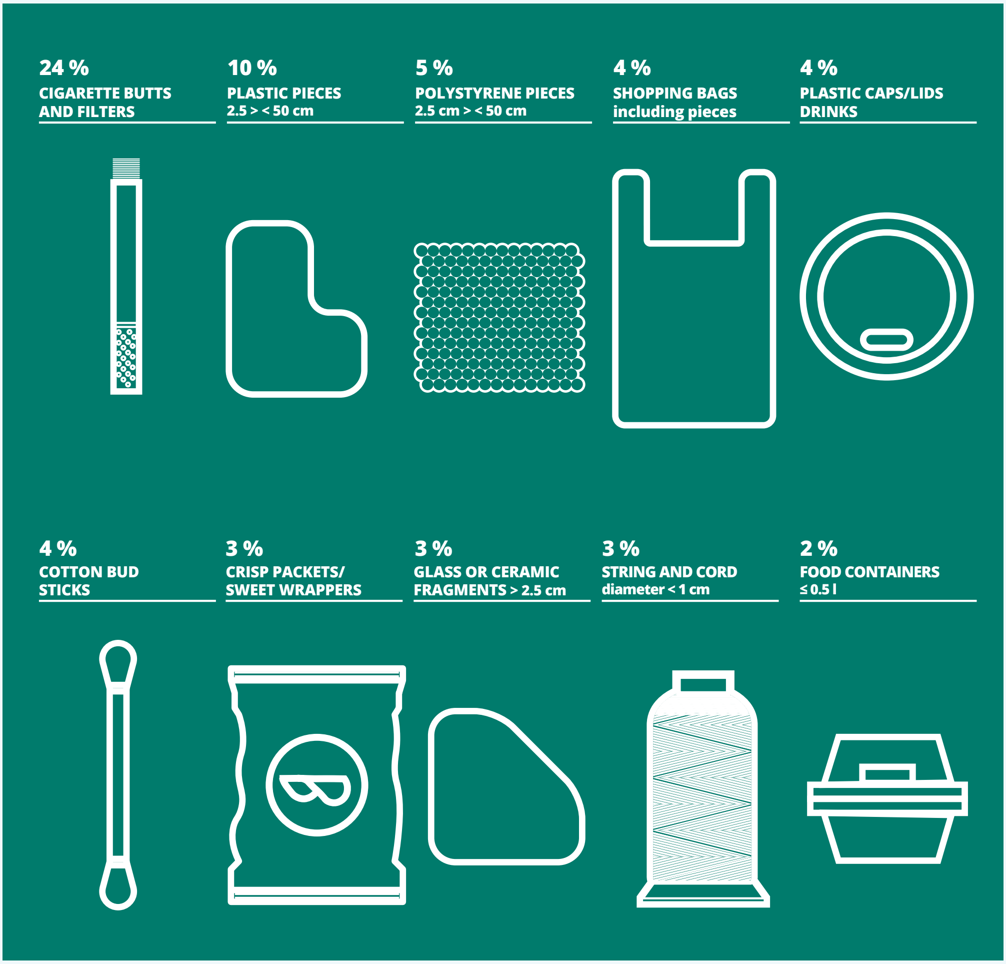
The majority of plastics found in the marine environment in Europe and elsewhere are carried there by rivers. Litter studies in European freshwater environments show that around 40 % of the identifiable plastic litter items were consumer-related products, mostly consisting of bottles, food wrappers and cigarette butts (Earthwatch Institute, 2019). Results from modelling show that most micro-plastics exported by rivers to seas in Europe are synthetic polymers from car tyres and plastic-based textiles from laundry (SAPEA, 2019).

The effects of plastics in the environment are not fully known. Risks are associated with the size of plastics. Macro-plastics such as plastic bags, lost fishing gear and ropes may have detrimental effects on animals because of entanglement, injuries or ingestion. To some species, plastics resemble their ordinary feeding sources, for example for sea turtles transparent plastic bags look similar to jellyfish (UNEP, 2018).

Box 7. Marine Litter Watch

Marine Litter Watch is an ongoing EEA initiative launched in 2014 to better understand the composition, movement and origin of beach litter and to combat plastic litter. By using the Marine Litter Watch app, communities and the public can organise beach clean-ups and record the litter they find on beaches using specific guidelines. The data are used to increase the knowledge base on beach litter and support policymaking under the Marine Strategy Framework Directive and the Single Use Plastics Directive. The top 10 litter items reported to Marine Litter Watch between January 2014 and October 2020 are displayed in Figure 15 below. The percentages are calculated based on the total number of items collected. Together, these items represent 60 % of the litter reported (EEA, 2020c).

Figure 15. Top 10 items reported to Marine Litter Watch (January 2014 and October 2020)



Source: EEA (2020c).

Many marine animal species have been documented as being entangled in and injured by plastics, but the consequences on a population level are not fully known. The animals most often studied include seabirds, turtles and mammals, but fish and invertebrates are receiving increasing attention. Smaller plastic items may be mistaken for food or enter organisms through filtration (e.g. in fish and mussels). All species of marine turtles, almost 60 % of whale species, 36 % of seal species and 40 % of seabird species have been documented as ingesting plastics (Kuhn et al., 2015).

There is some knowledge of the concentrations of micro-plastics in ocean surface waters and freshwaters, but similar information regarding air and soil is very limited. However, there are indications that microplastics in air, freshwater and soil are in need to be addressed similarly to marine microplastics (SAPEA, 2019). Micro-plastics have a negative effect on food consumption, growth, reproduction and survival. High levels of exposure to micro-plastics may cause inflammation and stress, as well as blockage of the gastrointestinal or respiratory tracts, reducing energy uptake or respiration. However, the extent to which this is happening in nature is not known. The concentrations of micro-plastics used in laboratory studies are much higher than those found in the environment (SAPEA, 2019).

The intake of micro- and nano-plastics through food and drink could pose a threat to human health. It is, however, not possible to assess human exposure to micro- and nano-plastics because of a lack of validated and standardised methods. At present, the impacts of micro- and nano-plastic contamination of food and beverages is largely unknown (Toussaint et al., 2019).

Impacts of plastic waste management

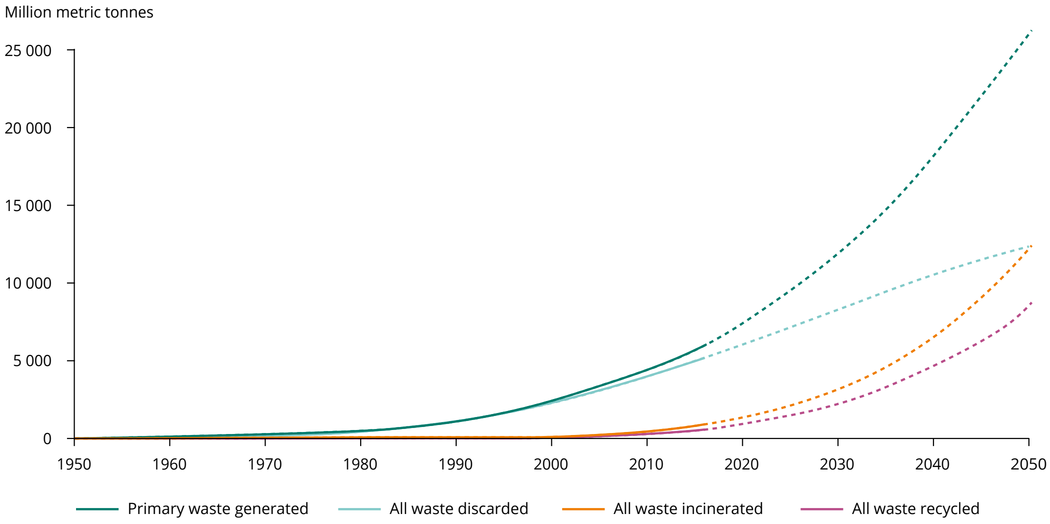
- Estimates suggest that 20-30 million tonnes of plastic waste is incinerated in Europe annually, leading to CO_2 emissions of around 50-80 million tonnes per year.

- Of the 29 million tonnes of plastic waste collected in Europe in 2018, 32 % was collected for recycling. Recycling rather than incinerating plastics can reduce emissions by 1.1-3.0 tonnes of CO_2 equivalent (CO_2e).

In addition to the growth in production, use and consumption of plastics — and the resulting direct environmental and climate impacts — the generation of plastic waste is also an issue, as it constitutes a considerable problem for waste management systems globally. Plastics today constitute a significant part of the total waste generated in Europe.

Humans have already produced a cumulative global total of over 8 billion tonnes of plastics since 1950, of which 6.3 billion tonnes became waste in 2015 (Figure 16). It has been projected that over 25 billion tonnes of plastic could be generated by 2050, much of which could end in landfills or the natural environment (Geyer et al., 2017).

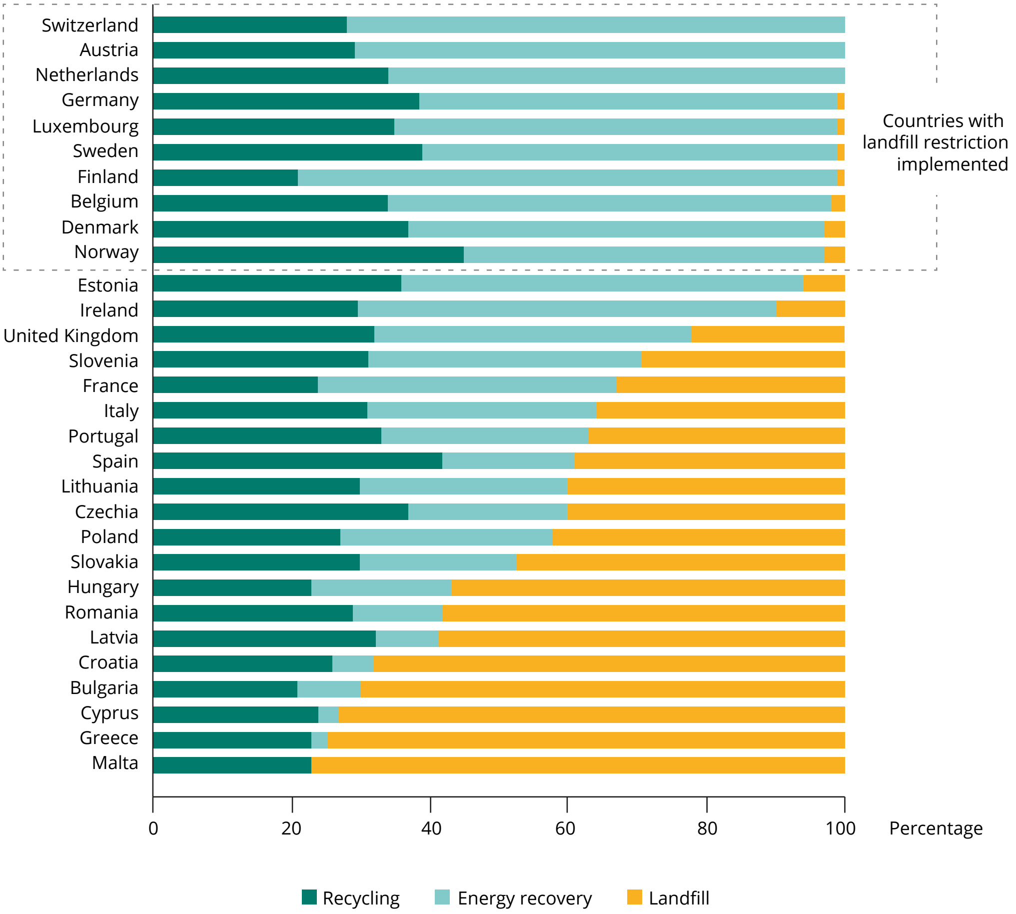
Figure 16. Cumulative global plastic waste generation and disposal



Source: Adapted from Geyer et al. (2017).

In 2018, 29 million tonnes of plastic waste was collected in Europe (EU-28, Norway and Switzerland), of which it has been estimated that 32 % was sent for recycling, 43 % was incinerated and 25 % was landfilled (PlasticsEurope, 2019). Whereas countries in north-western Europe have banned or restricted landfilling and thus incinerate the majority of plastic waste generated, landfilling is still the dominant treatment strategy for plastic waste in southern Europe, as shown in Figure 17.

Figure 17. Rates of recycling, energy recovery and landfill for post-consumer plastic waste in 2018 (EU-28, Norway and Switzerland)

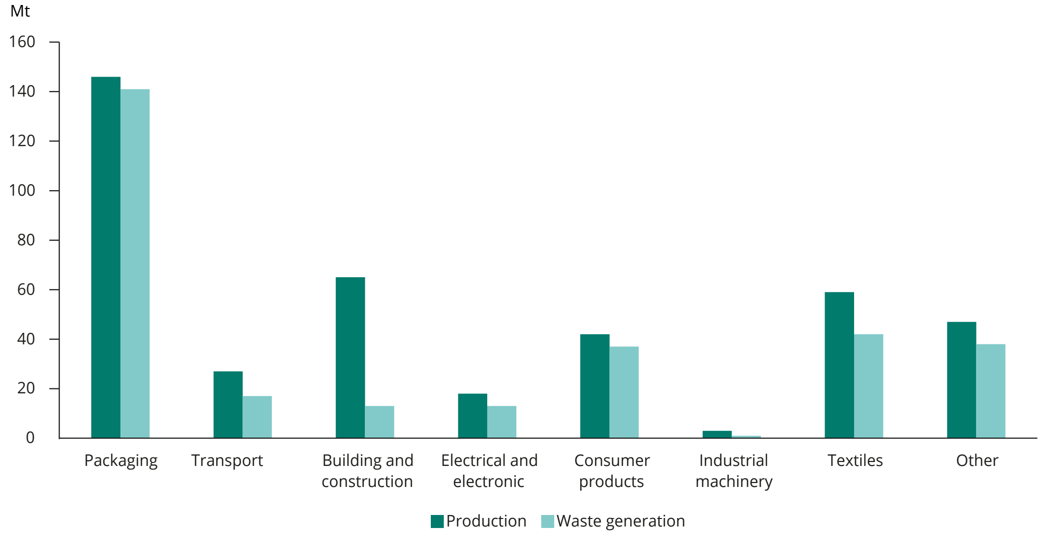


Note: The underlying data supporting this graph was not made available to the EEA.

Source: Reproduced from PlasticsEurope (2019).

Whether used for a short or long period, plastic products eventually end up as waste. Plastic packaging is usually discarded within days or weeks, whereas plastic car parts last for years, and water pipes for several decades. Figure 18 shows the global production of plastics for different end-use segments and the plastic waste generated in each of these. End-use segments in which products have short lifetimes, such as packaging and textiles, generate the majority of plastic waste.

Figure 18. Global plastic production and waste generation by end-use market in 2015



Source: Based on data from Geyer et al. (2017).

At the end of their lifetime, plastics are recycled, incinerated or landfilled (if not leaked into the environment). Of these options, recycling is far more beneficial to the environment and climate than incineration or landfilling, the last option being the least favourable. Overall, waste prevention is the most preferable option (EEA, 2019b).

Impacts of recycling plastic waste

The recycling of plastics reduces raw material extraction and the production of virgin plastics and therefore leads to reduced greenhouse gas emissions. Recycling instead of incinerating plastics could reduce emissions by 1.1–3.0 tonnes of CO_2e, compared with producing the same amount of plastics from virgin fossil fuel feedstock (Ellen MacArthur Foundation, 2016). At the same time, recycling requires waste to be collected, sorted and processed, which in turn requires fuel consumption (OECD and IEA, 2018).

Collection for recycling of plastic waste range from about 20 % in Bulgaria and Finland, to more than 40 % in Spain and Norway. Although many types of plastics can be recycled in principle, they are most often not because of the complexity involved, including issues such as the sorting of many different types of plastics and the combination of various plastics in one plastic material. As a result, a large share of the plastics that are collected for recycling are later discarded in the recycling process.

From the 21 million tonnes of plastic waste collected annually in the EU between 2016 and 2019, 5.2 million tonnes of recycled plastics were used in new products each year (Circular Plastics Alliance, 2020).

As packaging is the segment with the largest demand for plastics, it is also the largest plastic waste stream, as shown in Figure 18. Recycling rates for plastic packaging have steadily improved over the past decade. At the same time, however, the amount of plastic packaging waste has also increased, which means that the overall quantity of non-recycled material has remained stable (ECA, 2020). Today, only about 40 % of plastic packaging waste is recycled in the EU-28, Norway and Switzerland (PlasticsEurope, 2019).

When recycling end-of-life vehicles and electronic waste, more valuable metals are prioritised over plastics, leading to a low recycling rate for plastics from these products. Furthermore, these products often contain types of plastics or additives that create barriers to recycling, such as composite materials and flame retardants, which are not allowed in other applications. Also, some of the additives in plastics are hazardous and therefore these plastics cannot be recycled as they would recirculate the hazardous substances.

Apart from traditional mechanical recycling, there is currently growing interest in different processes for the chemical recycling of plastics. Chemical recycling can be done in different ways, with different impacts on the plastic material — from purification to feedstock conversion.

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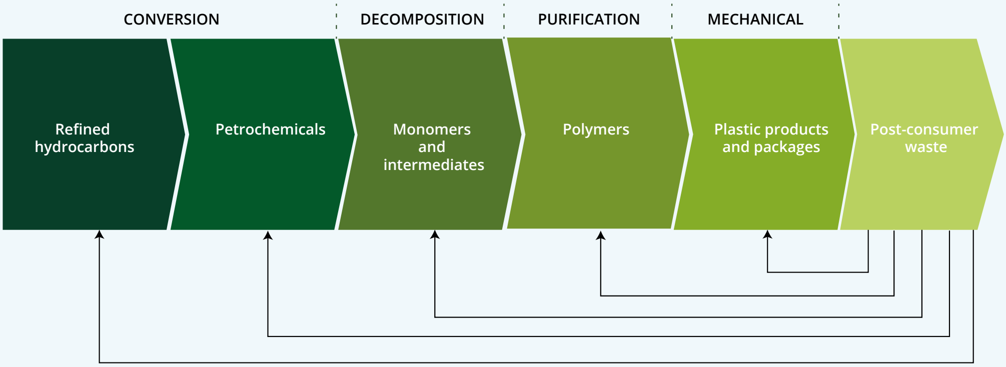
Box 8. Chemical recycling

Plastic recycling is dominated by mechanical recycling, that is, processes in which plastics are sorted by polymer type and colour and then re-melted and undergo regular conversion processes for the production of plastic goods. A new type of recycling process and technology, grouped together under the umbrella term 'chemical recycling' (Figure 19), has gained traction and given rise to discussions in recent years, in terms of business and recycling opportunities, as well as environmental risks and the lack of a sufficient knowledge base.

Chemical recycling offers potential new ways of expanding recycling so that it includes types of plastics and products that are difficult to recycle mechanically. Examples include plastics that are mixed with other materials or types of plastics, or are contaminated by hazardous chemicals. In chemical recycling, plastics can be converted, decomposed or purified by advanced chemical processes into their building blocks (monomers) or oil, which can be purified and used again, as shown in Figure 19 (Crippa et al., 2019; PlasticsleMag, 2019).

There is a significant lack of knowledge about the overall life cycle impacts of chemical recycling on the environment. There are indications, however, that chemical recycling works only under very specific and narrow conditions and that it consumes energy, water and chemical resources that increase the pollution of water, air and land. Volatile chemicals may also be generated during the pyrolysis and purification steps, and, if not carefully captured, they may be emitted to the air as pollution. If chemical recycling is to become a more widely used technology, it will be important to explore the environmental and climate implications and risks as well as the financial costs in more detail to determine whether there is an overall benefit to this type of recycling.

Figure 19. Chemical recycling process



Source: IVL and EEA.

Waste incineration plant Spittelau, Vienna © Pixabay

Impacts of incineration of plastic waste

If plastics are incinerated, with or without energy recovery, the carbon locked into the plastics is directly released into the atmosphere in the form of CO_2. The carbon content typically represents 50-80 % of the weight of plastics, depending on the type (OECD and IEA, 2018).

On average, 2.7 tonnes of CO_2 are released for every tonne of incinerated plastics (not taking into account the potential carbon savings of replacing it with another source of energy) (Material Economics, 2019). The total amount of plastic waste incinerated in the EU is uncertain, but estimates suggest that it is 20-30 million tonnes annually (Material Economics, 2019). This means that the total CO_2 emissions from the incineration of plastics in the EU would be somewhere in the region of 50-80 million tonnes per year.

Impacts of landfilling of plastic waste

The third and least favourable waste treatment option from an environmental perspective — landfilling — could, at least in theory, be regarded as a way of storing and postponing the release of carbon present in plastics. The fate of plastics in landfills is not fully understood, and the potential decomposition of plastics over hundreds of years may eventually lead to a leakage of greenhouse gases into the atmosphere. Fires on landfills (legal or illegal) also lead to uncontrolled greenhouse gas emissions. The EU has adopted a zero-landfill target to be achieved by 2030 for recyclable waste such as plastics. The future options for plastic waste in the EU will therefore favour recycling and reuse over landfilling and incineration.

Box 9. Bio-based, biodegradable and compostable plastics

Recently, the EEA (2020b) has shown that more and more plastic products are labelled as ‘compostable’, ‘biodegradable’, ‘oxo-degradable’ or ‘bio-based’. Biodegradable, compostable and bio-based plastics need clearer labelling and repeated awareness-raising campaigns targeting users to ensure their correct disposal and treatment.

Bio-based plastics are fully or partly derived from biomass, such as maize, sugarcane and cellulose. Many of the conventional plastics, such as polyethylene, polypropylene and polyethylene terephthalate, are available on the market as bio-based or partially bio-based. They can be designed to have the same chemical structure and properties as fossil-derived versions, making them technically equivalent to their fossil counterparts. The production of feedstock for bio-based plastics requires land, which is closely linked to direct and indirect environmental impacts on soil, biodiversity, greenhouse gas emissions and water (Spierling et al., 2018).

Plastics marketed as biodegradable or compostable can be made from biomass or fossil resources or from a combination of the two. Compostable plastics can biodegrade under the conditions of an industrial composting plant, but they do not fully compost in home composting bins or the natural environment. Biodegradable plastics can biodegrade in the environment, but only under certain conditions. These conditions depend on, for instance, temperature, the duration of the process, and the presence of microorganisms, nutrients, oxygen and moisture. Given this, many plastics labelled as compostable or biodegradable do not biodegrade if they end up in the open environment or they don’t degrade quickly enough to avoid being harmful to marine life or the accumulation of plastic in the environment (EEA, 2020b).

The fact that bio-based and biodegradable plastics are often mistaken for being biodegradable in the natural environment is highly problematic. Today, an increasing number of plastic products are labelled as compostable or biodegradable, and a myriad of different labels and claims of biodegradability or compostability exists. Together with the uncertainty around different plastic types, the many labels risk confusing citizens as to how they should dispose of such products. This confusion may even increase littering if consumers misinterpret these labels as a ‘licence to litter’. A clearer labelling system, as well as enhanced awareness-raising and communication with consumers, is therefore important to ensure proper disposal.

The demand for bio-based, biodegradable and compostable plastics is continuously increasing. However, so far, they only make up around 1 % of global plastic production, with packaging the largest field of application (European Bioplastics, 2019). Although biodegradable and compostable plastics can technically be circulated within the economy through recycling, they currently are not.

Source: EEA (2020b).

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TH-AL-20-025-EN-N
doi: 10.2800/5847

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Publications Office
of the European Union

European Environment Agency

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