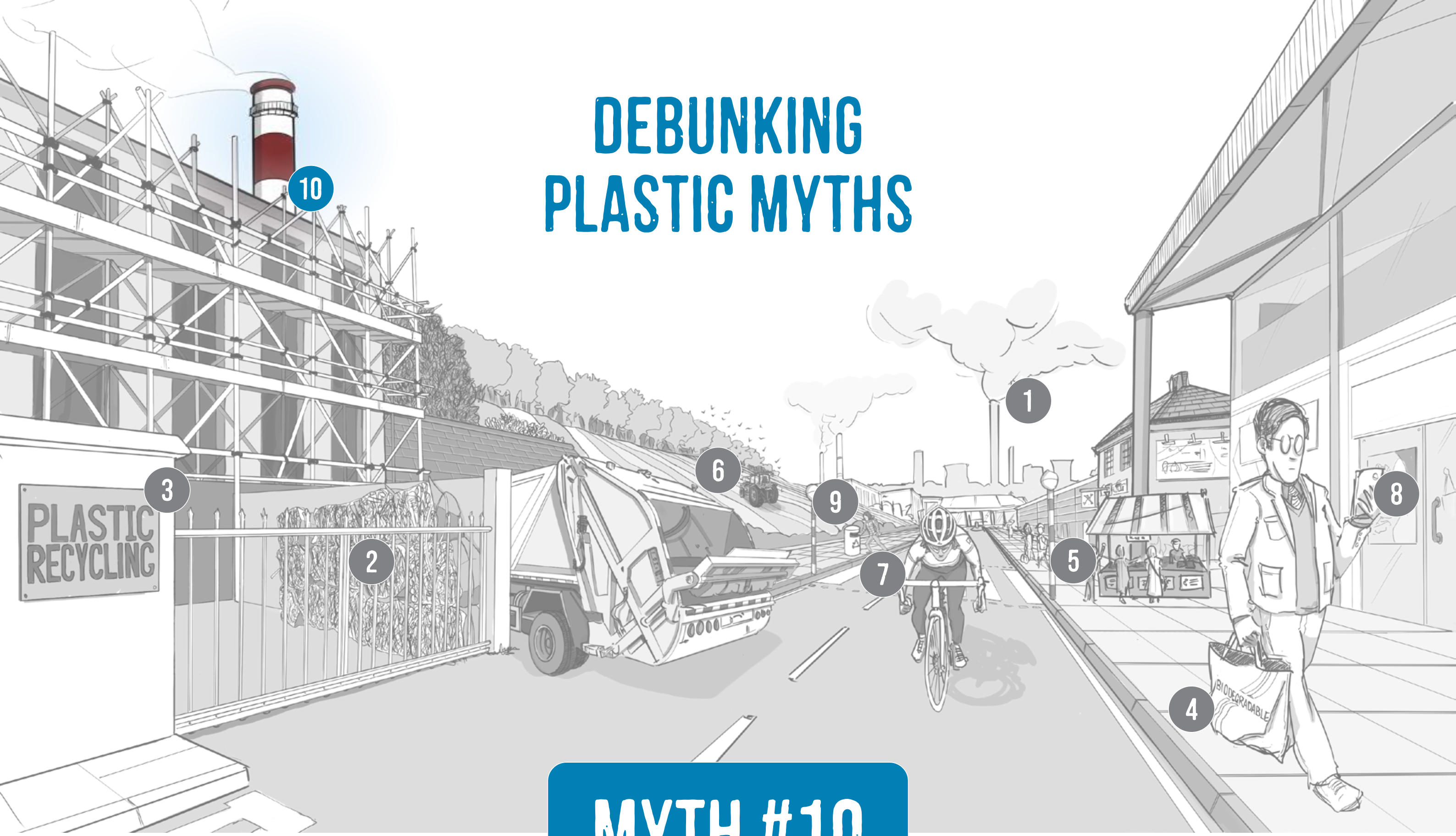
DEBUNKING PLASTIC MYTHS



MYTH #10

CHEMICAL RECYCLING CAN SOLVE THE PLASTIC POLLUTION CRISIS

Proponents say that chemical recycling is poised to be a part of the solution to plastic pollution but for now, chemical recycling is more of a promise than reality and is not likely to contribute substantially anytime soon. Chemical recycling is energy-intensive, produces greenhouse gas emissions, and has not demonstrated economic viability. It may ultimately make a valuable contribution as a complement to mechanical recycling but it urgently needs to improve yields and lower its energy requirements (SYSTEMIQ et al., 2021).

Despite promotion in recent years as a promising technology that may overcome the limitations of existing plastic recycling options (Thiounn & Smith 2020; CEFIC, 2020), chemical recycling is a work in progress. Research has focused on improving methods to handle contaminated or mixed plastic wastes including traditionally non-recyclable polymers and on producing recycled materials with a quality similar to virgin polymers (Rahimi & Garciá, 2017; Solis & Silveira, 2020). Methods to enable repeated chemical recycling of polymers are also being explored (Zhu et al., 2018) but in some cases "recycling" is a misnomer because some processes do not convert plastic waste into feedstock for subsequent uses, but rather (at least in partly) into fuel or chemicals.

The three main types of chemical recycling processes are solvent purification, chemical depolymerization, and thermal depolymerization (Pew Charitable Trusts & SYSTEMIQ, 2020; Eunomia, 2020). Solvent purification separates contaminants from plastic waste in a solvent and takes plastic back to the polymer stage. The process is energy intensive and because subsequent reprocessing degrades the polymer chain, infinite recycling is not a possibility (Eunomia, 2020). Chemical depolymerization, also known as chemolysis, breaks down plastic waste into monomers that can be used to produce a polymer for an application of the same or higher value of the product that generated the waste. However, applications target homogenous waste streams and so rely on effective sorting and pre-treatment (Eunomia, 2020).

Thermal depolymerization includes pyrolysis and gasification uses heat to break down polymer chains into smaller fragments that can be used to produce polymers or fuels. Pyrolysis, also known as thermal cracking, works at moderate to high temperatures and with no oxygen, while gasification uses a higher range of temperatures and manages the volume of oxygen to achieve the desired outcomes. One of the adaptations to the pyrolysis process is called catalytic cracking, a process which uses a catalyst that reduces processing temperatures and increases yields (ibid.).

The European Chemicals Agency (2021) considers four chemical recycling technologies to have achieved a commercial scale of operation – chemolysis, pyrolysis, catalytic cracking and gasification. Other chemical recycling methods for plastics are at the lab or pilot stage and some are nearing or at full-scale operations.

Complications

As chemical recycling continues its development, other related issues need attention: the energy intensity of the processes; the inherent emissions; the yield, or the usable proportion of the material produced by the technology; the availability and quality of feedstock; and the economics of chemical recycling (Pew Charitable Trusts & SYSTEMIQ, 2020; Eunomia, 2020). The overriding question is whether the benefits associated with chemical recycling outweigh the environmental and financial costs.

Chemical recycling is demonstrating a capacity for processing some plastic wastes that mechanical recycling cannot. It is not demonstrating that it can reduce emissions or have much effect in reducing demand for virgin plastic. Calls for more research, greater transparency and life cycle assessments come from across the spectrum of interested parties (CEFIC, 2020; European Chemicals Agency, 2021; Eunomia, 2020; Rollinson & Oladejo, 2020).

Energy consumption

Chemical recycling is a more intensive and complicated process than mechanical recycling and consumes more energy (Klemeš et al., 2020). Pyrolysis and gasification use significant amounts of energy to achieve the external heat necessary for pretreatment of plastic waste for decontamination and to break down the plastic products into gases, liquids and solids (Solis & Silveira, 2020; Eunomia, 2020). The repolymerization process requires yet more energy (Rollinson & Oladejo, 2020). The higher the temperature and expected purity of final products, the higher is the energy consumption (Solis & Silveira, 2020).

Emissions

Chemical recycling produces greenhouse gas emissions during the processing as well as during the burning of the resulting fuel products (Rollinson & Oladejo, 2020) but the research in this area is limited. One life cycle assessment finds that plastic-to-plastic chemical recycling has higher greenhouse gas emissions than mechanical recycling and almost the same greenhouse gas emissions as plastic-to-fuel chemical recycling (Pew Charitable Trusts & SYSTEMIQ, 2020). Another life cycle assessment finds that emissions from the pyrolysis of mixed plastic waste are half that of incineration and are similar to mechanical recycling emissions (Jeswani et al., 2021).

Yield

An important measure of the efficiency and financial viability of chemical recycling technology is the yield – how much of the output that can be used for new plastic production. One study indicates that the production of 1 tonne of low-density polyethylene (LDPE) through chemical recycling of mixed, non-recyclable, plastic material requires 4 tonnes of plastic waste (Santagata et al., 2019). Studies conducted at the lab scale or the demonstration stage are likely to include assumptions based on this finding but neither the assumptions nor the finding may hold up at scale (Eunomia, 2020).

Feedstock

Pyrolysis and gasification are sensitive to feedstock contamination and mixed plastic feedstock may lead to operational problems. Feedstock quality may influence both the yield and the energy use (ibid.). The product outputs may be heavily contaminated and of poor quality, requiring extensive decontamination and enrichment to meet the standards necessary for use. Poor quality feedstock may lead to substances of concern such as dioxins formed in pyrolysis and gasification that will need to be further purified (Crippa et al., 2019; Delavelle & De Caevel, 2015). The high level of feedstock quality required by chemical recycling needs to account for local collection coverage and sorting practices, an issue especially in the Global South where waste collection is lagging.

Economic viability

The economic viability of chemical recycling remains uncertain. The studies that suggest a viable future have not accounted for the costs of collection and sorting and at the industrial scale the cost-effectiveness of chemical recycling will depend on the volume and quality of feedstock, the costs of collection and sorting, and any gate fees charged for local municipal solid waste recycling (Solis & Silveira, 2020). Virgin materials have been able to compete on the basis of cost with mechanically recycled plastics and may be able to compete with chemically recycled plastic waste as well.

Circularity

Chemical recycling has raised hopes that it is a potential means of achieving a circular economy for plastics and that it can close the gaps left by mechanical recycling (CEFIC, 2020). When pyrolysis and gasification convert plastic waste to fuel, however, they do not produce new plastic. Therefore these processes do not replace virgin plastic and perpetuate a linear rather than circular model. Currently, chemical recycling experiences process losses at several points along the way, comes with high energy demands, and emits greenhouse gases. To date, chemical recycling has not demonstrated that it can turn much waste into new plastic for the economy.

What can we do?

Chemical recycling might become a part of the solution to plastic pollution but cannot solve the plastic crisis alone. At this stage in the development of chemical recycling, much remains uncertain: the feasibility of chemical recycling processes at an industrial scale; the potential logistical and economic issues related to collection and sorting; and chemical recycling's role in a circular economy. A recent study of the prospects for a circular plastic economy in Norway concludes that the reduction of avoidable consumption and the scaling up of sorting capacity are the core of the strategy for achieving circularity but also recommends the scaling-up of chemical recycling (SYSTEMIQ et al., 2021).

1. Conduct life cycle assessments

Life cycle assessments are commonly used to identify the environmental impacts of production and recycling and to view environmental issues from a wider perspective (Toniolo et al., 2013). In its effort to ensure the scaling up of chemical recycling, the industry advocates the use of life cycle assessments to compare the carbon footprints of chemically recycled products against virgin plastics or alternative feedstocks (CEFIC, 2020). A true comparison at the industrial scale may be difficult until chemical recycling reaches that scale. Preliminary work may help establish the feasibility of taking that step.

A certain amount of scaling up may be useful for a life cycle assessment, but some observers note with concern that scaling up chemical recycling may lock in an increased reliance on virgin material and a waste-to-energy pathway that leads to increased negative environmental effects (Eunomia, 2020).

2. Conduct research

Lacking a consensus on the relative environmental costs and benefits may be a barrier to the ability of chemical recycling to reach an industrial scale and the current state of knowledge is inadequate to arrive at a consensus. Fortunately however, both the proponents and sceptics agree that more knowledge is needed, and so the field is ripe for research. Studies to assess the emissions of the various chemical technologies against mechanical recycling and the use of virgin materials would provide valuable information for life cycle assessments and research on the energy demand for chemical recycling technologies would provide similarly useful input.

3. Improve the prospects for chemical recycling

Investments in process improvements could increase efficiency to the point that chemical recycling is economically viable enough to produce competitive products with the potential for multiple markets (Chandrasekaran et al., 2015). In light of the sensitivity of chemical recycling to feedstock contamination, better sorting of plastic waste and well-established collection systems may improve yields and support the economic viability of the chemical recycling process. Sorting and collection are important elements in mechanical recycling as well, and some synergies between mechanical and chemical recycling technologies may achieve higher recycling yields and lower transportation costs. Co-located mechanical and chemical facilities may maximize the synergies and handle most of the plastic waste stream (Pew Charitable Trusts & SYSTEMIQ, 2020). The durability and sustainability of the system ultimately depends on the operators' capacity to handle the costs.

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