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Explainer · May 2024

Overview of the global petrochemical industry

Key points:

- The petrochemical industry accounts for a significant and growing share of oil and gas demand and global greenhouse gas emissions.
- Nitrogen fertilisers represent 30% of the petrochemical industry's emissions, and create a greenhouse gas 300 times more potent than carbon dioxide.
- Excluding fertiliser, 63% of petrochemical output is plastics – more than a third of which is used in packaging.
- Demand for oil by the plastic and petrochemical industries is set to double by 2050 under a business as usual scenario, leading to emissions well above what is required to limit warming to 1.5°C.
- China's petrochemical industry is expanding rapidly – in five years it will add more capacity than currently exists in Europe, Japan and South Korea combined.
- Many petrochemical products, including plastics, contain chemicals that have been linked to health conditions in humans including cancer, neurodevelopmental harm and infertility.
- Tackling the climate impacts of plastics requires careful consideration of knock-on impacts of policy or regulatory changes, as well as a focus on reusing materials and reducing the amount of single-use materials that are produced, rather than purely on recycling or substituting plastics for other materials.

What are petrochemicals?

Petrochemicals are products derived from oil and natural gas, and include plastics, soaps, detergents, fertilisers, solvents, drugs, pesticides, synthetic fibres and rubbers, paints and insulating materials. Petrochemicals represent an increasing source of demand for oil and gas and are a growing source of greenhouse gas emissions.

Fertilisers

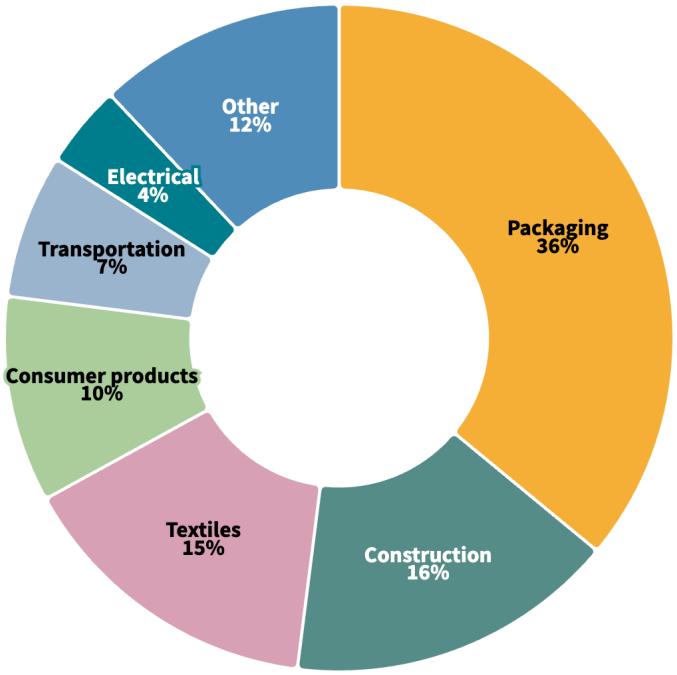
Nitrogen fertilisers, largely made from gas, account for around 30% of petrochemical emissions.[1] Their use on farms, which is expected to grow in the future, creates nitrous oxide, a greenhouse gas 300 times more potent than carbon dioxide with a lifetime of more than 100 years. Nitrogen pollution into waterways is the third most influential driver of biodiversity decline after habitat destruction and greenhouse gas emissions.

[1] Fertiliser accounts for 70% of ammonia output. Data from Direct CO2 emissions from primary chemical production in the Net Zero Scenario, 2010-2030 – Charts – Data & Statistics - IEA & Ammonia Technology Roadmap – Analysis - IEA.

Plastics

Excluding fertiliser, 63% of global petrochemical output by weight was plastics as of 2018. The three largest sectors for plastics production are packaging (36%), construction (16%) and textiles (15%).

Fig. 1 Estimated consumption of plastic by end-use sector



Source: IEA (2018), adapted from Geyer, R., et al (2017), "Production, use, and fate of all plastics ever made"

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Demand for plastics is forecast to rise significantly – with estimates for total plastics production and demand in 2050 set to be between two and 3.5 times recent levels. This growth is forecast across all regions, with the most significant growth in demand coming from China and developing Asia between now and 2050.[2]

Plastics use is largely assumed to increase in correlation with rising GDP, and plastics consumption has kept rising in OECD countries over the last 20 years. This contrasts with carbon emissions, which some richer countries have decoupled from economic growth. There are significant differences in plastic consumption, with OECD countries consuming 156 kg per capita, compared to 39 kg for non-OECD countries. Given these trends, the assumptions of significant growth in plastics demand from non-OECD countries are credible – unless there are significant changes in the behaviour of governments, investors, companies and/or consumers.

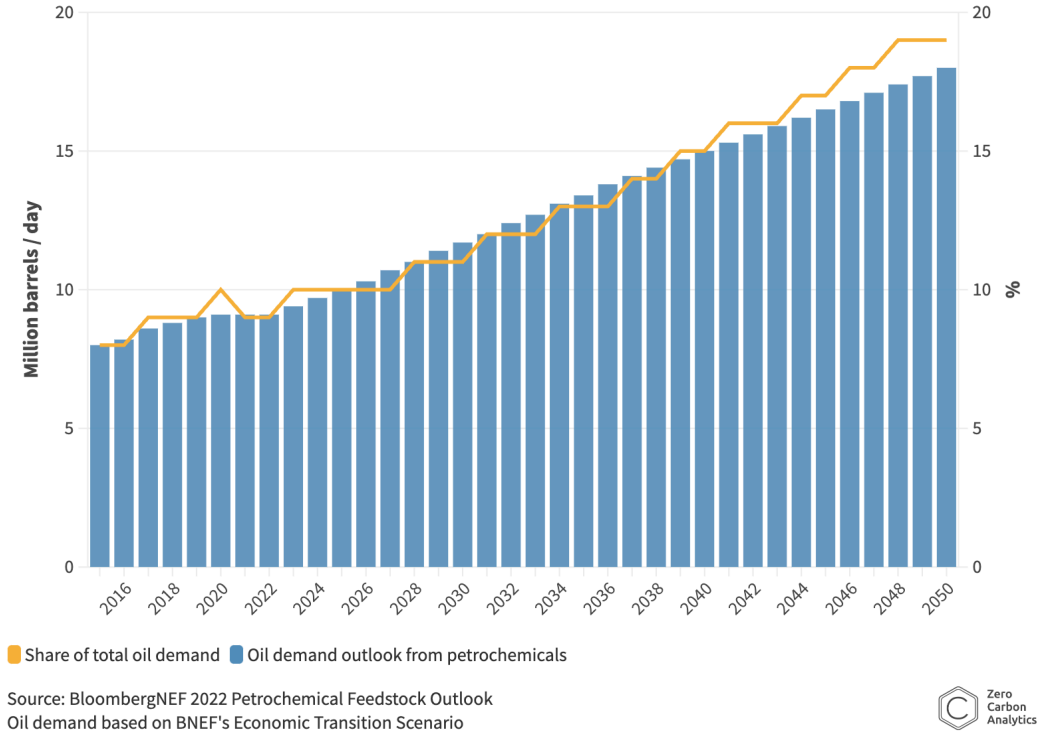
Oil demand for plastics and petrochemicals

Petrochemicals accounted for 14% of demand for oil and 8% of demand for gas in 2018. Excluding petrochemical feedstocks, global oil demand in 2023 remained lower than in 2019 and has grown little since 2017. In comparison, when petrochemical feedstocks are included, oil demand in late 2023 was above 2019 levels and nearly 5% up on late 2017.

[2] Developing Asia includes 46 economies in the Asia-Pacific and excludes Japan, Australia and New Zealand.

Oil demand for petrochemical feedstocks will account for 40% of total oil demand growth from 2022 to 2028, and will more than counterbalance the forecast reduction in road transport oil demand in 2026 and 2027. Oil demand for petrochemical feedstock is set to double in the next 30 years to 18 million barrels per day, in BloombergNEF's base-case Economic Transition Scenario.[3]

Fig. 2 Oil demand for petrochemicals



Source: BloombergNEF 2022 Petrochemical Feedstock Outlook
Oil demand based on BNEF's Economic Transition Scenario

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The vast majority of this growth is in China and Asia Pacific. As total demand increases, so does petrochemicals' share of the global oil market – rising to nearly 20% by 2050. This is even more striking in more ambitious climate scenarios – in the International Energy Agency (IEA)'s Net Zero Emissions scenario, 70% of oil demand in 2050 is for petrochemicals and other non-combustion uses such as asphalt and bitumen.

Plastics & health

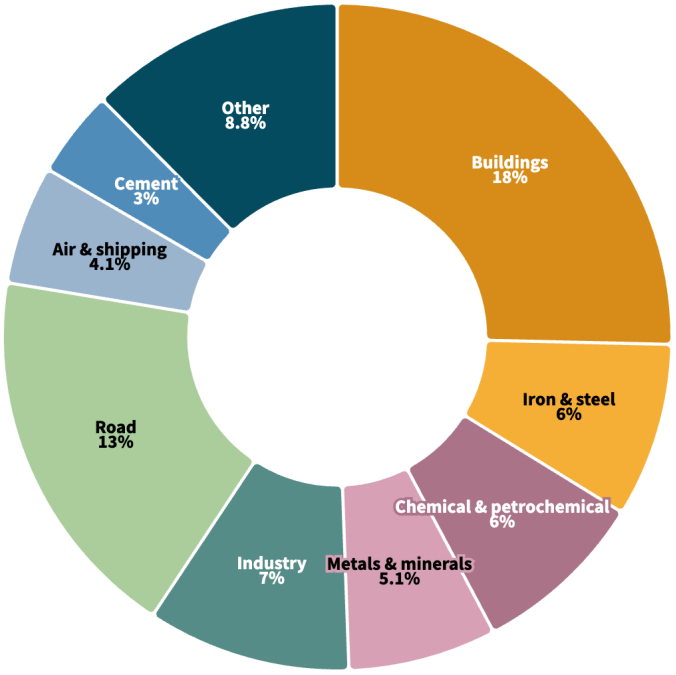
Around 60% of all plastic packaging is used for food and beverages, and synthetic textiles are estimated to be responsible for 16-35% of microplastics released to oceans. Many petrochemical products, including plastics, building materials, fabrics, detergents, cosmetics and pesticides, can interfere with the function of humans' hormone systems. Exposure to these endocrine-disrupting chemicals have been linked to multiple health conditions including cancer, neurodevelopmental harm and infertility.

Emissions from the petrochemical industry

Chemicals and petrochemicals make up 6.1% of global emissions by end use, similar to iron and steel and nearly double the emissions from cement. As petrochemical demand rises, emissions are forecast to increase.

[3] BloombergNEF – 2022 Petrochemicals Feedstock Demand Outlook.

Fig. 3 Energy and industry share of global greenhouse gas emissions by end use



Source: WRI, based on IEA

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Forecasts of current and future emissions from the chemical industry vary widely. Over the course of this decade, the IEA forecasts that emissions are set to rise by 10%, while consulting firm Oliver Wyman forecasts 20% emissions growth. Looking ahead to 2050, the IEA forecasts that chemical industry emissions will remain close to 2021 levels, while consultancy Material Economics estimates that emissions will reach double their current levels. This variation is likely driven by different definitions of the scope of the industry, as well as differing assumptions on the effectiveness of policies to reduce plastic demand, improve recycling and reform plastics production.

Table 1: Forecast chemical industry emissions - million tonnes CO_2e

	Oliver Wyman	IEA World Energy Outlook 2023
2020 / 2021	2,319	1,330
2030 (BAU / STEPS)	2,788	1,461
2030 (1.5C / NZE)	1,534	1,150
2050 (STEPS)		1,378
2050 (NZE)		45

Under a current trajectory / business as usual scenario, emissions from the chemical industry will far exceed what is required to limit warming to 1.5°C across all assessments. For context, in the IEA STEPS scenario, total emissions from natural gas in 2030 are forecast to be 7,499 million tonnes of carbon dioxide.

Forecast expansion

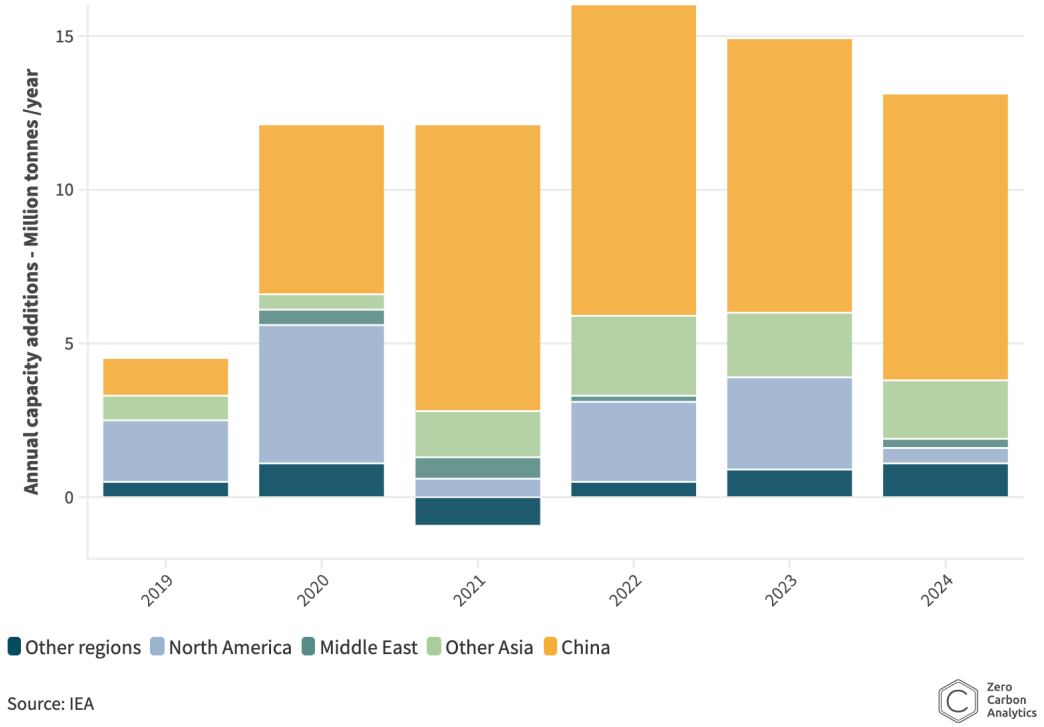
The petrochemical industry is currently undergoing significant growth. Production capacity for ethylene -one of the key precursor chemicals for plastics production - is set to rise by 46% from 2022 to 2030.

Asia is forecast to be the source of over 60% of additional oil demand growth in petrochemicals between now and 2050. Capacity growth in Asia is not set to slow until 2035, with 200,000 barrels per day of oil demand being added each year until then.[4]

Chinese demand for petrochemicals is driving this unprecedented growth in capacity. Domestic production is replacing petrochemical products that were previously imported - largely from the US. The Middle East is also set to contribute to petrochemicals growth, while US production is forecast to stagnate following a recent boom.

According to the IEA: *"The speed and scale of the expansion of China's petrochemical sector dwarfs any historical precedent, roughly doubling the pace of earlier capacity additions in the Middle East and United States. Between 2019 and 2024, China is set to add as much production capacity for ethylene and propylene – the two most important petrochemical building blocks – as presently exists in Europe, Japan and Korea combined."*

Fig. 4 Petrochemical capacity growth by region



Over the past seven years, global oil demand excluding the Chinese petrochemical industry has stayed relatively flat, while demand for Chinese petrochemicals has doubled, increasing by 2.9 million barrels per day over this period. Without the growth in China, total global oil consumption would remain below pre-pandemic levels in 2024.

With the planned expansion in production capacity for petrochemicals, supply is set to significantly outpace demand growth over this decade. By 2030, capacity additions

[4] BloombergNEF - 2022 Petrochemicals Feedstock Demand Outlook.

outpace demand growth, dropping global operating rates below 75%. Overcapacity will be pronounced in China, South Korea and Indonesia – which are planning huge capacity additions. Overcapacity will lead to low utilisation rates, undermining profit margins which were already negative in Asia in 2022.[5] This trend will change over the longer term as demand for petrochemicals is set to increase.

A 2023 review of the major oil and gas and chemicals companies found that over the next three years, Exxon plans to invest over USD 20 billion in expanding plastic production, while CPChem will spend USD 14.5 billion and Dow plans to invest USD 10 billion.

Solutions for plastics

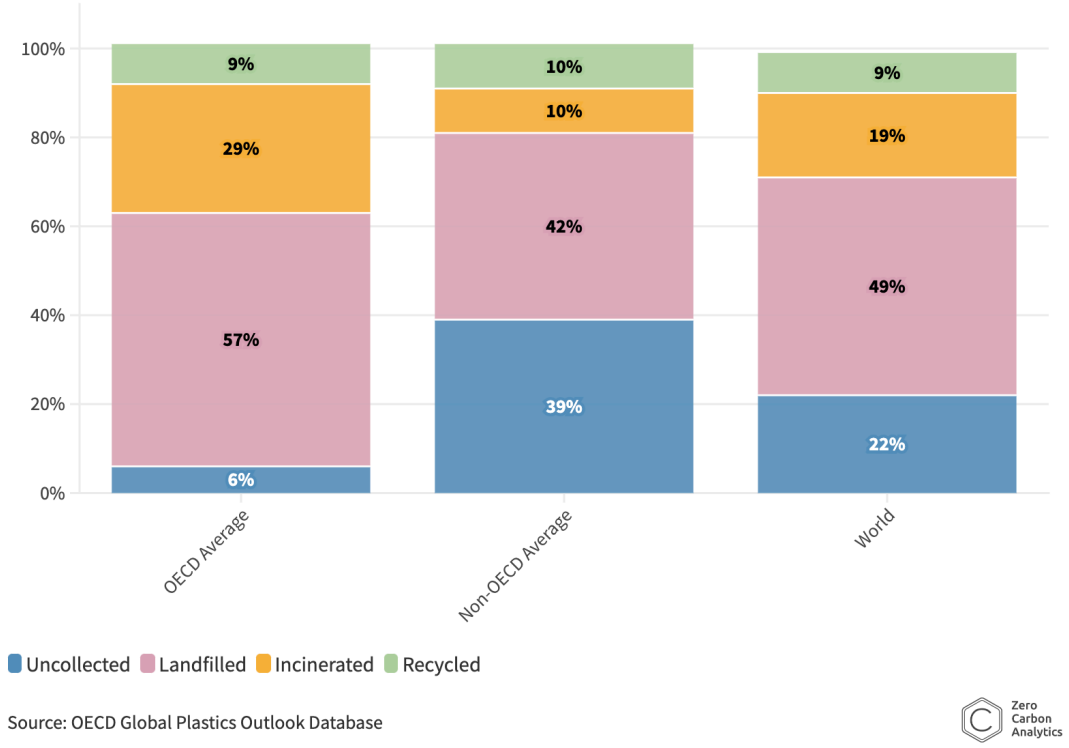
A range of technical solutions have been proposed to reduce emissions from plastics production, including replacing oil and gas with renewables as the energy source in the production process. However, per tonne, more carbon is embedded in plastics than the amount that is emitted through its production – so its climate impacts cannot be tackled without addressing recycling.

Globally, only 9% of plastics are recycled, and this percentage is relatively consistent across OECD and non-OECD countries. Recycling rates have remained flat over the past decade as policies to support more recycling have had limited impact.[6] To increase recycling rates, there needs to be better alignment between the types of plastic produced and the types of plastics that can be recycled, and there must be no contamination of recyclable plastics by non-recyclable plastics. However, this can be challenging due to the wide range of plastic materials in use and the need for mechanical sorting.

One significant obstacle to increasing recycling rates is that due to the rapid expansion of the industry, new plastics are now cheaper than recycled plastics. In the US, virgin high-density polyethylene (HDPE) dropped in price by about 44% between 2021 and 2023 to USD 943. By contrast, recycled HDPE costs USD 1,631 per tonne. Recycling plastics is also referred to as 'downcycling,' as the quality of plastic is reduced each time, meaning that recycling only delays rather than avoids the final disposal of plastics. Increasing plastic recycling is essential, but not sufficient to address its climate impacts.

[5] BloombergNEF – 2022 Petrochemicals Feedstock Demand Outlook.
[6] Ibid.

Fig. 5 Share of plastics recycled vs other waste methods



Source: OECD Global Plastics Outlook Database

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Effectively designed policies are crucial to ensure that measures to reduce the use of plastic or increase recycling achieve the intended climate benefit. In some cases, the adoption of recycling policies has led to unintended or harmful consequences:

- Japan introduced an 'Extended Producer Responsibility' where producers are required to finance the recycling of collected packaging. While Japan has achieved an 87% plastics recycling rate, 62% of this is 'thermally recycled' – incinerated – resulting in significant carbon emissions.
- New Jersey banned single use plastic bags, resulting in 46% fewer bags found on beaches. However this led to an increase in the use of heavier polypropylene bags, resulting in a 41% increase in emissions from plastic bag use overall.
- Bioplastics made from plant material have potential trade offs with other land uses. If all plastic packaging was replaced with bioplastics, this would require an estimated 54% of current global corn production, a land area larger than France and use 60% more freshwater than the EU's current use. Recycling of bioplastics is also generally not yet commercially available, and they cannot be composted in home or even most industrial facilities.

Policy changes should focus on encouraging the re-use of existing products and materials, and reducing the overall quantity of single-use products and packaging, rather than just increasing recycling or substituting plastics for other materials.