Defining Plastics Recycling and other End of Life Options

Ocean Conservancy®

What is plastics recycling?

The renowned "chasing arrows" recycling symbol represents, ideally, a closed-loop or circular economy for materials. For plastics, this means that plastic materials and products are collected, processed and manufactured into new products *again and again*. This reduces waste, pollution and the need for new virgin plastics, 99% of which are derived from fossil fuels.

The most common form of recycling for plastics, known as **mechanical recycling,** uses mechanical processes (e.g., washing, grinding, re-granulating) to recover plastic resins to be remade back into new plastic products.

Unfortunately, scientists estimate that less than 9% of all plastics ever made have been recycled; and only 10% of that has been recycled more than once.

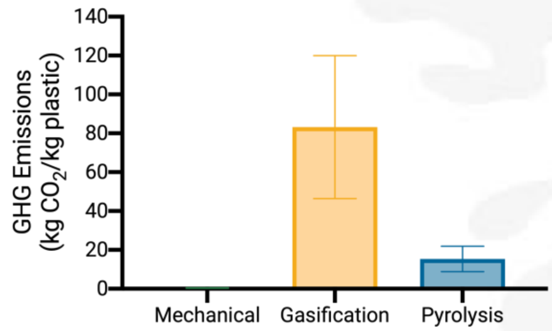
What are other end of life options for plastics?

- **Landfilling** – Landfills are engineered facilities designed for the disposal of solid waste by burying or storing it in or on the ground. They require careful planning and control methods (e.g., piping and lining) to collect and treat liquid and gas discharges and protect the surrounding environment from contaminants. No materials are recovered in the landfilling process.
  - In 2018, 75.5% of plastic waste in the U.S. was landfilled.
  - There are more than 2,600 landfills in the U.S.; about half are already at capacity.
  - Landfills are a significant source of greenhouse gas emissions in addition to causing local air and water pollution.
- **Incineration** (also known as **waste-to-energy**) – Incinerators use controlled burning (combustion) of waste at very high temperatures (1100ºF to 1200ºF) to break down plastics and other waste from solids into gases (predominantly CO_2), heat, and residual ash. Like with burning coal and other fossil fuel technology, the heat, in turn, fuels turbines to produce electricity.
  - Incinerators have been used in the U.S. since 1885.
  - In 2018, nearly twice as much plastic waste in the U.S. was incinerated (15.8%) as was recycled (8.7%).
  - There are 73 municipal solid waste incinerators in the U.S., which made up 0.4% of total electricity generation in the U.S. in 2015.
  - A recent study found that 79% of the incinerators in the U.S. are located in predominantly minority or low-income communities.
  - Incineration is known to release harmful chemicals and pollutants including greenhouse gases, particular matter, heavy metals and toxic chemicals such as PFAS and dioxins.
- **Chemical recycling** (also called **advanced recycling** or **molecular recycling**) – This umbrella term encompasses a suite of technologies that use non-mechanical processes to break down plastics. Chemical recycling technologies can be roughly broken down into three categories: systems that use high heat and pressure (conversion) or systems that use chemicals (purification and depolymerization) to break down plastics.
  - **Conversion technologies** – These technologies use heat and pressure to break the chemical bonds in plastic to produce hydrocarbons such as synthesis gas ("syngas") and oils. These technologies have been available at scale for decades and are largely another form of **plastic-to-fuel**.
    - **Pyrolysis** – These systems use high heat (575ºF to 1650ºF) with limited oxygen to break down plastic waste into a synthetic crude oil (pyrolysis oil) that can then be refined for use in diesel fuels, gasoline, or heating oils.

        - **Gasification** – These systems use very high temperatures (930ºF to 2370ºF) and a small amount of oxygen to break down plastic waste into syngas that can be combusted for electricity or converted into other fuels or chemicals.
    - **Purification technologies** – These technologies use chemicals rather than heat to break down plastics to produce monomers, polymer feedstocks, or polymers. These systems often involve multiple steps to remove contaminants, filter, and then re-precipitate the polymer. These technologies are recent innovations and are largely not available at scale.
    - **Depolymerization technologies** – These systems use chemicals or enzymes to break down plastics into their basic building blocks (monomers), essentially reversing the polymerization process that made the plastics in the first place. This technology is only applicable for certain types of plastics (e.g., PET, nylon) based on how they were originally made. For the most part, these technologies are still being developed and are not available at scale.
        - **Solvent-based depolymerization** – These systems use solvents and catalysts (typically metals) to break plastics back into their monomers. The monomers then need to be recovered from or distilled out of the chemicals used in the process.
            - One example where this technology is currently in use is for nylon, allowing for textile waste and fishing gear to be recycled back into nylon.
        - **Enzymatic depolymerization** – While there has been a lot of research using microorganisms (e.g., bacteria, fungi) and their enzymes to break down plastics, this technology remains in a research stage and challenges remain for these systems to meet the scale of the crisis.

Assessing ocean impacts

- **Plastic pollution** – Plastic production, and pollution, is skyrocketing; half of all plastics ever made have been produced in the last 20 years and every year, over 11 million metric tons of plastics enter the ocean from land-based sources alone. While we cannot recycle our way out of the plastic pollution crisis, we need recycling to work if we want to decrease our dependence on fossil fuel-derived virgin plastic. But how we recycle matters and only recycling that recovers usable plastics, like mechanical recycling, will help achieve these goals.
- **Climate impacts** – Recovering reusable plastic material from recycling (i.e., plastics-to-plastics) will yield the lowest lifecycle greenhouse gas impacts because of the emissions avoided by the production of new virgin plastics. Waste-to-fuel technologies, in addition to not recovering plastic material, are energy-intensive processes.



    - Conversion technologies release 30-200 times more greenhouse gas emissions than mechanical recycling.
- **Toxic emissions** – Plastic products and packaging contain a variety of potentially toxic chemical additives, from residual monomers used to make plastics (e.g., styrene or vinyl chloride) to flame retardants and other additives (e.g., phthalates). End-of-life management for plastic waste needs to ensure these toxic chemicals are not released to cause harm.
    - Toxics from plastics have been found in the products (e.g., pyrolysis oil), byproducts (e.g., char), and air emissions from chemical recycling like pyrolysis.
    - Scientists estimated that in 2015, seven of the most commonly polluted plastic items carried with them approximately 190 metric tons of 20 different chemicals additives into the ocean.

Ocean Conservancy's position on chemical recycling

Ocean Conservancy does not presently support any form of chemical recycling. In its current form, chemical recycling does not contribute to a circular plastics economy and creates environmental and social harms.