Ending Plastic Waste
Symposium 2023

Breaking Down Plastic Waste: Assessing the Environmental Impact of Chemical Recycling Processes

Life cycle assessment helps to evaluate the environmental impacts and benefits of chemical recycling processes in plastic waste management.

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LCA and Chemical Recycling

- Efforts to recover plastic wastes in Australia can benefit from adopting chemical recycling (CR) processes (Figure 1).
- However, research must show that CR can provide quantifiable benefits to the environment.
- Life cycle analysis (LCA) can assist in this endeavour as it evaluate the environmental impacts of a process throughout its life cycle, from production to disposal[1].
- Few LCA research has been published for CR technologies due to insufficient data.
- Our research aims to populate this gap by:
  - Create a single database for common CR processes (pyrolysis, gasification, purification, and depolymerisation).
  - Assess the impacts of these processes.

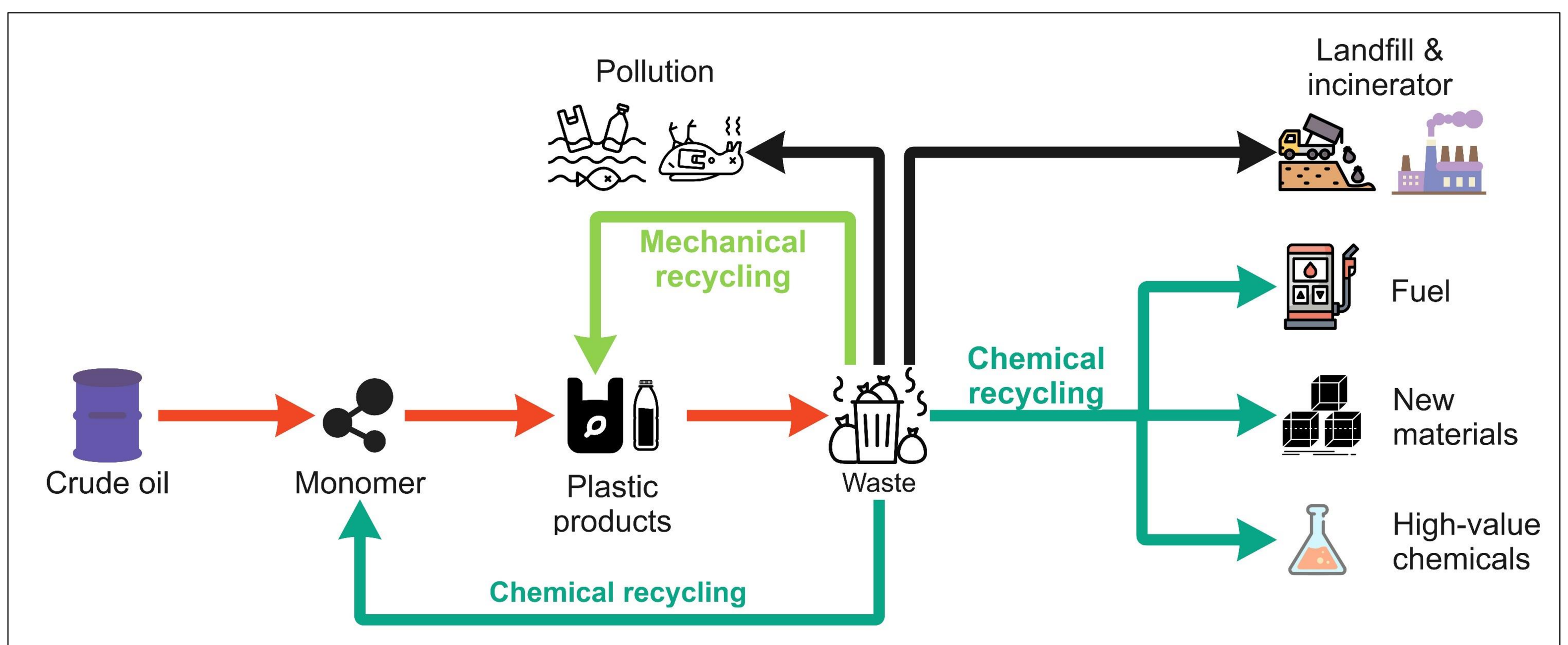

Figure 1: Chemical recycling can convert plastic wastes into monomers or completely new products. Thus, reducing the amount of waste that would go to landfill, incinerator, or leaked to the environment. Adapted from [2].

Review of CR Technologies: Plastic Pyrolysis

- Plastic pyrolysis is the most common chemical recycling process, behind depolymerisation[3].
- The process involves heating plastic waste to a desirable temperature in the absence of oxygen to produce a liquid product that can be refined into plastic monomers, fuels, and high-value chemicals.
- Our literature review found no consensus regarding the optimal operating conditions to achieve maximum liquid products (Figure 2a).
- No studies used the same mixtures of plastic waste during analysis. Some studies used virgin, un-mixed plastic samples while others used real, mixed samples → disparity in the literature (Figure 2b).

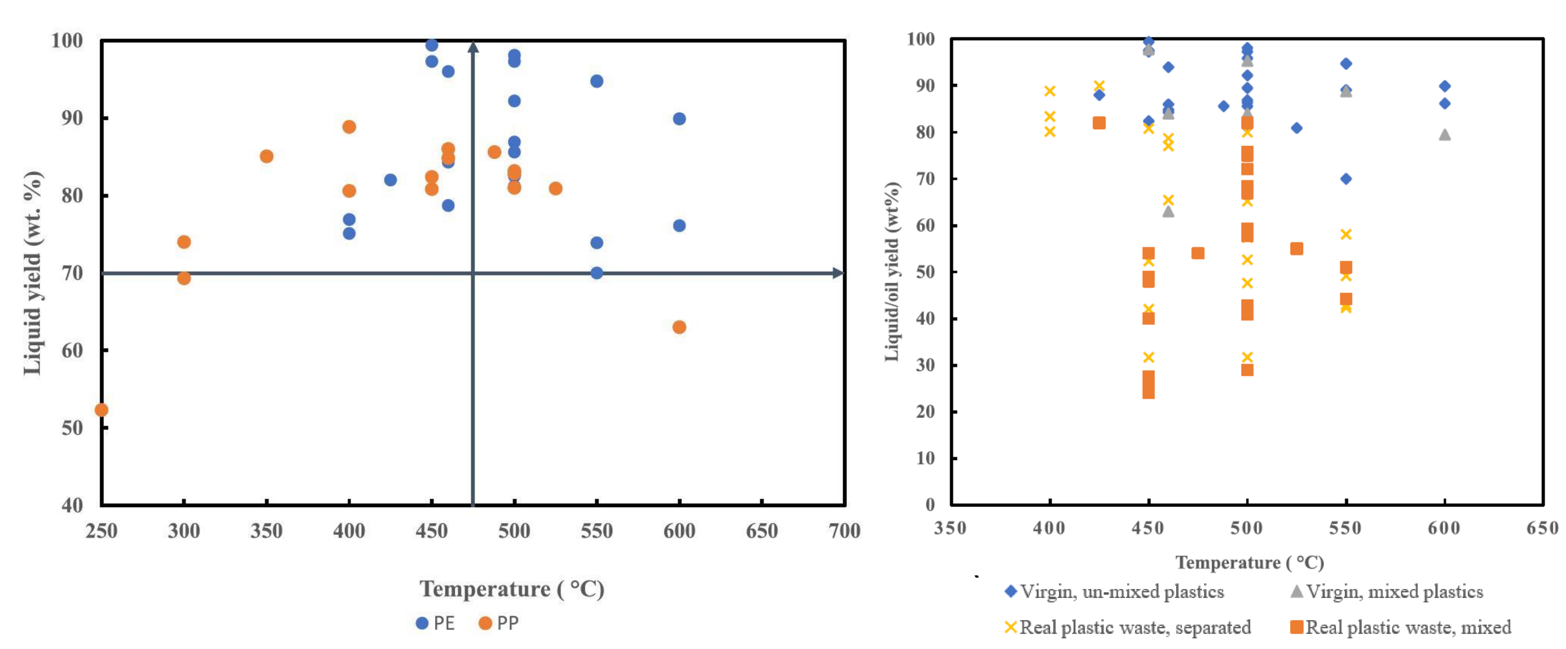

Figure 2: **(a)** relationship between pyrolysis temperatures and liquid yields from virgin polyethylene (PE) and polypropylene (PP); our review found that temperature ranges between 450 and 500°C yielded the highest liquid quantity. **(b)** comparison of liquid yield from pyrolysis of different types of plastic samples; results showed that pyrolysis of real plastic wastes exhibited modest and unpredictable liquid yields due to the presence of contaminants[3]. This comparison also showed that future research must use plastic samples that are more reflective of real-world applications to promote the uptake of pyrolysis as a method of plastic waste disposal.

Creating a Database for Chemical Recycling Processes

- To promote LCA research in chemical recycling, we aggregated data from various sources to create a unified, consistent life cycle inventory (LCI) database (Figure 3).
- Future LCA studies can apply this database to:
  - Select the most suitable CR technology for a specific setting.
  - Identify environmental "hotspot" during plastic waste management.

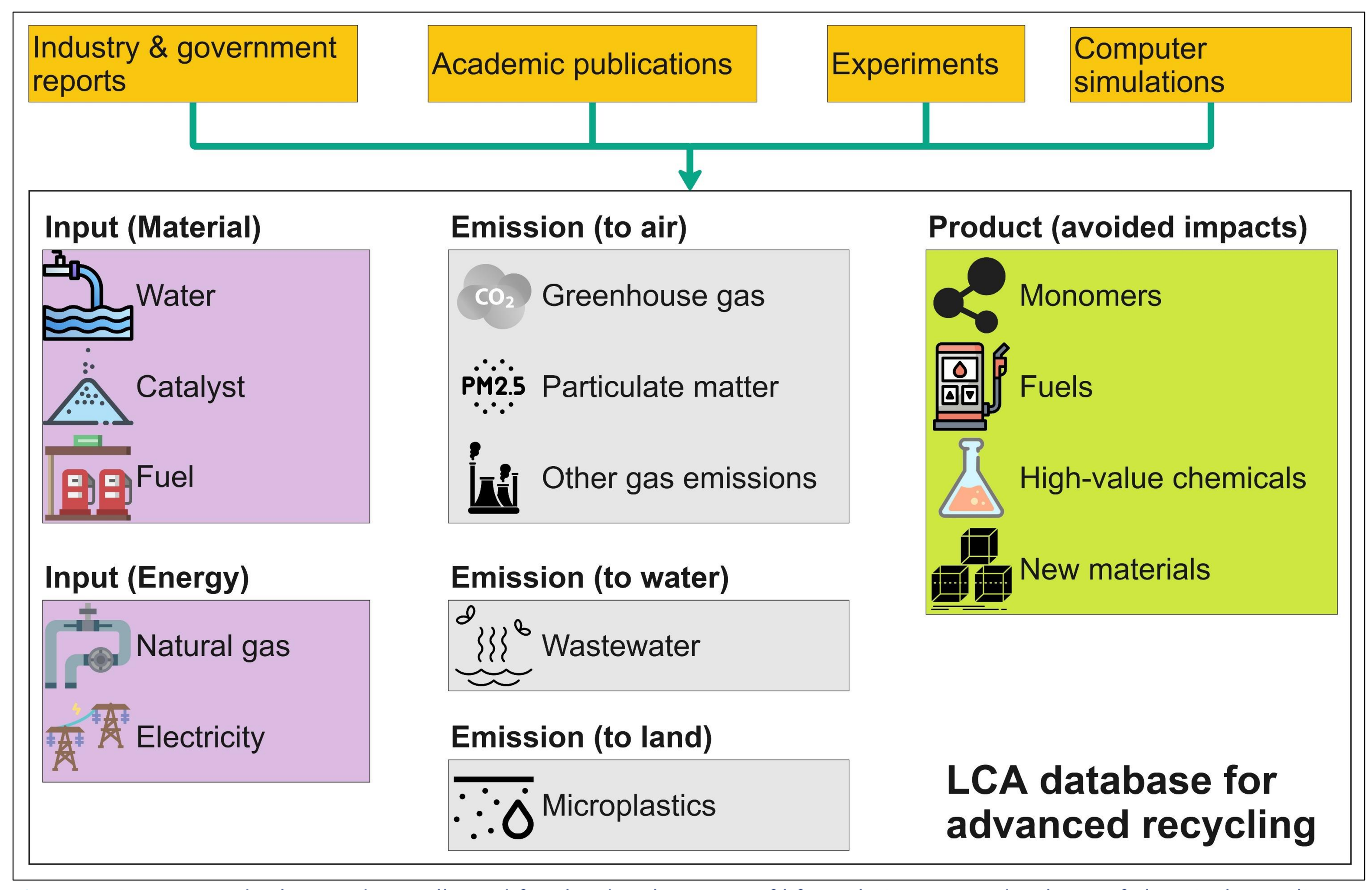

Figure 3: Sources and relevant data collected for the development of life cycle inventory database of chemical recycling technologies.

Case Study: Management of Discarded Hard Plastics

- Comparative LCA of different management options for hard plastic wastes, including (i) pyrolysis; (ii) gasification; and (iii) landfill.
- Monte Carlo analysis showed that impact score of CR processes (pyrolysis and gasification) had higher variability compared to landfill. Indicating high uncertainty (Figure 4).
- Future research and data collection can minimise this uncertainty.
- Accounting for data uncertainty, the plastic waste management options were ranked as: Pyrolysis > Landfill > Gasification.
- Impact score in other categories, such as eutrophication, acidification, and fossil fuel depletion potentials are presented in detail in Xayachak et al. [4].

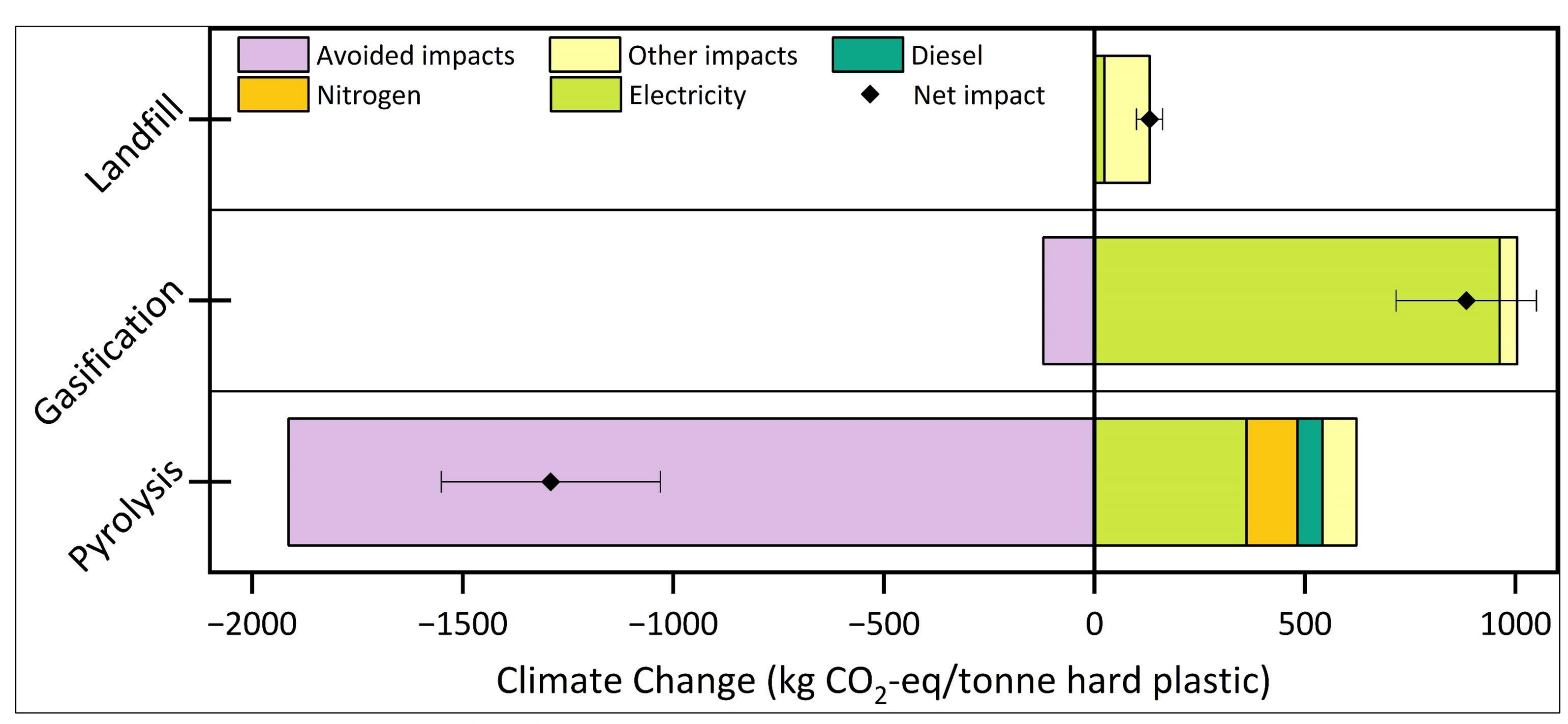

Figure 4: Greenhouse gas emission (GHG) of different management options for hard plastic wastes. Diamond symbols indicate net impacts and error bars represents variability of impact scores due to data uncertainty. Results showed that pyrolysis had the best environmental performance whereas gasification had the worst. Although the operation of landfill has the least GHG emission it has impacts in other areas, such as eutrophication and fossil fuel depletion.

FOR FURTHER INFORMATION
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