

PLASTICS

Risks, Refuse, and the Road Ahead



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Introduction

Plastics have shaped the modern world to the point that they are now practically ubiquitous.

The growth in usage is unlikely to slow down; on a per capita basis, the major developed economies use up to 20 times as much plastic as their developing counterparts. Plastics demand will further increase as economies develop and become more sustainable. For example, to increase fuel economy, plastics are used to make vehicles lighter. Plastics are also used in clean energy infrastructure, such as wind turbine blades.

Unfortunately, most plastic items do not have a long lifespan, nor do they safely and completely degrade in the environment after they are discarded by consumers. Over the past few years, plastic pollution has become a top issue for the public, regulators, and investors.

Items designed to be used once and discarded, or “single-use” plastics, account for the lion’s share of plastic pollution. Because many of these single-use plastics are used to make food and beverage packaging, the packaging sector accounts for both the most plastic production and plastic waste.¹

Investors have taken notice, and some socially-responsible investors have used the shareholder proposal process to engage with several packaged food companies, restaurants, and grocers, such as **The Kroger Co.**, **Mondelez International, Inc.**, and **Starbucks Corporation**. As such, until recently, shareholder engagement has largely been focused downstream in the plastic lifecycle. In some cases, these efforts have been met with success. At the very least, they have generally pressured companies to address how they contribute to plastic pollution and consider their readiness to new regulatory efforts to curb plastic waste.

As research on the environmental impacts of plastics has evolved, it has refocused attention upstream to where plastics originate. For the most part, the spotlight has been directed towards the major oil and gas companies that produce the petrochemical feedstock used to make plastic. In 2019, shareholder proposals at some of the largest petrochemical producers, including **DowDuPont Inc.**, **Phillips 66**, **Chevron Corporation**, and **Exxon Mobil Corporation**, raised questions about how the plastics and oil and gas giants are responding to issues related to plastic pollution and their plan for a low-carbon future, including potential hedging against declining gasoline demand. The proposals also raised questions about how these companies are going to meet their own goals to curb GHG emissions, and the potential health and safety consequences of production along the vulnerable American Gulf Coast.

¹ Hannah Ritchie, Max Roser. “[Plastic Pollution \(Which sectors produce the most plastic?\)](#).” Our World in Data. 2019

About This Report

In light of the plastics industry's rapid development and increasing shareholder interest on how companies are grappling with issues related to plastic pollution, this report is intended to provide an in-depth overview of the direct and indirect risks associated with the material, along with insights into how massive investments on behalf of oil and gas companies are shaping the industry's future. In the wake of unprecedented global investor scrutiny of fossil fuel holdings in recent years, we also consider how plastics are inextricably linked to their fossil fuel-based components.

- The Risks section explores how companies both directly and indirectly tied to plastics are exposed to physical, reputational, direct, and legal risks. Upstream, we examine how producers of plastic and its components are linked to emissions and safety concerns inherent to the industry and exacerbated by the impact of natural disasters at their American epicenter. We also investigate why plastic waste has become a major global concern downstream, delving into issues such as recycling and marine plastic waste, from microscopic particles to state-sized garbage patches in the Pacific Ocean.
- In the Responses section, we explore how stakeholders are responding to the risks posed by plastics. Investors have taken action by submitting proposals to some of the largest producers and purchasers of plastics, while a range of individual companies have begun to phase out plastic products. Investors and industry have also formed coalitions with governments, which have also begun to address the issue through the legislative process. However, these efforts are being stymied by lobbying from groups representing the plastics industry.
- In Supply and Demand, we take a deep dive into plastic production to discuss its interdependence with the fossil fuel industry, discussing the market forces that are currently reshaping the industry, from the shale gas boom to the forecasted production of petrochemicals directly from crude oil. We also examine how emerging technologies such as bioplastics and chemical recycling will present new challenges and opportunities in the plastics sector.

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Risks

Although plastics have mostly attracted mainstream public scrutiny when made into single-use products and discarded into the environment, investors should also be cognizant of a range of risks in the material's production phase. Much like the oil and gas industry from which plastics originate, the material's upstream and downstream operations are each exposed to a distinct set of environmental and social risks.

In some cases, the risks have already manifested. Explosions at petrochemical facilities on the Gulf Coast, for example, provide a particularly tangible example. Other issues might presently exist as potential emerging risks, such as single-use plastic regulation. It is unlikely that single-use plastics will be regulated out of existence in the near-term, although the scale of industry pushback indicates that it could become increasingly problematic for producers in the future. As this issue gathers momentum, actionable knowledge is critical for investors to make informed voting decisions on shareholder proposals and manage exposure to risk.

GULF COAST: HURRICANE AND SAFETY RISK

As multinational energy companies are scrambling to take advantage of inexpensive shale gas, the already plastics-rich U.S. Gulf Coast is becoming even more concentrated with plastics production. However, as highlighted by a few shareholder proposals in the 2019 proxy season, the region is particularly vulnerable to natural disaster risk, namely from hurricanes.

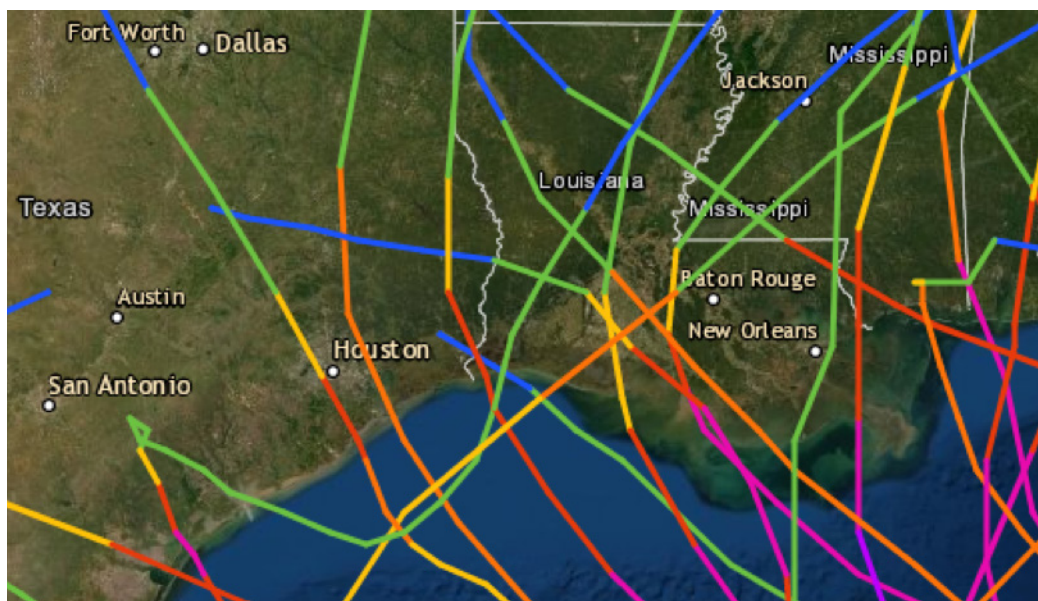


Figure 1: This map shows the paths of Category 3+ hurricanes in the Gulf Basin since 1970. Image downloaded from <https://coast.noaa.gov/hurricanes/> in July 2019

In August 2017, Hurricane Harvey became the first major hurricane to hit the region since the petrochemicals boom. The storm first hit the Texas coast before hovering over the Houston area, which has roughly 500 chemical plants, 10 refineries, and more than 6,670 miles of oil, gas, and chemical pipelines.

Nearly every major Texas and Louisiana refinery was either partly or completely shut down for Hurricane Harvey. Effects rippled throughout petrochemical markets; driven primarily by higher crude oil prices, prices rose by about 14% and didn't return to normal (compared to crude oil) until March 2018. Additionally, refinery utilization rates did not return to pre-Harvey levels until June 2018.

In the aftermath, reporters cataloged more than 100 Harvey-related toxic releases, with more than a dozen occurring in a 2-mile radius, ranging from spills to leaks to toxic plumes.

- Texas' largest reported Harvey-related venting of air pollutants occurred as a spill at the Magellan terminal;
- At Exxon's Olefins Plant in Baytown, roughly 457 million gallons of stormwater mixed with untreated wastewater, including oil and grease, and ran into a nearby creek;
- A large plastics plant operated by Formosa Plastics released over a million pounds of excess emissions when it restarted after the hurricane;
- At Dow's chemical plant in Freeport, Texas, toxic gas leaked after operations were disrupted due to a lightning strike; and
- Dow Chemical's Deer Park plant spilled about 50 tons of what it called "non-hazardous biosolids."

According to an analysis by the Environmental Defense Fund, Air Alliance Houston, and Public Citizen, from August 23 to August 30, 46 facilities in 13 counties reported an estimated 4.6 million pounds of airborne emissions that exceeded state limits. Several known human carcinogens, including benzene, vinyl chloride, and butadiene, were among the dozens of industrial chemicals released by the storm. Two of the largest chemical releases were from a Shell chemical and refinery plant and a chemical plant operated by the Chevron Phillips Chemical Company. A pipeline leak unleashed a chemical plume of hydrogen chloride, and one Shell chemical and refinery plant reported a leak of more than 3,000 pounds of benzene. Chevron Phillips Chemical Company, a joint venture between Chevron and Phillips 66, reported a leak of about 34,000 pounds of sodium hydroxide and emissions of 28,000 pounds of benzene.

Case Study: Arkema North America

One particular toxic release, from **Arkema North America**, has led to several indictments. The firm's Crosby, Texas plant manufactured organic peroxides used to produce consumer plastics, such as polystyrene cups and plates. The chemicals had to be kept below 32°F in order to prevent them from decomposing and combusting. During Harvey's heavy rainfall, the plant lost both primary and backup power. Although the chemicals were moved into refrigerated trailers and taken to higher ground, three trailers could not be relocated; as a result, flooding caused the three trailers to explode on August 31 and September 1. The explosions forced the evacuation of over 200 people who lived near the plant, while 21 people sought medical attention for exposure to fumes and smoke.

In August 2018, a grand jury indicted Arkema, its CEO, and the Crosby plant manager. Prosecutors maintain that the release was preventable and that the firm and its leaders had a role in the explosions. The individuals could face a penalty of up to five years in prison, while the company could face a fine of up to \$1 million. The following April, Arkema's vice president for logistics was indicted on third-degree felony assault charges for allegedly misrepresenting what was known about the disaster. Allegedly, by falsely claiming that Arkema had "real-time data monitoring" of chemical tanks, sheriff's deputies and first responders were sent into the path of harm's way, leading to hospitalization for toxic exposure. The executive can face 2-10 years of jail time if found guilty.

Experts remain concerned about the long-term effects to the area, including those related to residents' health, as well as the potential for floodwaters to spread toxins to broader communities. To date, air and soil samples have showed mixed results.

September 2019's Tropical Storm Imelda brought similar environmental impacts, again demonstrating the risk to operations in the Gulf region. About a dozen facilities reported releases totaling 100,000 pounds of toxins, including 1,3 butadiene, benzene, and ethylene oxide. The largest emission attributed to Imelda was reported by Exxon at its Beaumont facility. Another [significant release](#) occurred at its Baytown refinery, echoing a similar issue during Harvey. Notably, both facilities are directly involved in the production of plastics feedstock.

Other Safety Incidents

Apart from hurricane risk, petrochemical facilities on the Gulf are also vulnerable to accidents and other safety incidents. Just last year Exxon's Baytown operations experienced two significant fires, leading to extensive injuries, release of pollutants, and ongoing production restrictions – along with multiple lawsuits filed by employees and local government. According to a 2016 Houston Chronicle [investigation](#), a major chemical incident occurs once every six weeks in the greater Houston area.

A December 2019 report from the Environmental Integrity Project ("EIP") highlighted the potential impact of state environmental funding rollbacks, particularly in Texas. The EIP claims that, while the petrochemical boom was heating up, the state of Texas slashed its environmental funding while still growing its state budget.² In light of easing environmental oversight at the state level, investors should be aware of the potential for safety and pollution control issues to persist or increase on the Gulf Coast and the heightened relevance of corporate responsibility in the region.

GHG AND CHEMICAL EMISSIONS

Greenhouse gas emissions remain one of the foremost environmental impacts resulting from plastics production. As such, the climate impacts of plastics will rise in line with the ongoing expansion in production.

The production of plastic feedstocks and resins—in particular, steam cracking—is the most energy-intensive sub-sector of the chemical industry. In 2015, emissions from cracking to produce ethylene were 184.3–213.0 million metric tons of CO₂e, comparable to 45 million passenger vehicles driven for one year. It is predicted that, by 2050, annual emissions from plastic production and incineration (which comprises a far smaller portion of the total) could surpass 2.75 billion metric tons of CO₂e. Notably, these estimates are only based on the emissions profile of North American and European plastic, and thus do not account for the exponentially more polluting process of converting coal to chemicals, which is expected to grow in other regions.³

Unlike the transportation and utilities sectors, the plastics sector is not expected to reduce its carbon intensity as a result of a shift towards renewables. Studies show that a low-carbon public energy grid based on renewable energy sources has negligible impact on the carbon footprint of facilities in the plastic supply chain which utilize on-site combined heat and power technology. Further, even if fully powered by carbon-free power sources, plastics production would still release a significant amount of emissions from the chemical processes alone.⁴ Moreover, as some regions are more dependent on less energy-efficient forms of feedstock, such as coal or crude-derived naphtha, the global plastics emissions profile is somewhat dependent on the geopolitical factors in each region.

2 Keene Kelderman, Eric Schaeffer, Tom Pelton, Ari Phillips, Courtney Bernhardt. "[The Thin Green Line](#)." Environmental Integrity Project. Page 14. December 5, 2019.

3 Center for International Environmental Law. "[Plastic & Climate: The Hidden Costs of a Plastic Planet](#)." Pages 2, 5, 16 and 44. May 2019.

4 Center for International Environmental Law. "[Plastic & Climate: The Hidden Costs of a Plastic Planet](#)." Pages 16-17. May 2019.

ENVIRONMENTAL POLLUTION

Solid Waste

Since 1950, 8.3 billion metrics tons of plastic have been produced. Of this total, 3.6 billion metric tons have become plastic waste. Only 9% of total plastic waste generated since 1950 has been recycled, with the rest mostly ending up in landfills or otherwise escaping into the environment. In recent years, the recycling rate has grown to reach about 20%.⁵

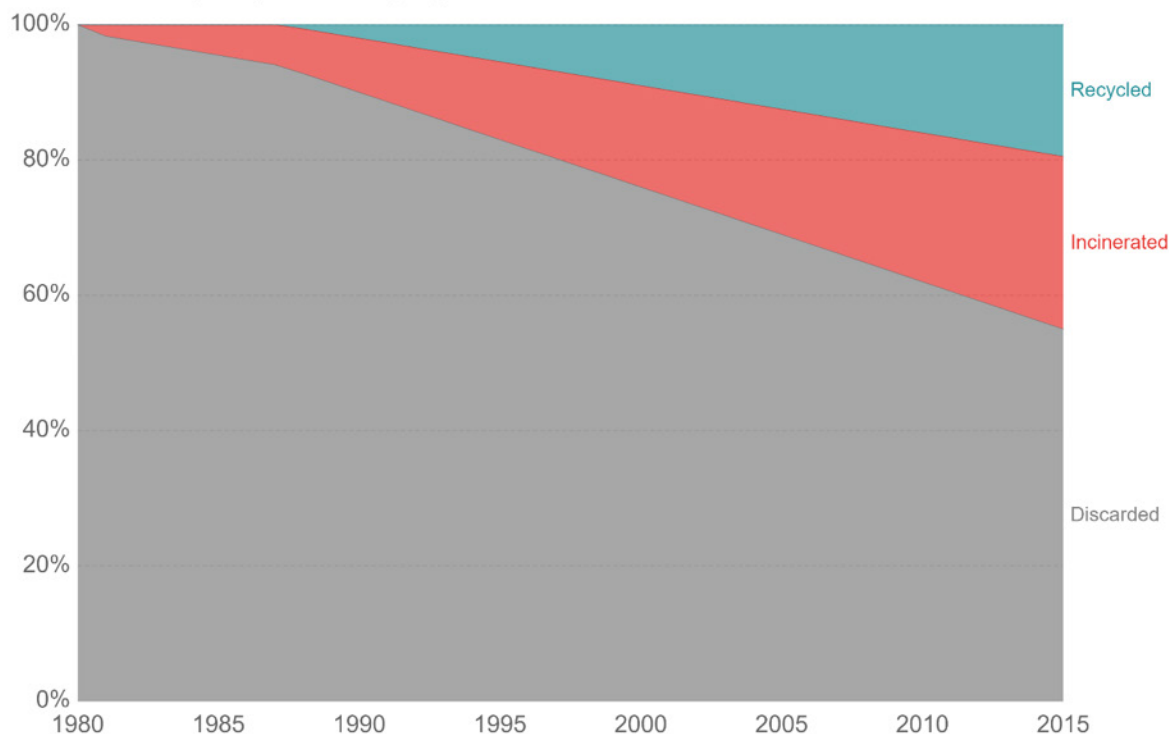
Market conditions play a critical role in determining the success or failure of recycling pathways; the values of different types of recyclable plastics differ greatly. Plastic packaging and products that are low in value are far more likely to be mismanaged compared to higher value plastics. These low residual value items, which include plastic shopping bags, comprise 80% of plastic waste.⁶

In 2015, 146 million tonnes of plastic were produced for packaging; 97% of which became waste, reflecting the short 'in-use' lifetime that leads to a quick turnaround from use to disposal. Other notable sectors include textiles and consumer/institutional products, which combined to produce 89 million tonnes of plastic, generating 75 million tonnes of waste (84%). To compare, the building and construction sector accounted for 65 million tonnes of primary plastic production, but produced only 13 million tonnes of waste (20%).⁷

Global plastic waste by disposal

Estimated share of global plastic waste by disposal method.

Our World
in Data



Source: Geyer et al. (2017)

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Figure 2: This chart shows the share of global plastic waste that is discarded, recycled, or incinerated from 1980 through to 2015. Image downloaded from <https://ourworldindata.org/plastic-pollution#global-plastic-fate> in July 2019.

⁵ "The Future of Petrochemicals." International Energy Agency. Page 61. October 5, 2018.

⁶ "Stemming the Tide: Land-Based Strategies for a Plastic-Free Ocean." Ocean Conservancy, the McKinsey Center for Business and Environment. Page 14. September 2015.

⁷ Hannah Ritchie, Max Roser. "Plastic Pollution (Global Plastic by Sector)." Our World in Data. 2019.

Chinese Plastics Import Ban

Recycling programs have historically relied heavily on China, which since 1992 had imported 45% of all plastic waste intended for recycling. That changed in January 2018, when China announced that it would stop buying recyclable material from the U.S. unless it adhered to strict contamination rules that are exceedingly difficult for cities to meet. The policy has led some American cities to either suspend curbside recycling programs or divert recyclable material to incinerators. It has also made the management of single-use plastics an even more pressing issue in the United States, given that 89% of exported plastics are made up of single-use food packaging. It may have a significant global impact if it continues; based on the near-100% import ban, an estimated 110 million tonnes of plastic will have to be handled domestically or exported to another country by 2030.⁸

Marine Plastic Waste

Of course, not all plastic waste makes it to a landfill, incinerator, or recycling facility; much of the remainder makes its way to ocean waters.

In 2010, approximately 5-13 Mt of land-based plastic entered the ocean. Estimates for the current annual rate of oceanic plastic pollution is expected to be somewhat higher, in line with growing demand and production figures.⁹ Although marine-based sources such as oil rigs, fishing vessels, piers, and boats are partially to blame for ocean plastic waste, the UN estimates that about 80% of ocean plastic originates from land-based sources.¹⁰ About three-quarters of the plastic from land-based sources has never been collected as waste, with the remainder emanating from within waste management systems. The most common type of plastic waste found in marine debris is polyethylene (in the form of plastic bags, bottles, plastic wrap, etc.), followed by polypropylene (in the form of bottle caps, food wrappers, food containers, etc.).¹¹

Because of ocean circulation, plastic waste can be found across the marine ecosystem, including on coastlines, in Arctic sea ice, at the sea surface, and on the seafloor.¹² Indeed only about half of all plastic floats, and even floating plastic debris can eventually sink due to biological buildup. As a result, plastic is distributed throughout the water column, including at extreme ocean depths. One recent study found bags, bottles, packaging, and other plastics to be ubiquitous even at depths of over 6,000 meters, and evidence of single-use waste has been found 10,927 meters deep in the Mariana Trench. Oceanic circulation has also brought plastics to the most remote areas of the planet, as far as the Greenland and Barents seas in the Arctic.

Gyres, a circulatory feature of the oceans, funnel plastic pollution into high concentrations. The most notorious example is known as the Great Pacific Garbage Patch, a gyre that comprises an area roughly four times the size of California and is growing at an exponential rate. Not all of the plastic debris in the gyre is floating on the surface and easily recoverable; much of it is actually distributed throughout the water column in tiny pieces.¹³

When plastic waste reaches the ocean, its harmful effects are both numerous and ubiquitous. For example, sea turtles mistake plastic bags for jellyfish and seabirds have been killed by plastics clogging their digestive system. Several whale fatalities have been directly linked to the consumption of plastic pollution, and evidence has suggested that even small amounts of ingested plastic can have significant effects on marine life, as observed in pygmy sperm whales, bottlenose dolphins, marine birds, and turtles. Reefs are particularly vulnerable; contact with plastic spreads bacteria, blocks light, and can wound corals, in each case increasing the potential for infection—one study identified coral as clearly diseased over 90% of the time when in contact with plastic.

As the body of research on the subject grows, an ever-increasing range of flora and fauna appears to be affected by ocean plastic.

8 Hannah Ritchie, Max Roser. "Plastic Pollution (How Much Plastic Will Be Displaced from the Chinese Import Ban?)." Our World in Data. 2019.

9 "The Future of Petrochemicals." International Energy Agency. Page 63. October 5, 2018.

10 "Stemming the Tide..." Ocean Conservancy, the McKinsey Center for Business and Environment. Page 13. September 2015.

11 "The Future of Petrochemicals." International Energy Agency. Page 63. October 5, 2018.

12 Jenna R. Jambeck et al. "Plastic Waste Inputs from Land into the Ocean." Science. Vol. 347. Issue 6223. Page 768.

13 "The Future of Petrochemicals." International Energy Agency. Page 64. October 5, 2018.

Nurdles

A decade ago, the word “nurdle” probably would have been known only to followers of the legal [battle](#) between Colgate-Palmolive and rival GlaxoSmithKline, when it served as shorthand for the wave-like length of toothpaste applied on a toothbrush in advertisements. In the last few years, nurdles [have become](#) more well known in the public lexicon as the tiny, lentil-sized pre-production building blocks for almost all plastic goods.

Mismanagement of the pellets during transportation and processing leads to billions of nurdles being unintentionally released into rivers and oceans through effluent pipes, after having been blown from land, or via industrial spillage.

Nurdles are risky for marine animals, which may mistake them for food because of their small size and bright colors. Further, because of their rough surface and chemical composition, persistent organic pollutants in seawater tend to accumulate on their surfaces, exacerbating the toxic impact of nurdle ingestion by marine life.

Ingestion of these pellets poses risks to people as well, given that nurdles can house microbes that are dangerous to humans. A study investigating nurdles on five Scottish beaches found that every beach contained nurdles covered with *E. coli*, which is responsible for food poisoning. Nurdles can be so toxic that people cleaning up beaches or investigating nurdles for scientific surveys are advised not to handle them with their bare skin.¹⁴

Firms involved in nurdle production and transport were the recipients of shareholder proposals in 2019 (see “Shareholder Opposition” on page 10). Specifically, **DowDuPont Inc.**, **Phillips 66**, **Chevron Corporation**, and **Exxon Mobil Corporation** were asked to report annually on plastic pollution, with a focus on pellet (nurdle) loss prevention, cleanup, and containment.

Given the shareholder proposal activity around this issue, the historic *Waterkeeper* settlement, and ongoing headlines about the environmental risks of nurdle production and handling, nurdles entail a host of risks even before they are melted into more commonly-recognized products.

Microplastics

“Microplastics,” defined as plastic pieces that are 5 millimeters or smaller, further expand the risk to marine life. Some plastic particles can be defined as microplastics as soon as they enter waterways, such as microbeads (used in cosmetics) and synthetic microfibers (shed from clothing during washing). Microbeads are [inherently problematic](#) because they are flushed down the drain and cannot be filtered by many wastewater treatment plants.

Microplastics can also be formed when solar UV radiation degrades larger plastic pieces. According to NOAA, the quantity of microplastics in the ocean could increase 30-fold as larger debris, including containers, bottle caps, crates, and discarded commercial fishing gear, continues to degrade over time.¹⁵

Case Study: Waterkeeper v. Formosa

Nurdles were front and center in 2019’s *Waterkeeper v. Formosa*. In the ruling, **Formosa Plastics**, which operates a plant in the Gulf Coast, agreed to pay a \$50 million fine and eliminate plastic discharges from its Point Comfort, Texas plant. For about four years, a shrimp boat captain and a group of former Formosa employees had collected nurdles to prove that Formosa was in violation of the Clean Water Act. Ultimately, the group’s collection of nearly 30 million nurdles proved pivotal in the ruling. The penalty [will go towards](#) educational, research, and conservation initiatives in the Gulf Coast. Approved by a federal judge in December 2019, the [settlement](#) is the largest in U.S. history involving a private lawsuit against an industrial polluter under federal clean air and water laws and five times larger than the next top historical settlement.

¹⁴ Claire Gwinnett. “The Major Source of Ocean Plastic Pollution You’ve Probably Never Heard of.” *The Conversation*. February 14, 2019

¹⁵ “The Future of Petrochemicals.” International Energy Agency. Page 63. October 5, 2018.

Microplastics have long been known to contaminate marine ecosystems, and recent research shows that microplastics pass from zooplankton, to fish, and finally to marine predators which consume fish as prey.¹⁶ As plastics degrade even further, they may release persistent, bioaccumulative (retained and built up in a single organism), and toxic (“PBT”) contaminants. Aquatic plastic debris has been found to accumulate contaminants at concentrations that are thousands to millions of times greater than the surrounding environment. However, even at low concentrations, PBTs can biomagnify up the food web such that they eventually reach toxic levels.

PBTs also include harmful chemicals inherent to the plastics themselves, such as flame retardants, antimicrobial agents, and antioxidants. These chemicals are known to cause harm to animal health, specifically in relation to hormone production, affecting reproduction.¹⁷ Chemicals that leach out of plastics may even be toxic to *Prochlorococcus*, a kind of ocean-going cyanobacteria that produces an estimated 20% of the world’s oxygen through photosynthesis. In a lab experiment, researchers observed that toxins leaching from plastic inhibits the growth and photosynthetic efficiency of the bacteria.

Humans are also at risk of ingesting microplastics through seafood consumption. Because microplastics mainly accumulate in the gastrointestinal tract of animals, they can largely be avoided by degutting fish prior to consumption. Species that are eaten whole, such as sardines, anchovies, small freshwater fish, shrimp, mussels, and oysters, are more problematic because the entire gastrointestinal tract is consumed. While plastic is suspected to interact with the immune system, causing oxidative stress and changes to DNA, much remains unknown about the possible adverse human health effects from microplastic consumption, and the World Health Organization has called for further study.

¹⁶ Setälä et al. "Ingestion and Transfer of Microplastics in the Planktonic Food Web." *Environmental Pollution*. Vol. 185. February 2014. pp.77-83 ; & Nelms et al. "Investigating Microplastic Trophic Transfer in Marine Top Predators." *Environmental Pollution*. Vol. 238. July 2018. pp.999-1007;

¹⁷ Dr. Jenna Jambeck. "Marine Plastics." *Smithsonian*. April 2018.

Responses

SHAREHOLDER OPPOSITION

As the body of research has blossomed and as media coverage has increased, plastic pollution has become a serious environmental problem that has won the ire of governments, businesses, and the public. In the U.S., the shareholder proposal process has enabled engagement between the two parties on this issue.

Over the past few years, the international uproar over plastic packaging has led to a flurry of shareholder proposal activity at several packaged food companies, restaurants, and grocers, including **The Kroger Co.**, **Mondelez International, Inc.**, and **Starbucks Corporation**. However, the attention is shifting upstream – to plastic producers themselves.

During the 2019 proxy season, proposals were submitted to some of the largest American petrochemical producers, including: **DowDuPont Inc.**, **Phillips 66**, **Chevron Corporation**, and **Exxon Mobil Corporation** requesting that the companies report annually on plastic pollution, with a focus on pellet (nurdle) loss prevention, cleanup, and containment. In response, Exxon and Chevron Phillips Chemical agreed to produce the requested reporting and the proposals were withdrawn. In contrast, the proposal submitted to DowDuPont went to vote. However, the targeting of this proposal was somewhat curious given that the company was undergoing a reorganization which would effectively spin-off its materials science division. Likely as a result of this spin-off, the proposal received paltry support. Still, the willingness of Chevron Phillips Chemical and Exxon to engage with the proponent and reach a resolution is powerful evidence that microplastics pollution is not merely a fringe issue.

A second proposal submitted to both Exxon and DowDuPont was focused on their exposure to climate risks. The proposals were rooted in the massive petrochemical expansion on the Gulf Coast and the region's vulnerability to powerful hurricanes, such as Hurricane Harvey in August 2017. Specifically, the proponent sought reporting on the climate change-induced flooding and public health risks related to these companies' petrochemical operations and investments. As previously discussed, the Gulf Coast is vulnerable to environmental risks, which may lead to chemical releases and health impact to surrounding communities. While the proposal at DowDuPont was poorly targeted considering the spin-off of its specialty plastics and packaging segment, it was entirely relevant to Exxon and its \$20 billion "Growing the Gulf" initiative. A considerable portion of the oil and gas giant's shareholders agreed, with a quarter of voting shares in support.

Shareholder proposals can often act as harbingers of issues that emerge as significant topics of engagement between companies and their shareholders. The proposals in 2019 were particularly interesting because they reflected not only the fomenting of public concern about plastic pollution, but also the ongoing concern regarding climate risk. Although lucrative in the short term, the pivot to plastics is concerning some investors as it could demonstrate that the climate and other environmental risks associated with oil and gas are not abated even if gasoline demand continues to decline.

REGULATION

Single-use plastics have been targeted by regulators around the world using a wide array of legally-binding instruments that include bans and restrictions, taxes and levies, and waste management measures to enhance disposal, encourage reuse and recycling, and promote alternatives to plastic products. Although regulatory efforts to address the global plastics issue are progressing at the international level, the political climate in the U.S. is stifling domestic regulation.

Single-Use Plastics

The first regulatory measures specifically targeting plastic bags were enacted in the early 2000s and as of July 2018, 127 countries have adopted legislation to regulate plastic bags. The most common form of regulation is a restriction on free retail distribution of plastic bags, which has been adopted by 83 countries, followed closely by manufacturing and import bans, which have been adopted by 61 countries. Other measures implemented at the national level include taxes on the manufacture and production of plastic bags, consumer surcharges, recycling targets, and extended producer responsibility requirements.¹⁸

Map 1 | Global Overview of Countries with Bans on the Manufacture, Free Distribution, and Importation of Plastic Bags

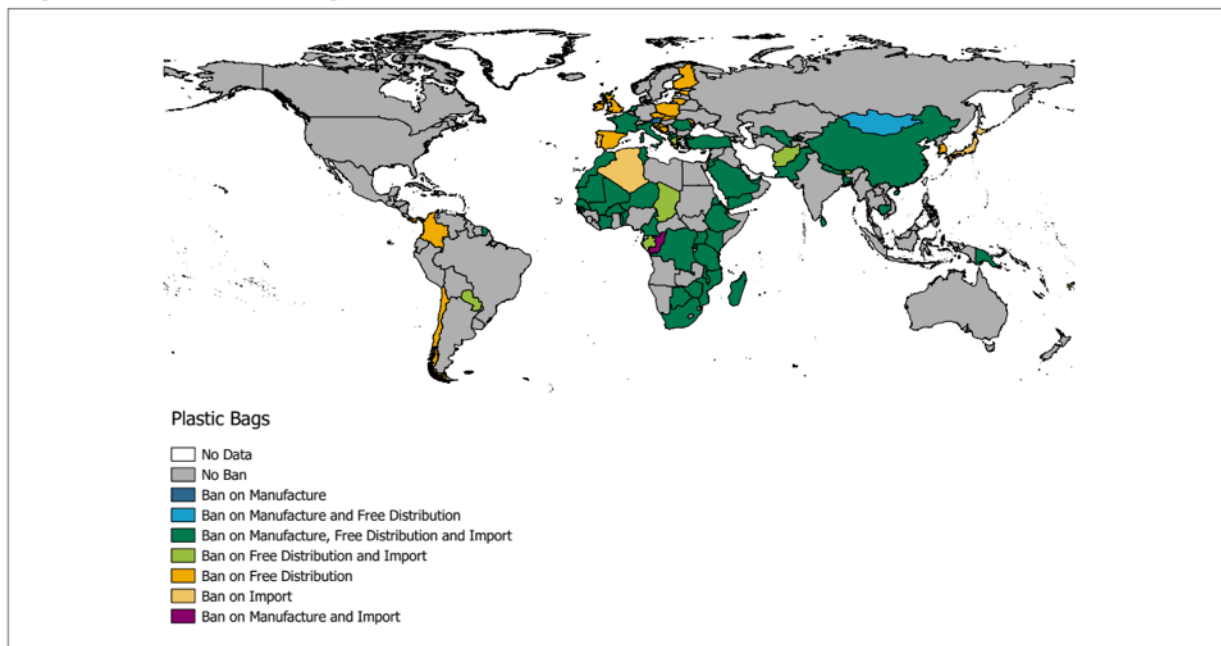


Figure 3: This map shows the global diversity of plastic bag bans. Image downloaded from https://wed-ocs.unep.org/bitstream/handle/20.500.11822/27113/plastics_limits.pdf?sequence=1&isAllowed=y in July 2019.

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of UNEP concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

¹⁸ "Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations." United Nations Environment Programme. Pages 3 and 10. December 2018.

Many countries have expanded regulatory efforts to address not only plastic bags, but other single-use plastics as well. Twenty-seven countries have enacted some type of ban on single-use plastics, either on specific products, materials, or production levels. Further, 29 countries have enacted some type of tax on single-use plastics and many others have recycling requirements and solid waste management laws which may either set targets for plastics or implicitly include single-use plastics under household or commercial waste.¹⁹

MAP 5 | Bans on Single-Use Plastics

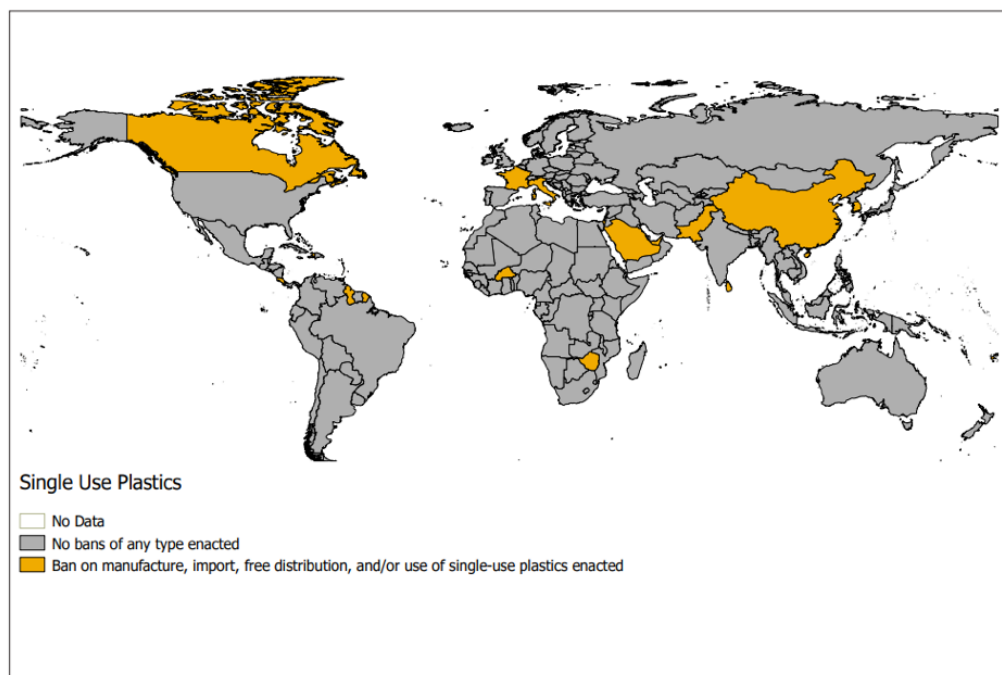


Figure 4: This map shows the global diversity of single-use plastics bans. Image downloaded from https://wedocs.unep.org/bitstream/handle/20.500.11822/27113/plastics_limits.pdf?sequence=1&isAllowed=y in September 2019

Disclaimer: The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of UNEP concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Microbeads

The public outcry in 2015 over microbeads, used in many cosmetic products to add grit, was a major catalyst for the current regulatory environment around plastic pollution. As of July 2018, eight out of 192 countries reviewed by the UN Environment Programme have banned microbeads through national laws or regulations; currently, the U.S. and UK are joined by Canada, France, Italy, Republic of Korea, New Zealand, Sweden, and Taiwan.²⁰

Following the global backlash, **Johnson & Johnson**, **L'Oreal S.A.**, and **The Procter & Gamble Company** announced plans to remove microbeads from their products, further reducing demand. Although biodegradable microbeads were quickly developed and marketed as potential replacements for their plastic counterparts, concerns remain about their long-term degradability in marine environments.

¹⁹ "Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations." United Nations Environment Programme. Page 10. December 2018.

²⁰ Ibid, page 11.

U.S. REGULATORY OVERVIEW

Federal

In the U.S., there are no federal restrictions on single-use plastics.

The U.S. has also stymied international efforts to confront the plastic pollution crisis. At a summit held in Nairobi, Kenya in March 2019, ministers of the United Nations Environmental Assembly (“UNEA”) agreed to “address the damage to our ecosystems caused by the unsustainable use and disposal of plastic products, including by significantly reducing single-use plastic products by 2030.” However, most nations, including the EU, backed a much stronger commitment to “phasing-out most problematic single-use plastic product by 2025.” Instead of focusing on the idea that the problem of plastic pollution in the oceans starts with the production and use of single-use plastic products, the U.S. echoed the plastics industry’s position (see “Plastics Industry Response” on page 17) that the issue is solvable exclusively by waste management. Ultimately, a few countries led by the U.S., including Saudi Arabia and Cuba, were instrumental in watering down the final text.

Nevertheless, in response to public interest, the U.S. federal government has taken some steps to address marine plastic waste domestically.

- Signed into law in 2006 and most recently amended in 2018, the Marine Debris Act requires the NOAA Marine Debris Program to “identify, determine sources of, assess, prevent, reduce, and remove marine debris and address the adverse impacts of marine debris on the economy of the United States, marine environment, and navigation safety.”
- The Save Our Seas Act of 2018 was signed in October 2018 and, among other things, amends and reauthorizes the Marine Debris Act for four years, promotes international action to reduce marine debris, and authorizes cleanup and response actions needed as a result of severe marine debris events, such as hurricanes or tsunamis. A new Save Our Seas Act 2.0 bill, introduced to the Senate in June 2019, would support research and recycling infrastructure.

State

In the absence of strong federal action to restrict single-use plastics, many states have sought to fill the regulatory void. In 2015, Hawaii was the first state to effectively achieve a statewide ban on non-biodegradable plastic bags at checkout through a series of county-level ordinances. A year later, California enacted the first statewide ban in 2016. In 2019, a handful of states followed California’s lead and passed similar bans that will take effect in either 2020 or 2021, including New York, Maine, Vermont, Oregon, and Delaware. Carveouts in the legislation are common to account for certain use cases where substitutes are sparse, including food packaging, newsprint, and trash collection. Some states have also passed legislation to limit other single-use plastic products, including polystyrene containers and plastic straws and utensils.

Single-Use Plastics: State-Level Bans

State	What is banned?	Status
California	Plastic straws must be requested by customers, fast-food restaurants exempted	Effective January 1, 2019
Maryland	Polystyrene containers	Effective July 1, 2020
Maine	Polystyrene containers	Effective January 1, 2021
New York	Polystyrene containers	Proposed
Hawaii	Polystyrene containers and plastic drink bottles, utensils, stirring sticks, bags, and straws	Pending in legislature
New Jersey	Polystyrene containers	Pending in legislature

Figure 5: This table details major statewide non-bag-related, passed, and pending bans on single-use plastics as of December 2019.

State-level legislative attempts to address plastic packaging waste have been impaired by fierce lobbying from the plastics industry. For example, in late 2018, a bill was introduced in Washington that was intended to hold all plastic packaging manufacturers responsible for the recycling of their products. However, representatives of approximately 20 companies and trade groups testified against the bill, including the American Institute for Packaging and the Environment, which is led by representatives of companies such as **Dow Inc.**, **Sonoco Products Co.**, and **Nestlé SA**. Unlike the original draft, the bill ultimately adopted in May 2019 merely funded a study of different approaches to recycling plastic packaging.

In California, two companion bills addressing plastic pollution in a novel way met a similar fate when they went to a vote at the end of the 2019 legislative session. The aim of the legislation was to require plastic manufacturers to ensure that their products are recyclable by 2030 or face having them banned. Following intensive lobbying by industry groups, California's legislative session ended without votes on the measures. However, they are expected to be brought to session again in 2020.

City and County

Many American cities and counties have also passed regulation to limit single-use plastics -- primarily plastic bags. As of June 2019, over 400 local ordinances related to plastic bags have been passed in 28 states, from Washington D.C. to Seattle, Washington.

However, state and local plastics regulation has been significantly hampered by preemption laws. These laws, passed by at least 14 states as of August 2019, prohibit municipalities from adopting local ordinances that further regulate a particular product, primarily bans or fees on plastic bags;²¹ see "Plastics Industry Response" on page 17 for further discussion.

CORPORATE RESPONSE

Coalitions

To address the global plastic pollution crisis, companies and governments have banded together to form a range of coalitions:

- Together with the World Business Council for Sustainable Development as a founding strategic partner, almost 40 companies that make, use, sell, process, collect, and recycle plastics have formed the Alliance to End Plastic Waste. The companies have committed more than \$1 billion, with the goal of investing \$1.5 billion over the next five years, to develop, deploy, and bring to scale solutions that will minimize and manage plastic waste and promote solutions for used plastics, including reuse, recovery, and recycling plastic to keep it out of the environment. However, the industry coalition has been criticized for the scale of its pledge; critics maintain that it is more of a symbolic gesture given the scale of the plastic pollution crisis and the roughly \$200 billion recent and announced investment in the petrochemical industry.
- In May 2018, the American Chemistry Council's Plastics Division announced three goals related to capturing, recycling, and recovering plastics:
 - ◇ 100% of plastics packaging is re-used, recycled or recovered by 2040;
 - ◇ 100% of plastics packaging is recyclable or recoverable by 2030; and
 - ◇ 100% of the U.S. manufacturing sites operated by ACC's Plastics Division members will participate in Operation Clean Sweep-Blue by 2020, with all of their manufacturing sites across North America involved by 2022.

²¹ "Preemption Laws." Plasticbaglaws.org.

- The American Chemistry Council's [Operation Clean Sweep-Blue](#) is a special member level for excellent members within the industry group's [Operation Clean Sweep](#) ("OCS") program. OCS was created in 1991 and has a goal "to help every plastic resin handling operation implement good housekeeping and pellet, flake, and powder containment practices to work towards achieving zero pellet, flake, and powder loss." OCS notes that "these efforts can also help improve relations with stakeholder groups and community organizations that expect the industry to minimize its environmental footprint." A number of major plastic producers have become OCS partners in the U.S., including **BASF SE**, **Exxon Mobil Corporation**, **Novolex**, **Saudi Basic Industries Corp.**, and **Royal Dutch Shell plc**.
- In collaboration with UN Environment, the Ellen MacArthur Foundation's [New Plastics Economy Global Commitment](#) launched in October 2018 to unite organizations behind a common vision and a set of 2025 targets to address the plastic waste and pollution crisis. The Global Commitment has amassed over 400 signatories, including companies representing 20% of all plastic packaging produced globally. Signatories also include 16 governments across five countries, 26 financial institutions with a combined \$4.2 trillion AUM, and more than 50 academics, universities, and other educational or research organizations.²² All corporate and government signatories have signed up to the 2025 targets, which are tailored for each signatory type, and will report on their progress annually.

CORPORATE ACTION

Some of the most prominent corporate commitments made to address the plastic pollution crisis are rooted in the New Plastics Economy Global Commitment and its 2025 goals. For example, in April 2018, **Nestlé SA** [pledged](#) to make all of its plastic packaging 100% recyclable or reusable by 2025. It followed up on its commitment in January 2019 by [announcing](#) tangible steps to meet these goals, giving specific timelines for implementing more sustainable packaging alternatives for its products and undertaking several collaborative efforts specific to plastics. Similarly, **Unilever NV** [committed](#) in January 2017 to ensuring that all of its plastic packaging is fully reusable, recyclable, or compostable by 2025. In April 2019, it [announced](#) that half of its plastic used in its North American packaging would come from post-consumer recycled content by the end of 2019. Some U.S. beverage companies have also taken action in response to this issue. For example, in January 2018, **The Coca-Cola Company** [announced](#) goals to help collect and recycle the equivalent of every bottle it sells globally by 2030 and make its packaging 100% recyclable by 2025. **PepsiCo, Inc.** has also taken action. In 2016, it [announced](#) 2025 goals to strive to design 100% of its packaging to be recyclable, compostable or biodegradable; to increase its use of recycled materials; and to reduce the carbon impact of its packaging and to work to increase recycling rates. In October 2018, PepsiCo expanded on goals by announcing that it would strive to use 25% recycled content in its plastic packaging by 2025.

Food service companies have also taken action to reduce their plastics footprint; in the last few years, three of the largest food service companies have announced similar commitments. In May 2018, Bon Appétit Management became the first American food service company, or major restaurant company, to [ban](#) plastic straws and stirrers. The phase out was scheduled to be completed by September 2019. In July 2018, **Aramark** [committed](#) to significantly reducing single-use disposable plastics globally by 2022. Notably, part of its reduction strategy includes phasing out plastic straws and stirrers from September 2018, resulting in a 60% decrease in plastic straws by 2020. A few months later, **Sodexo S.A.** followed its industry peers by [announcing](#) a plan to eliminate single use plastic bags and stirrers by 2019, polystyrene foam items by 2025, and shift straws to a "by request" system by 2019.

Fast food companies and franchises have also taken action. **McDonald's Corporation** [announced](#) in January 2018 that by 2025, all of its guest packaging will come from renewable or recycled sources. It also set a goal to recycle guest packaging in all of its restaurants. In July 2018, **Starbucks Corporation** [announced](#) that it would

²² "New Plastics Economy Global Commitment: June 2019 Report." The Ellen MacArthur Foundation. June 17, 2019.

eliminate single-use plastic straws and instead implement a strawless lid or provide an alternative-material straw on request. Internationally, a number of [fast food chains](#) have taken similar actions, especially in advance of the EU's broad plastic waste ban [coming into force](#) in 2021.

According to the Ellen MacArthur Foundation's June 2019 report, 123 signatories of the Global Commitment in the packaged goods, retail, and packaging production sectors, have committed to making all their plastic packaging reusable, recyclable, or compostable by 2025.²³

Consumer goods companies and fast food companies are responsible for a considerable slice of the plastic pollution crisis. Nevertheless, firms in other industries are also taking action to address their exposure to the growing plastic pollution crisis, which primarily stems from the use of packaging.²⁴ For example, theme parks, hotel chains, airlines, and cruise lines [are also taking steps](#) to ban or significantly reduce single-use plastics:

- **Norwegian Cruise Line Holdings Ltd.** eliminated plastic straws across its fleet in 2018 and eliminated single-use plastic bottles on its ships at the turn of 2020.
- **Marriott International, Inc.** expects most of its hotels to switch from single-use toiletry bottles of shampoo, conditioner, and bath gel to larger, pump-topped bottles by December 2020. **Hyatt Hotels Corporation** has made a similar commitment, and expects it to be fulfilled worldwide no later than June 2021.
- Since September 1, 2018, plastic straws and drink picks have been available only by request at all Hyatt hotels. Similarly, Marriott removed disposable plastic straws and stirrers at all of its properties by July 2019 and **Hilton Worldwide Holdings Inc.** removed plastic straws from its managed properties in 2018.
- **United Airlines Holdings, Inc.** began eliminating non-recyclable plastic stirring sticks and cocktail picks on its aircraft in November 2018.
- In July 2018, **American Airlines Group Inc.** began eliminating plastic straws from its lounges and transitioning to “eco-friendly flatware” within lounges. In November 2018, it began to phase out plastic straw/stir sticks on its aircraft.
- **Delta Air Lines, Inc.** began replacing plastic straws and stir sticks in its lounges in 2018. These efforts would extend in aircraft in mid-2019.
- **SeaWorld Entertainment, Inc.** removed all single-use plastic drinking straws and single-use plastic shopping bags from all 12 of its theme parks in June 2018.

Bottlenecked

To meet the demand for these corporate commitments, Wood Mackenzie [predicts](#) that up to \$3 billion in capital investment would be required in the next decade (see “On the Horizon” on page 23). Specifically, the estimate is focused on recyclable bottles made from recycled PET, or “RPET.” The research firm recognizes that there is a “huge gap” between the announced corporate sustainability goals and the current state of the RPET market in the U.S.

²³ “New Plastics Economy Global Commitment: June 2019 Report.” The Ellen MacArthur Foundation. Page 11. June 17, 2019.

²⁴ Hannah Ritchie, Max Roser. “Plastic Pollution (Plastic Waste by Sector).” Our World in Data. 2019.

PLASTICS INDUSTRY RESPONSE

While a broad swath of companies has responded to the plastics pollution crisis by committing to significant recycling and reduction goals, the petrochemicals industry stands in opposition to the regulatory momentum.

With regard to single-use plastic restrictions, the industry has attempted to highlight the overall GHG emissions associated with alternatives; and has argued that bans could be counterproductive based on usage and disposal practices. As discussed under “State” and “City and County,” industry lobbying has pushed back on state-level regulation, and bodies such as the Plastics Industry Association and American Chemical Council have been active in pushing for preemption laws, which prohibit municipalities from adopting local ordinances that further regulate a particular product, primarily bans or fees on plastic bags.²⁵

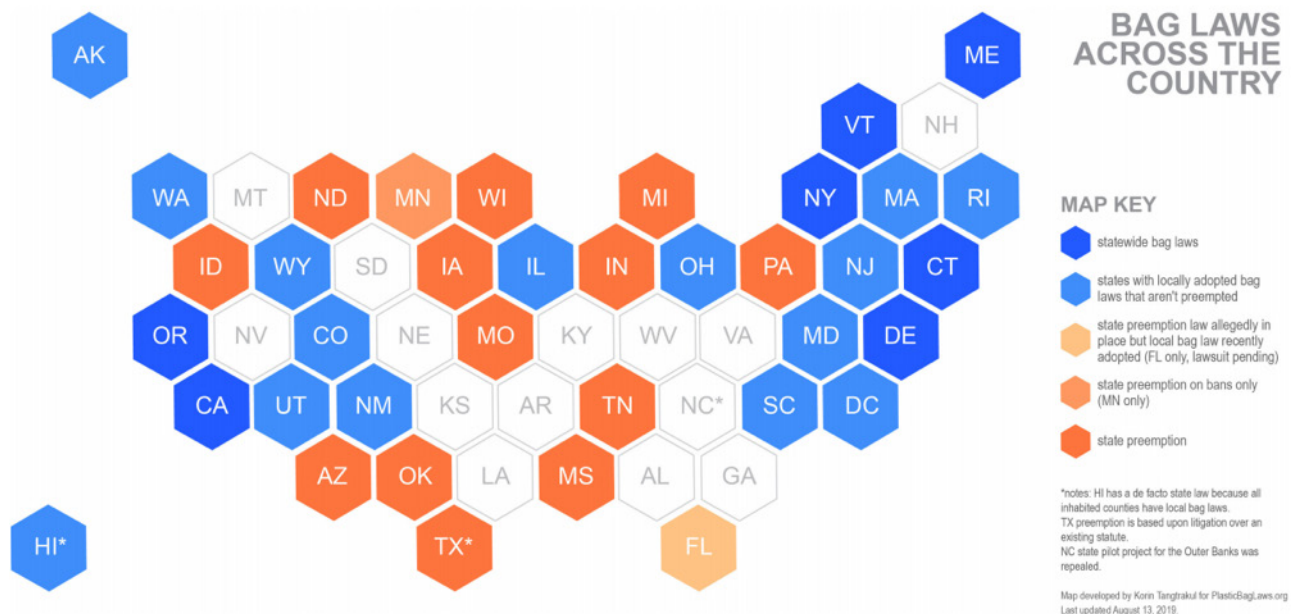


Figure 6: This map shows the U.S. distribution of statewide plastic bag bans (blue) and ban preemptions (orange). Image downloaded from https://static1.squarespace.com/static/59bd5150e45a7caf6bee56f8/t/5d64153c6598d5000117cb52/1566840127794/PBL_+August+Bag+Laws+%281%29.pdf in September 2019

This position has caused a strain, particularly for consumer-facing companies. In the past few years, environmental groups have pressured multiple companies into leaving the Plastics Industry Association and defending the democratic right for governments to effect bans. Notable departures in 2018-2019 include **The Clorox Company; Becton, Dickinson and Company; Ecolab Inc., Coca-Cola Company; PepsiCo, Inc.; General Motors Co.,** and S.C. Johnson. While companies are frequently pressured to leave trade associations when their policy positions differ, it is relatively rare to see such major departures based on environmental issues.

More broadly, the industry has attempted to steer the plastics pollution conversation—and related legislative agenda—to focus on the need to build and improve American recycling infrastructure. For example, the Realizing the Economic Opportunities and Values of Expanding Recycling Act, proposed in November 2019 and supported by a range of plastics companies and industry associations, would set aside \$500 million in federal matching funds for states, local governments, and tribes to invest in recycling infrastructure.

²⁵ "Life Cycle Impacts of Plastic Packaging Compared to Substitutes in the United States and Canada." Franklin Associates, a Division of Eastern Research Group ("ERG"). April 2018.

Supply & Demand

FOSSIL FUEL FEEDSTOCK

Plastics are primarily petrochemicals produced from natural gas, feedstocks derived from natural gas processing, and feedstocks derived from crude oil refining. In fact, over 99% of plastics are produced from chemicals sourced from fossil fuels. Just five kinds of plastic comprise over 90% (by weight) of all plastic produced; ethylene is used to make four of these plastics - polyethylene, polyvinyl chloride (“PVC”), polyethylene terephthalate (“PET”), and polystyrene. Thus, 65% of global plastic production (by weight) depends on **ethylene** as a critical feedstock.

Ethylene is almost entirely manufactured through steam cracking gaseous feedstocks, such as **ethane**, or liquid feedstocks, such as **naphtha**, a produce of crude oil refining. In the U.S., nearly 90% of ethylene is sourced from **natural gas liquids** (“NGL”), due largely to the domestic natural gas boom. Although this has driven down the price of NGL, it is difficult to transport, so it is generally more lucrative to produce ethylene near the source compared to trading NGL overseas. Ethylene production in the Middle East is also relatively dependent on NGL.

However, in China, Europe, Southeast Asia, and Japan, ethylene is primarily made from naphtha, a product of crude oil refining. As a result, plastic production accounts for roughly 4-8% of global oil consumption. Unlike NGL, naphtha is easily transported, so nearly 30% is traded internationally.²⁶

Naphtha and ethane differ in two significant ways as ethylene feedstock. First, emissions from steam cracking tend to be higher when naphtha is used as a feedstock instead of ethane; according to one estimate, naphtha cracking generates 73% more CO₂ per unit of ethylene than ethane cracking. Naphtha and ethane also have different geographic tendencies; most ethylene crackers in the U.S. and the Middle East use ethane as the primary feedstock, whereas those in Western Europe, Japan, and China use naphtha.²⁷

The steam cracking process runs at very high temperatures and while ethylene is the intended product, other valuable molecules are coproduced, including propylene, butadiene, and benzene.²⁸ Propylene is a particularly valuable coproduct for plastic production, as it is the building block for polypropylene.

²⁶ “Fossils, Plastics, & Petrochemical Feedstocks,” Center for International Environmental Law. Page 2. September 21, 2017.

²⁷ Center for International Environmental Law. “Plastic & Climate: The Hidden Costs of a Plastic Planet.” Page 46. May 2019.

²⁸ Jeffrey S. Plotkin. “Beyond the Ethylene Steam Cracker.” American Chemistry Society. October 17, 2016.

SHALE GAS GROWTH

In the United States, the swelling plastic production industry is inextricably linked to the shale gas boom of the 2010s. As cheap domestic natural gas has flooded the market, ethylene production has become more cost-effective, inviting investment²⁹ According to the American Chemistry Council (“ACC”), total cumulative announced chemical industry investments from shale gas have surpassed \$200 billion.

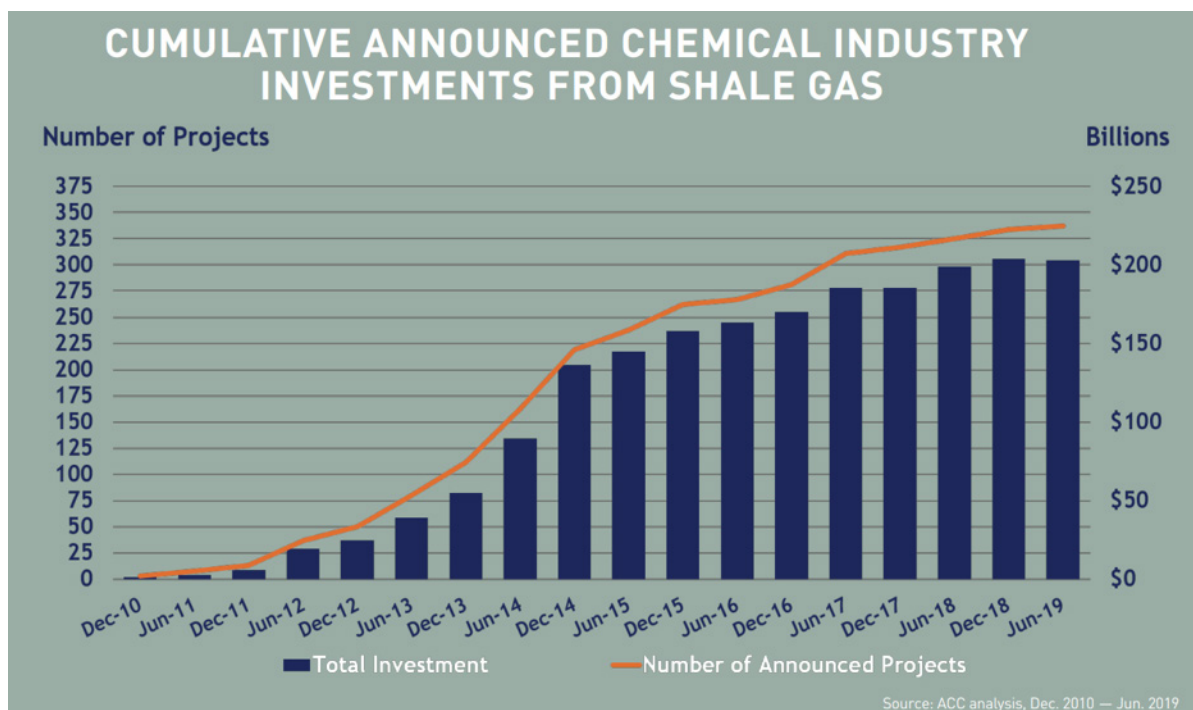


Figure 7: Image downloaded from <https://www.americanchemistry.com/ACC-US-Chem-Energy-Infographic/> in September 2019

By and large, the epicenter of domestic chemical investments linked to shale gas has been the Gulf of Mexico, mostly coastal Texas and Louisiana. As of July 2019, **Exxon Mobil Corporation**, **Dow Inc.**, France’s **Total SA**, South Africa’s **Sasol Ltd.**, and **Saudi Basic Industries Corp.** (“**SABIC**”), have built or announced at least \$40 billion in new petrochemical facilities in the two states. More than 20 U.S. cracker projects have been proposed over the last decade, while a handful have come online over the last few years. By the end of 2019, five new crackers will begin operation in the Gulf. Two more crackers are scheduled to begin production over the next two years, while several plastics plants are also expected to come online in the next few years.

- Sasol’s Lake Charles Chemicals Project is the largest project in the region to date. In February 2019, the plant’s linear low-density polyethylene (“LLDPE”) unit was commissioned, with an integrated ethane cracker and downstream derivatives complex following suit in June. Projected total costs have been revised upwards multiple times since the original \$5-\$7 billion estimate in 2012, reaching \$12.6-\$12.9 billion in May 2019.
- Gulf Coast Growth Ventures, an Exxon and SABIC joint venture, will include the world’s largest ethane steam cracker, two polyethylene units, and a monoethylene glycol unit. The project is projected to cost \$10 billion and startup is expected by 2022.

²⁹ “Fueling Plastics: How Fracked Gas, Cheap Oil, and Unburnable Coal are Driving the Plastics Boom.” Center for International Environmental Law. Page 3. September 2017.

- Exxon is also investing \$2 billion into expanding its Baytown, Texas chemical plant. One of the outcomes of the project will be Exxon's entry into the linear alpha olefins market, which will further extend its reach into the polyethylene plastic packaging market. The investments make up part of a broader \$20 billion program to expand the company's manufacturing facilities on the Gulf Coast.
- In July 2019, Chevron Phillips Chemical and Qatar Petroleum announced plans to develop an \$8 billion petrochemical plant on the Gulf Coast. The plant will focus on hard plastics production and will include an ethylene cracker and two polyethylene units. A final investment decision is slated for no later than 2021, with targeted startup in 2024.

There is also investment activity in other U.S. natural gas hubs. For example, Royal Dutch Shell plc's Beaver County, Pennsylvania petrochemicals complex is one of the largest active construction projects in the United States and is expected to open in the early 2020s. North Dakota is also eyeing investments in petrochemical infrastructure to further capitalize on its NGL-rich Bakken Formation.

Aftershocks

The growth in upstream ethane-cracking infrastructure has outpaced the midstream infrastructure to provide ethane. While some ethane can be supplied by drilling, the rest must be fractionated from NGL by midstream companies. Only about half of the consumption capacity of the crackers that came online since 2017 will be satisfied by new fractionators starting up in 2019. As such, IHS Markit predicts that ethane supply will be limited at least through early 2020 and possibly later.

Because new crackers are designed to take ethane only, limited ethane supplies will likely require flexible-feed crackers to favor propane over ethane. Given that propane cracking produces roughly 10 times as much propylene as ethane cracking, the increased propane supply could lead to increased propylene supply and polypropylene production.

Further, relying on cheap shale gas means that producers inexorably depend on its market economics. Since oil prices began to decline steeply in 2014, U.S. oil and gas companies have vastly underperformed the S&P 500. As the law of diminishing returns plays out, share prices of shale companies are declining and capital is becoming more expensive.

The shale gas boom has also spurred significant investments in plastic and feedstock production abroad, including construction of the first new cracker in Europe for two decades as part of a €2.7 billion project by Ineos, a British chemical company that has spent billions bringing U.S. shale gas to Europe.

In China, Lianyungang Petrochemical Co. ("LPCL") is working on a project linked to U.S. natural gas that will result in the country's first 100% ethane cracker. In addition, the project will also include separate units for plastics production, including polyethylene and styrene.

OTHER INTERNATIONAL INVESTMENT

Regions surfeit with local natural gas resources are investing in infrastructure without any direct ties to the U.S. shale gas market.

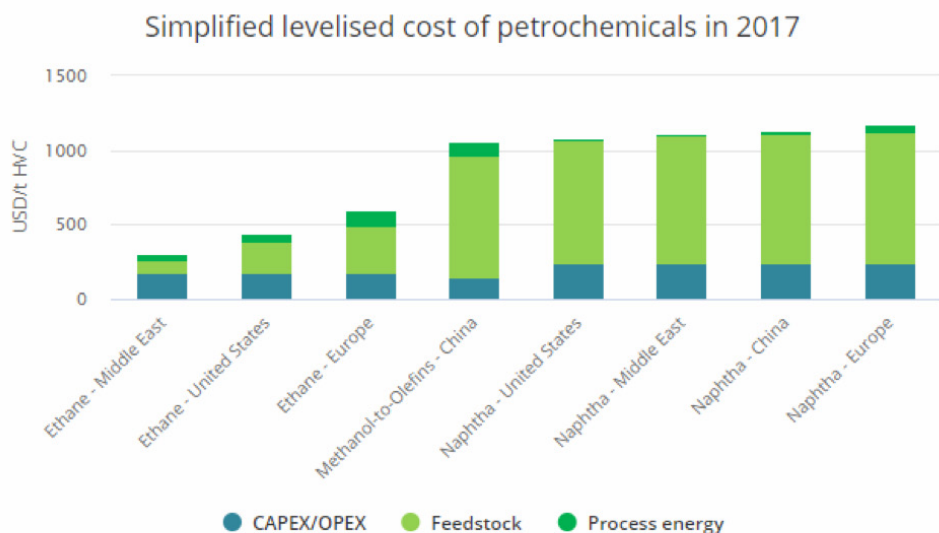
In June 2019, Chevron Phillips Chemical and Qatar Petroleum announced the signing of an agreement to pursue the development, construction, and operation of a petrochemicals complex in Qatar to produce ethylene and high-density polyethylene (“HDPE”). According to the announcement, start-up is slated for late 2025. The plant will include the Middle East’s largest ethylene production facility. The venture has been estimated to cost billions, but a more precise estimate is pending the completion of engineering studies.

Houston-headquartered LyondellBasell also recently formed a joint venture with China’s Liaoning Bora Enterprise Group to build a \$2.5 billion petrochemical and plastics complex in northeast China. The JV could invest up to \$12 billion over 10 years through additional phases, according to the companies. The complex, which will include an ethylene cracker, will manufacture polyethylene, polypropylene, and styrene, among other common co-products.

LESS OIL, MORE PLASTICS

The enormous uptick in plastics and plastics feedstock production owes much to the shale gas boom in the U.S., which has led to a glut of NGL supply and thus a significant amount of cheap ethane to produce ethylene. However, ethylene can also be made from naphtha, a product of crude oil refining.

Approximately two-thirds of the cost of ethylene, the main plastics feedstock, is the cost of the energy inputs required for its production. Accordingly, the relative cost of gas (for ethane) compared to oil (for naphtha) correlates to whether each of the two resources is favored for ethylene production. Since the U.S. shale gas boom, new cracker projects have generally been designed to only process NGL. Overseas, naphtha crackers are much more common, especially in Asia.³⁰



IEA. All rights reserved.

Figure 8: This chart demonstrates the cost difference between the most common plastic feedstock chemicals. Image downloaded from <https://www.iea.org/petrochemicals/> in July 2019. IEA (2019), ‘The Future of Petrochemicals’, <https://www.iea.org/petrochemicals/>. All rights reserved.

30 “Fueling Plastics: How Fracked Gas, Cheap Oil, and Unburnable Coal are Driving the Plastics Boom.” Center for International Environmental Law. Page 2. September 2017.

The market for crude oil will change in the next few decades; fuel economy, rising public transport, alternative fuels, and electrification, will continue to shape the dominant sources of oil demand. As a result, petrochemicals are forecast to account for more than a third of the growth in oil demand to 2030, and almost half to 2050. According to these International Energy Agency (“IEA”) estimates, petrochemicals would thus account for a greater share of oil demand than trucks, aviation, and shipping.³¹

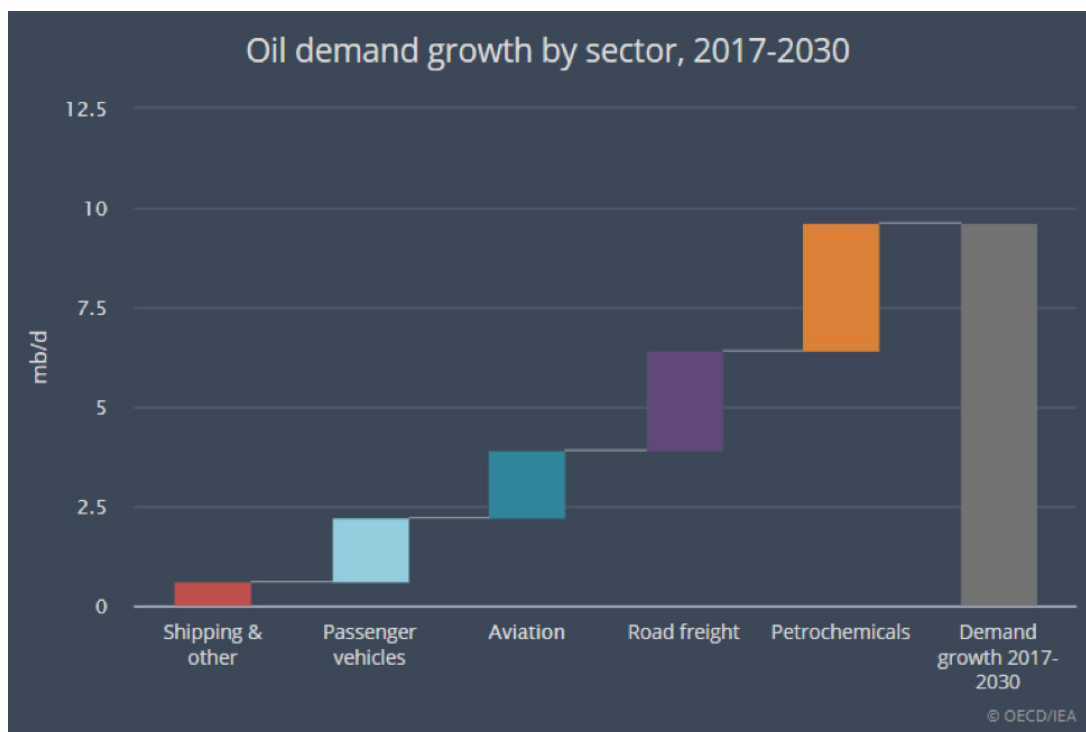


Figure 9: This chart demonstrates oil demand growth by sector for the period 2017-2030. Image downloaded from <https://www.iea.org/petrochemicals/> in September 2019. IEA (2019), ‘The Future of Petrochemicals’, <https://www.iea.org/petrochemicals/>. All rights reserved.

Cheap inputs alone only tell part of the story for why the petrochemicals industry has demonstrated such enormous growth. The other main factor is rising demand for plastics, which has nearly doubled since 2000 outpacing steel, aluminum, and cement. Growth in demand is set to continue—as citizens in developing countries enjoy longer lifespans and increasing living standards, they are more likely to consume more plastic products.

CRUDE-TO-CHEMICALS

As the growth of gasoline demand slows, oil companies are becoming increasingly integrated in petrochemical markets. While the technology has room to evolve, new, direct crude-to-chemicals processing may give crude oil a renewed permanence in years to come. Similarly, coal-to-chemicals processing may also give coal a stronger foothold in regions where it is still common, such as China.³²

According to the IEA, the direct crude-to-chemicals route “may soon come to challenge the current model of upstream integration.” Whereas chemicals production has typically followed from a synergistic relationship with crude oil refining (feeding naphtha directly into an adjacent steam cracker, for example), some refineries

³¹ “The Future of Petrochemicals.” International Energy Agency. Page 11. October 5, 2018.

³² “The Future of Petrochemicals.” International Energy Agency. Pages 12 and 33. October 5, 2018.

are starting to prioritize chemical production over oil derivatives such as gasoline and diesel. According to IHS Markit, refineries that are solely focused on petrochemical production may output 5-10 times more yield compared to those that produce petrochemicals as a byproduct of crude oil refining.³³

- Saudi Aramco (the world's largest oil producer) and SABIC (the world's fourth-largest petrochemicals firm, now majority-owned by Aramco) are collaborating to produce chemicals from crude oil on a refinery scale. Whereas refineries generally convert 5-20% of incoming oil into petrochemicals, roughly 45% of the output at the planned facility will be chemicals, including the building blocks for plastics. Total ethylene output alone from the facility matches a quarter of the total capacity installations underway in the Gulf Coast.
- Aramco is also planning to invest \$15 billion in an Indian oil-to-chemicals unit and supply Arabian crude to the unit on a long-term basis. The refinery is reportedly the largest and most complex refinery in the world, and the investment would be one of the largest foreign investments ever made in India.
- In China, Zhejiang Petrochemical is building a crude-to-chemicals complex which will double the petrochemical output of the Aramco complex. Meanwhile, Exxon has been processing crude oil directly into chemicals in Singapore since 2014, and the company has plans to build a similar unit in China.

Looking ahead to 2030, McKinsey predicts that slower demand growth in emerging economies and less abundant cheap feedstocks will likely drive companies to focus more analytics and productivity and manage the transition to a circular economy. McKinsey refers to cheap feedstock such as NGL from North American shale formations as “advantaged” and predicts that fewer “truly advantaged investments will take place from 2020-2025. Ethylene cracker investments based on liquid feedstocks, including naphtha, will be relied upon to meet demand growth.”³⁴

ON THE HORIZON

Bioplastics

Sustainable alternatives to plastic are also being explored, many of which fall under the common family of bioplastics. These materials have attracted interest as an alternative to plastics derived from fossil fuels; however, their relative sustainability remains contested.

Bio-based raw materials, such as waste and residue oils, are one plastics feedstock which is just on the cusp of going mainstream. In June 2019, plastics, chemicals, and refining company **LyondellBasell Industries N.V.** and **Neste Corporation**, a producer of renewable diesel from waste and residues, announced the first parallel production of bio-based polypropylene and bio-based low-density polyethylene at a commercial scale. The outputs have been approved for the production of food packaging and are marketed under LyondellBasell's group of circular economy product brands.

On the consumer side, several companies have started to introduce products made using bioplastics, but the pace has been slow. Lego, the world's largest toy maker, pledged to find and start using sustainable alternatives to its raw materials by 2030. However, currently, just 2% of its products are made from plant-based plas-

³³ Alexander H. Tullo. “Why the Future of Oil Is in Chemicals, Not Fuels.” Chemical and Engineering News. Volume 97, Issue 8. February 20, 2019.

³⁴ Eren Cetinkaya, Nathan Liu, Theo Jan Simons, Jeremy Wallach. “Petrochemicals 2030: Reinventing the Way to Win in a Changing Industry.” McKinsey & Company. February 2018.

tic due to engineering difficulties. Meanwhile, IKEA has introduced a plant-based plastic freezer bag. In 2013, Coca-Cola promised that all its plastic bottles would include plant-based material by 2020, but later retreated, citing “resource constraints.”

Although bioplastics have been around for decades, they represent only 1% of annual plastic production. The European Bioplastics association, an industry group, cites R&D costs and misconceptions about environmental benefits as hurdles that the industry has to face.

These “misconceptions” have driven governments and academia [to examine](#) the costs and benefits of bioplastics. For example, researchers at the University of Bonn have found that conversion of managed forests, which act as valuable carbon sinks, into cropland to produce sugar- and starch-based feedstock could lead to an overall rise in GHG emissions. Accordingly, they encourage research into advanced technologies that do not rely on crops that compete with food and feed uses, and endorse regulatory measures that prioritize recycling efforts over biodegradability.

Meanwhile, the UK government recently [sought](#) evidence to help it develop standards for biodegradable, compostable, and bio-based plastics, and an understanding of their environmental impacts. The review reflects uncertainty about the materials’ sustainability compared to petrochemicals.

Further, not all [bioplastics](#) are biodegradable, even though they are typically derived from plants. Bio-based, non-biodegradable plastics currently make up for around 50% of the global bioplastics production capacities. Although bioplastics are currently being used in many sectors, packaging remains the sector in which bioplastics have the strongest foothold; packaging accounted for almost 65% of the total bioplastics market in 2016.

Chemical Recycling

The well-established and often-profitable practice of mechanical recycling generally breaks down plastic waste into polymers, the building blocks of most plastics, and less commonly, into monomers, an even more fundamental feedstock. Chemical recycling, through processes such as pyrolysis (which is similar to cracking) can provide a technically feasible route to reprocess waste into feedstocks that could displace naphtha or NGL demand, which is referred to as chemical recycling. According to McKinsey, this could be economically viable and more resistant to lower oil prices. Pyrolysis also offers a recycling solution for multiple polymer streams (i.e. mixed materials), which mechanical technologies currently cannot handle.³⁵

Chemical recycling on an industrial scale is still in its infancy, but [there are exceptions](#). One notable example in the U.S. is BP’s planned \$25 million pilot plant in Naperville, Illinois. At the plant, the company aims to employ its own technology to divert unrecyclable PET, which would have otherwise gone to landfills or been incinerated. The plant is [scheduled to open](#) in late 2020. Also in the U.S., Americas Styrenics, a Chevron Phillips Chemical and Trinseo LLC joint venture, has partnered with Agilyx to chemically recycle polystyrene that would have otherwise gone to waste. In Germany, **Henkel AG & Co. KGaA**, **BASF SE**, and Alpla are collaborating on a chemical recycling project which began producing chemically-recycled bottles of Perwoll in October 2019, while **LyondellBasell Industries N.V.** is partnering with Karlsruhe Institute of Technology to test chemical recycling. In the Netherlands, **Saudi Basic Industries Corp.** is also planning to open a plant to convert mixed plastic waste into original feedstock in 2021.

These new recycling technologies may be a boon for companies that have set ambitious recycling goals, in addition to California and the EU in meeting their 2030 recyclable beverage container targets. In fact, the attainment of these goals [may not even be feasible](#) with current mechanical recycling technologies alone. According to Closed Loop Partners, an investment firm focused on building the circular economy, the [amount of](#)

³⁵ Thomas Hundertmark, Mirjam Mayer, Chris McNally, Theo Jan Simons, Christof Witte. “How Plastics Waste Recycling Could Transform the Chemical Industry.” McKinsey & Company. December 2018.

recycled plastic that is generated in North America is 1/15 of current demand.

These oncoming technologies could even be so lucrative that they suppress oil demand as recycled feedstock replaces its virgin precursor. McKinsey projects that demand growth for chemicals production might only be a quarter of that suggested by recent oil-industry demand forecasts. According to the research firm:

While increased recycling of plastics represents a gain in circular-economy terms, it is less good news for oil-resource-holding countries and oil companies, which will lose part of a source of future demand growth and could even depress oil pricing.

According to this projection, almost 60% of plastics demand is covered using recovered plastics as raw material by 2050, corresponding to oil demand that is 30% lower than a business-as-usual scenario. This clashes with the IEA's view that declining oil demand, primarily caused by the electrification of the transportation sector, will be offset by growing demand for virgin plastics.³⁶ While the projection is quite bullish on both mechanical and chemical recycling technologies, it nevertheless raises a fascinating point. Because oil majors are publishing carbon risk reports that are heavily dependent on IEA data, the resulting oil demand projections may be predicated on a deceptively sanguine forecast of plastics recycling over the next few decades.

³⁶ Thomas Hundertmark, Mirjam Mayer, Chris McNally, Theo Jan Simons, Christof Witte. "How Plastics Waste Recycling Could Transform the Chemical Industry." McKinsey & Company. December 2018.

Conclusion

The plastics industry is in a critical phase – whether from the perspective of the public troubled by the plastic pollution crisis, regulators reflecting the demands of their constituencies and banning single-use plastics, or investors concerned about regulatory, reputational, and environmental risks.

While documentaries, photographs, and viral video clips have helped make marine plastic pollution one of the top environmental issues of the last few years, there are less visible impacts worthy of investor concern for years to come. For example, companies are making huge investments on the American Gulf Coast that are wholly dependent on the region's shale gas supply, leaving them vulnerable to anti-fracking sentiment and American natural gas pricing. Plastic production also offers a buffer against declining fossil fuel prices as the world progressively moves towards a low-carbon economy. As such, oil and gas companies will likely face increasing investor pressure over the role that expanding plastic production will play in the achievement of climate commitments.

Further, although future recycling technologies and bio-based plastics offer a tantalizing potential pathway towards achieving a true circular economy for plastics, there are still many unanswered questions about their industrial-scale viability and, in the case of bio-based plastics, actual environmental sustainability impacts from converting plants into plastics.

Meanwhile, in the most tangible consequence of the growing public awareness about the plastic pollution crisis, regulators and companies are banning or significantly reducing the sale of single-use plastics en masse.

These issues serve as a warning to companies and investors that have yet to address their exposure — and signal the arrival of plastics as a legitimate source of ESG risk.

Glossary

Since 1907, when the first modern petrochemical-derived plastic (bakelite) was created, a [wide variety of different plastics](#) have been created, encompassing a similarly wide range of applications.

Polyethylene Terephthalate (“PET” or “PETE”) is used to make carbonated beverage containers, heatable pre-prepared food trays, heatable film, clothing and carpet fibers, bottles, food containers, strapping, and engineering plastics for precision molded parts. More than half of the world’s synthetic fiber is made from PET, which is typically referred to as “polyester.” PET is [completely recyclable](#); its U.S. recycling rate is roughly 31%, while its European recycling rate is 52%. PET accounts for 10.2% of plastic produced.

High Density Polyethylene (“HDPE”) is used in a range of packaging applications. In film form, HDPE is used in snack food packages and cereal box liners. In blow-molded bottle form, it is used to make milk and non-carbonated beverage bottles. In injection-molded tub form, it is used to make packages for margarine, whipped toppings, and deli foods. It is also used to package household and industrial chemicals including detergents, bleach, and acids. Other HDPE applications include injection-molded beverage cases, bread trays, and films for grocery sacks.

Low Density Polyethylene (“LDPE”) is used to manufacture flexible films, including dry cleaned garment bags and produce bags, as well as some flexible lids and bottles. It is also widely used in wire and cable applications. Altogether, polyethylene accounts for 36.3% of plastic produced.

Polyvinyl Chloride (“PVC”) is used to create both rigid and flexible materials. Rigid materials made from PVC are mostly used for construction, including pipe and fittings, siding, flooring, and windows. Flexible vinyl is used in wire and cable sheathing, insulation, film and sheet, flexible floor coverings, synthetic leather products, coatings, blood bags, and medical tubing. PVC accounts for 11.8% of plastic produced.

Polypropylene (“PP”) is found in flexible and rigid packaging, fibers for fabrics and carpets, and large molded parts for automotive and consumer products. Applications include ketchup bottles, yogurt containers, medicine bottles, pancake syrup bottles, and automobile battery casings. PP accounts for 21% of plastic produced.

Polystyrene (“PS”) can be either rigid or foamed. Its general-purpose form is clear, hard, and brittle, making it suitable for medical and food packaging, laboratory ware, and certain electronic uses. Expandable Polystyrene (“EPS”) is extruded into sheet for thermoforming into trays and egg crates and is directly formed into cups and tubs for dry foods. PS is most commonly known by Dupont’s Styrofoam™ product. PS accounts for 7.6% of plastic produced.

Source: “[Plastic & Climate: The Hidden Costs of a Plastic Planet.](#)” Center for International Environmental Law. Page 22. May 2019.

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