Plastics sustainability: Myths, facts and a path to a circular economy sustainability

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The word "plastic" evokes passions; add the words "single use" and we must be prepared to take cover. There is no doubt that there is civic, political, and corporate momentum towards a circular economy sustainability. Unfortunately, plastics have become the popular bogeyman of the modern sustainability movement.

It took a pandemic to remind people of the value, safety, security, efficiency and economy of plastics. The time is ripe to re-assess the potential of plastics to lead our way towards this circular economy; we must check our biases and premises, stop advocating for a smorgasbord of irrational solutions for reducing, replacing, remaking and/or eliminating plastics. Instead, we should be embracing solutions that successfully and robustly process mixed waste streams into refined, value-added feedstocks that are equivalent in quality to those produced from fossil sources. The good news is that the technology already exists and has been used commercially in various forms for more than a century.

Since the 1960s, technological advances have helped to refine processes to make them sufficiently robust for handling mixed municipal solid waste (MSW). These processes will serve as a backstop or final option for the many materials that are simply not economically recyclable by traditional methods. As we have adopted the philosophy of "reduce," industry has responded with many remarkably capable multi-layer/multi-material, minimal structures that are not readily recyclable. Adding robust backstop processes for waste enables us to close the loop on virtually all waste, reduce harmful emissions from landfills and incineration while supporting existing infrastructure for traditional recycling of the few materials that are readily and economically recyclable.

Before describing such backstop technologies, it is worth addressing the common myths about the future of plastics in the circular economy:

Myth 1: "We must reduce the amount of plastic in our waste" – Reduction is naturally driven by economics even in the absence of a sustainability goal. When landfilling was socially acceptable, reduction, e.g., glass, rigid plastics to flexible film, also offered an environmental benefit, mostly from production and distribution efficiencies. However, reduction has negatively affected the economics of recycling which has put the entire recycling system in jeopardy.

Myth 2: "If only we made plastics from renewable biological sources" - Whilst biobased materials are technically renewable, they also require large quantities of water, energy, fertiliser, chemicals and other processes that have a significant impact on recycling. Additionally, whether polyethylene is made from fossil fuel or fermented sugar, the result is the same material, polyethylene, which is not bio-degradable. This is not an argument against bio-based plastics, but rather a call to realise that "bio-based" does not automatically mean more sustainable or biodegradable.

Regardless of source, bio-based plastics enter the waste stream just like all other plastics. From a circular economy standpoint using our existing infrastructure, the only benefit of using bio-based plastics would be via waste-to-energy, since bio-energy is often viewed as zero net carbon, even though just a few inputs may not be. Since, it is unlikely that all plastics will be bio-based and that its successful sorting from fossil-based plastics is not practical, there is no clear environmental benefit from bio-plastics.

Myth 3: "If only all plastics were Biodegradable/compostable" – Biodegradability is often touted as the ultimate solution for sustainable plastic packaging. This notion is probably fueled by a desire to have unsightly plastic litter disappear on its own. Whilst litter is a problem that will require persistent mitigations, we should not expect biodegradable plastics to solve it. In fact, biodegradable plastics are much more likely to exacerbate environmental impacts than promote sustainability. There are three significant problems with biodegradable and/or compostable plastics;

Firstly, we often use plastics to protect products that are themselves biodegradable and/ or compostable. It is the fragility of these products that we seek to protect with efficient and durable materials such as plastics. Due to its inherent nature, inferior biodegradable plastic packaging is likely to lead to increased losses of the products they are intended to protect. Secondly, products and packaging are occasionally made from more than one polymer/material. The latter, for instance, often requires multiple materials, labels, adhesives, decorations and fitments to serve its function. Compostable packaging has been shown to contaminate otherwise "organic" compost, destroying its usability and value. Thirdly, whilst litter is an unsightly problem, most of the plastic waste ends up in landfills which the United States Environmental Protection Agency

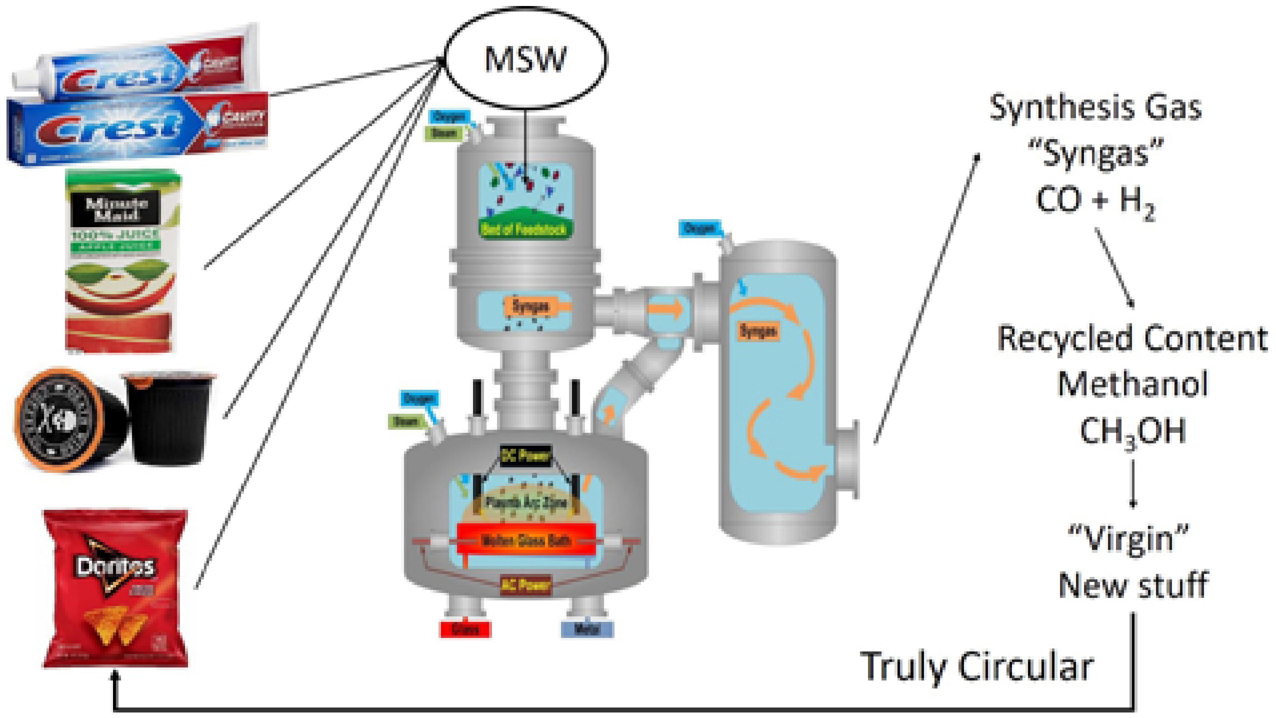

Figure 1: Plasma Assisted Gasification and Vitrification (PAG/V) process converts mixed waste into syngas.

(EPA) has already identified as the third largest contributor of global atmospheric methane, which has a considerably higher impact as a greenhouse gas than carbon dioxide (EPA, 2021). Whilst sanitary landfills are intended to store waste, they serve as giant, uncontrolled anaerobic digestors also producing methane. Seeding landfills with more biodegradable materials will drive production and release of even more methane exacerbating problem further. It is doubtful that those advocating that biodegradable plastics will solve the litter problem particularly if this is at the expense of a further release of potent greenhouse gases.

Myth 4: "We must redesign multi-material structure to be monolithic" – Multi-layer flexible films are designed to deliver required barrier and structural properties for specific applications that are often not attainable from monolithic materials. Flexible military food packaging provides a valuable example (Jahner, 2015). Packaged military foods often have shelf lives measured in years. It must be light and strong while protecting food from moisture changes and oxidation. If monolithic materials existed that could deliver such performance, we wouldn't go through the trouble manufacturing multilayer materials. This is not likely to change.

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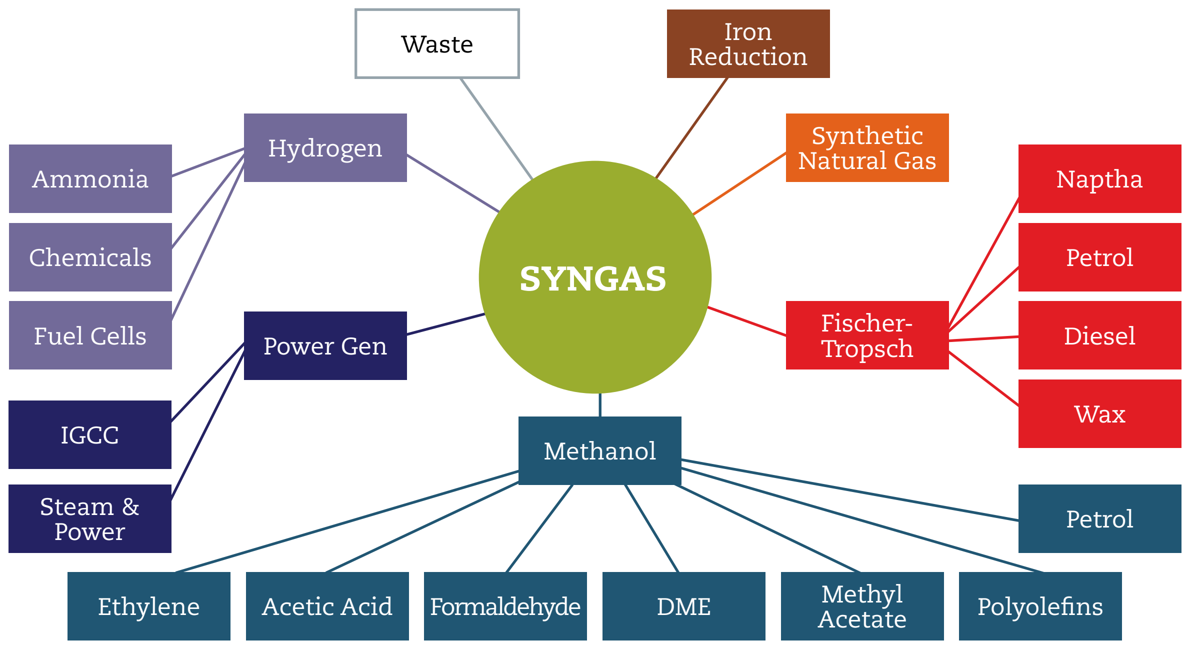

Figure 2--Gasification converts carbon-based materials into syngas. Syngas can be converted into methanol. Methanol

Myth 5: "There is no silver bullet!" – The Miriam-Webster Dictionary defines "silver bullet" as "something that acts as a magic weapon, especially one that instantly solves a long-standing problem." Problems related to waste are long-standing and complex, however, technologies exist that can mitigate the problems. Some technologies promise to mitigate more problems than others. A few technologies promise to fundamentally change the way we view waste. There may be no silver bullet, but that does not mean we are devoid of promising options.

Perhaps the most robust and flexible technology for treating mixed MSW is thermochemical conversion. Various approaches are commercially practised ranging from the almost ancient gasification process to modern plasma assisted gasification and vitrification (PAG/V). PAG/V is very robust and can deliver clean syngas for subsequent processing. Historically, industry has relied upon biomass and fossil fuels to produce syngas via gasification. PAG/V can accept all materials found in municipal solid waste as well as organic chemical and biological wastes. The process can melt down metals and mineral oxides while converting organic materials into syngas (Figure 1).

Syngas is produced commercially on a global scale for subsequent production of fuels, chemicals, plastics, power, and other products (Figure 2).

With PAG/V we do not need to reinvent plastics to make them amenable to the circular economy. All non-recyclable materials that are currently going to landfills such as multi-layer, flexible, filthy, coloured, labelled, metallised, foil and/or fitment laden packaging, can all be recovered through the syngas route. Ideally, syngas is converted to recycled content methanol, which can be used as a feedstock to reconstitute virgin plastics.

The Methanol Institute (Washington D.C.) is reporting that methanol-to-olefins/plastics (MTO) has emerged as a significant market for methanol in the last decade and is growing rapidly (Anon, 2021). Syngas is not a magical silver bullet, but is, potentially, the key to plastic packaging circular economy, sustainability.

PAG/V technology's ability "have one's cake and eat it" is unique amongst all recycling technology options and, therefore, demands special attention and interest by the packaging and packaged goods' industries. The plastics packaging industry must recognise the value and importance recycled-content-methanol will play in the future and help to promote its production and use for recycled content in virgin quality plastics. Creating and sustaining a market for waste-to-syngas-to-methanol-to-plastics is a much better alternative to legislative extended producer responsibility (EPR) taxes (Lahkan, 2020).

PAG/V also offers the opportunity to simplify collection and sorting, providing significant, offset energy and emissions savings. It is also simpler and more straightforward to promote the use of renewable energy to drive PAG/V waste conversion systems than to continue failing to recycle waste.

The Consortium for Waste to Syngas Circularity (CWSC) is supporting education, research, and policy initiatives to promote investment in robust and flexible waste conversion infrastructure. Companies interested in solving intractable problems with waste should seek to join CWSC (www.wastecircularity.org) ■

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