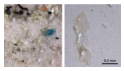
Plastic Waste

Due to the design potential, diversity, flexibility, low cost, and durability of plastics, their global use now exceeds most other man-made materials in nearly all industrial sectors. Plastics have made possible many technological advances and a tremendous array of products, creating numerous societal benefits. The high performance-to-weight ratio of plastics relative to alternative materials has reduced environmental footprints across the life cycle of several key sectors including transportation and food delivery. Despite the material value plastics hold, plastics often end up landfilled at end of life (EOL) and are a major source of marine litter. Plastics leakage out of the economy is due to the low cost of virgin plastic feedstocks and the challenges that come with recycling combinations of different plastic resins, plastics with additives, and contaminated plastics. Thus, design and reuse strategies along with policy instruments such as recycled content standards, virgin resin taxes, and tradable permits are needed to increase the service life of plastic products and plastic circularity. Impact investing is also needed for plastic waste reduction innovation and commercialization; sustainability criteria and life cycle assessment should be used to guide such investment to avoid greenwashing.[1, 2]

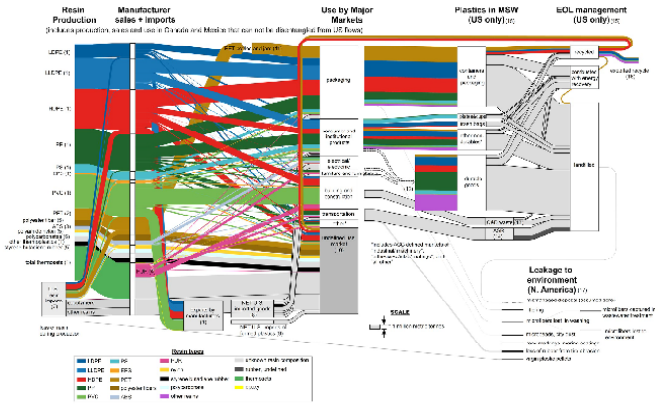
Table of Plastic Definitions

Term	Definition
Thermoplastics  E.g. PVC Piping	Thermoplastics are polymers that melt or soften when heated and can be melted down, molded, and recycled into something new. Common thermoplastics include polyvinyl chloride (PVC), low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), and polystyrene. Thermoplastics have wide-ranging applications from plastic bags to piping.
Thermosets  E.g. Epoxy resins	Thermosets are plastic polymers that form strong, cross-linked, three-dimensional chemical networks when they react with one another and, once formed, harden irreversibly. They are commonly used in construction, as well as in transportation, adhesives, and electrical equipment. Unlike thermoplastics, thermosets are resistant to high heat so recycling them is challenging. Examples of thermosets include silicones, polyesters, polyurethanes, and epoxies.
Bioplastics  E.g. PLA cups	Bioplastics are partially or entirely composed of plant-based renewable sources such as sugarcane, vegetable oils, starches, and even microbes. By 2025, bioplastics could decrease the amount of petroleum used in plastic production by 15–20%.[3] Given the right conditions, many bioplastics can biodegrade or become compost. Applications of bioplastics include food packaging, agriculture, and hygiene.
Composites  E.g. Fiberglass in wind turbine blades Note: Epoxy thermoset resins are also used.	Plastic composites are plastic polymers that are reinforced with non-plastic fillers, giving the resulting composite different properties than the materials that comprise it. Examples of plastic composites include fiberglass reinforced polyesters and biofiber-reinforced plastic composites used for building and construction. Plastic composites are difficult to recycle due to the combination of materials used to create them.
Macroplastics  E.g. Fishing nets Credit: NOAA	Macroplastics are plastics that are equal to or over 5mm in diameter.Examples of macroplastics include fishing nets, food wrappers, plastic bottles, and plastic bags.[4]
Microplastics  E.g. Microplastics found in table salt[5]	Microplastics are plastic particles that are under 5 mm in diameter. Microplastics fall into two categories: primary, which are designed and produced to be small (e.g. virgin plastic pellets used to manufacture plastic products and microbeads used in cosmetic products) and secondary microplastics, which are smaller pieces of plastic released from larger plastics when they break down (e.g. microfibers from clothing and microplastics released from tire abrasion).[6]

Patterns of Use

- Global plastic use is estimated to increase from 460 Mt in 2019 to 1231 Mt in 2060.[7]
- At 139 kg per capita per year (not including fiber and rubber polymers) North America has the highest per capita plastic consumption in the world and represents 19% of global plastics production and 21% of consumption.[1]
- Packaging was the largest defined use market for plastics that entered the U.S. economy in 2017. However, two-thirds of the plastic put into use went into other markets. The plastic products in these different applications have varying lifetimes: short (disposable serviceware, trash bags, diapers), medium (clothing, tools, electronics, furniture, small appliances), or long (large appliances, automobiles, buildings).[1]
- By 2060, the use of plastic in packaging will more than double compared to 2019. Of the seven commodity plastics, the amount of LDPE (including LLDPE) used in packaging is expected to triple, and PP, HDPE, and PET used in packaging will more than double.[7]
- About 30% of all the plastics ever made globally are still in use, and 60% have been discarded in landfills or elsewhere in the environment.[1,2]
- 12% of plastics put into use in the U.S. in 2017 went into building and construction. Plastic use in buildings is increasing, primarily in the form of PVC and HDPE used for piping, house wraps and siding, trim and window framing, and plastic-wood composites, as well as PUR used primarily as insulation. EOL recovery of these plastic materials is challenging because building demolition often produces mixed waste with low fractions of plastics, and materials such as PVC and PUR thermosets cannot be recycled easily.[1]
- The transportation sector used over 4% of plastics that entered the U.S. economy in 2017, primarily in the production of new automobiles. Due to lightweighting efforts and new applications of engineering resins, plastics in automobiles have increased over the past several decades, representing 8.6% of the material weight of N. American light vehicles in 2017. Over 95% of EOL vehicles in the US are recycled for their metals content. However, due to the large variety of plastics used in automobiles and the cost of collection, separation, and cleaning often exceeding that of virgin plastic materials, most automotive plastics end up in automotive shredder residue (ASR) and then go to landfill.[1, 8]
- Electronic waste (e-waste) is becoming an increasing concern, with a global annual growth rate of 3%–4%. An estimated 2.6 Mt of selected consumer electronics appeared in MSW in the U.S. in 2017 with plastic contents of 20% to 33%. If efficient and cost-effective recovery methods become available, up to 2.5 Mt of polycarbonates can potentially be recovered from e-waste globally each year.[1]

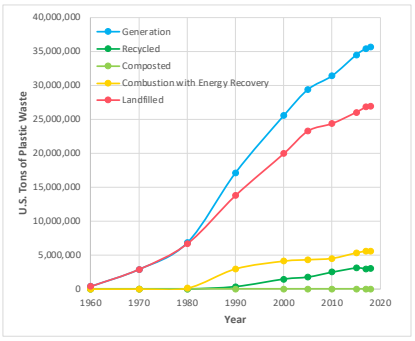
Plastic Production, Use, Disposal, and Leakage, in the US, 2017[1]



Link to Flow Diagram

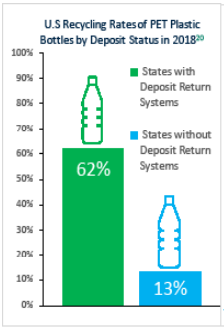
Environmental Impacts

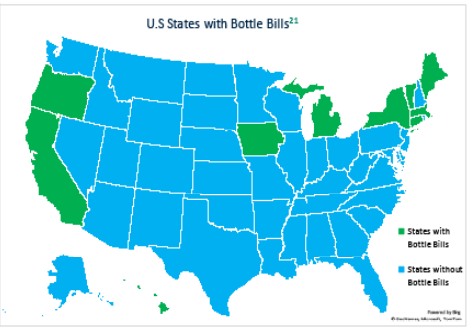
Plastic Materials Management of U.S. Municipal Solid Waste (MSW)[10]



- Globally, 99% of plastic resin is derived from fossil-based feedstocks. Global production (including both feedstock and manufacturing energy requirements) currently represents around 8% of global annual oil and gas consumption.[1, 9]
- According to projections based on current growth rates, life-cycle greenhouse gas emissions from plastics could reach 15% of the global carbon budget by 2050.[11]
- Despite representing only 4.3% of the global population, in 2016, the U.S. produced more plastic waste than any other nation, generating 42 MMT of plastic waste total and 130 kg of plastic waste per capita per year.[9]
- In 2017, 2% of plastics disposed of in the U.S. "leaked" into the environment, often in the form of microplastics from tire abrasion and synthetic textiles, which is of growing concern due to impacts on organisms and unknown health consequences in humans.[1, 9]
- In 2019, 86% of plastic waste managed as MSW in the U.S. went to landfill with only 5% of plastic waste being recycled and 9% being combusted. This plastic lost to landfills had an average market value of 7.2 billion USD.[12]
- In 2019, 9% of global plastic waste was recycled, 19% was incinerated, about 50% was sent to sanitary landfills, and 22% was openly burned, sent to unsanitary dumpsites, or leaked into the environment.[7]
- Rapidly developing middle-income countries in Asia, which often have inadequate collection systems, are responsible for an estimated 80% of global leakage. However, even though the U.S. and Europe have advanced collection systems, they leak 170,000 metric tonnes of plastics into the ocean annually, making them responsible for about 2% of global leakage.[13]
- Ocean plastic pollution impacts over 800 species of marine organisms, affecting all sea turtle species, 40% of cetacean species, and 44% of marine bird species.[14]
- If current practices continue, by 2050, there could be more plastic than fish in the ocean by weight.[15]

Solutions





- A circular economy for plastics is one in which plastic follows a circular path where it remains in service and maintains its material value.[16]
- By 2040, a circular economy could result in an 80% reduction in the volume of plastics entering oceans each year, a 25% reduction in greenhouse gas emissions, savings of 200 billion USD per year, and the creation of 700,000 net additional jobs.[17]
- Redesigning products to increase recyclability can help increase plastic circularity. For example, using thermoplastic resin as opposed to thermoset resin in wind turbine blades can make them recyclable.[13, 18]
- Reuse is a key circular economy strategy to encourage; for food containers sustainability performance depends on reuse rates and washing practices.[2, 19]
- Policy instruments that can reduce plastic packaging pollution and increase plastic recycling rates include command-and-control policies (e.g. product take-back mandates, landfill/disposal bans, product/material bans, and recycled content standards) as well as market-based policies (e.g. advanced disposal fees, deposit-refund systems, pay-as-you-throw programs, product taxes, virgin resin taxes, and tradable permits).[1]
- In 2018, states with deposit return systems had a PET plastic bottle recycling rate of 62% whereas states without deposit return systems had a rate of 13%. In the U.S., 10 of the 50 states plus Guam have bottle bills as of 2022.[20, 21]
- Taxes on specific plastic polymers and specific uses of plastics can lead to reductions in plastic consumption. For example, in 2002, Ireland introduced a EUR 0.15 plastic bag tax (raised to EUR 0.22 in 2006), leading to an immediate 90% reduction in the use of plastic bags.[22]
- In December 2022, Canada will ban importing and manufacturing single-use plastics such as plastic bags, utensils, and ring carriers. This ban is expected to eliminate about 1.3 million tonnes of plastic waste and over 22,000 tonnes of plastic litter over the next ten years. While bans are one tool that can be used to reduce plastic waste, providing alternatives before imposing bans is important to avoid perverse outcomes.[23]
- Combustion and pyrolysis solutions for energy recovery and fuels can address plastic waste but are problematic with regard to carbon emissions.[1]
- Some restaurants and food manufacturers have begun to transition to reusable containers as an alternative to plastic packaging such as Burger King®, which launched reusable container programs in its New York City, Portland, and Tokyo restaurants in 2021.[24]
- Finding new creative uses for plastic waste can help establish a circular plastics economy. For example, the company Rebricks processes low-value plastic waste such as bubble wrap and combines it with cement to create building materials. Additionally, larger brands such as Patagonia®, which makes its Baggies™ (shorts) out of recycled nylon from fishing nets, are incorporating recycled plastic waste into their products.[25, 26]

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