Evaluation of Waste-to-Energy Technologies for Non-recyclable Plastic Waste

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Introduction

Non-recyclable plastic waste disposal without adequate treatment leads to significant pollution of the environment. An effective system for managing plastic waste must be techno-economically, environmentally, and socially sound. Energy recovery technologies from *non-recyclable plastic waste* can play a vital role in mitigating pollution from the environment. In addition to recovering significant energy, these technologies can lead to a substantial reduction in the total quantity of *non-recyclable plastic waste* requiring final disposal and simultaneously fulfill pollution control standards (Johnke et al., 2001). The rate of *non-recyclable plastic waste* generation is affected by socio-economic development, the degree of industrialization, and climate.

A range of *waste-to-energy technologies* are now well-known for exploiting the potential of *non-recyclable plastic waste* as an energy source, varying from basic systems to more advanced conversion processes capable of handling large quantities of *non-recyclable plastic waste*. The conversion of *non-recyclable plastic waste* to energy is based on three main routes: *thermochemical*, biochemical, and physicochemical. Due to limited available reports, this research article examines the *thermochemical* conversion of *non-recyclable plastic waste* for energy recovery. There is also no publicly available reference pertaining to work done on the techno-economic, environmental, and social outcomes of *non-recyclable plastic waste* processed via *thermochemical conversion technologies* based on their associated characteristics.

This research paper attempts to provide a new perspective on the *evaluation* of *waste-to-energy technologies* for *non-recyclable plastic waste* by including various *thermochemical* process characteristics in the *PROMETHEE II* multicriteria evaluation method.

Material and Methods

The method of *thermochemical* conversion includes thermal decomposition of organic matter (plastic waste) to generate either heat or petroleum or gas. *Thermochemical* conversion, marked by increased temperature and conversion rates, is best aligned to feedstock with reduced humidity and is usually less selective for materials. *Gasification*, *pyrolysis*, and *incineration* are the primary technological choices in this category (Indrawan, 2008). *Figure 1* shows the processes and its products of *thermochemical* conversion, as well as energy and material recovery systems.

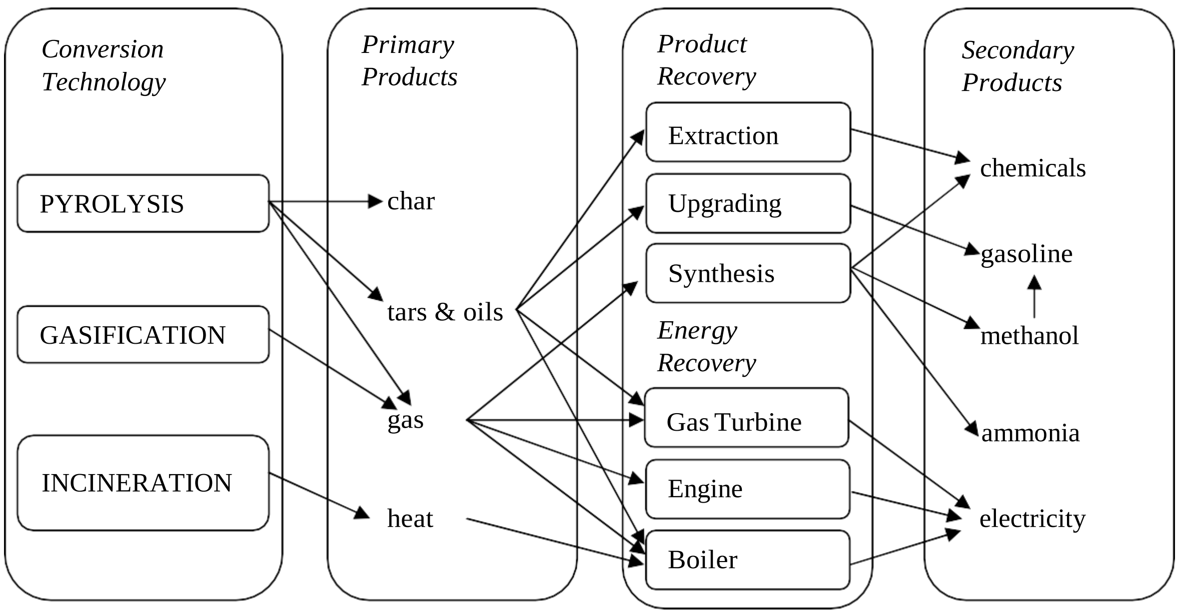

Figure 1: *Thermochemical* conversion processes and products (Bridgwater, 1995)

There are several *thermochemical* technology options that can be used to recover energy from plastic waste. While some of these have already been implemented on a big scale, others are under sophisticated phases of development. *Gasification* can be widely defined as the *thermochemical* conversion, by the supply of a gasifying agent, of a solid carbon-based material (feedstock / plastic waste) into a fuel gas (Gershman et al., 2013). *Pyrolysis* is a *thermochemical* reaction which involves the molecular breakdown of larger molecules into smaller molecules in the presence of heat and in the absence of oxygen (Serio et al., 2001). *Incineration* is a *thermochemical* process done via a grate system that combusts the (plastic) waste, which is not refined and is crude (World Energy Council, 2016).

The multicriteria method, *PROMETHEE II* (Preference Ranking Organization Method for Enrichment Evaluation), was chosen for the evaluation process of the study. It utilizes the outranking principle to rank alternatives, coupled with ease of use and reduced complexity. It performs a comparison of alternatives in pairs, taking into account the chosen criteria. It also uses preference functions to measure the level of difference between the alternatives. Alternative actions can be ranked by either positive or negative flow. In *PROMETHEE II*, the net flow (Φ) is computed by taking the difference of output minus input flows allowing a complete ranking of all alternatives (Strantzali et al., 2017).

Results and Discussion

Detailed research (RTI International, 2012) on *thermochemical* processes of *non-recyclable plastic waste* shows that *gasification* procedures offer more favorable solutions in terms of public acceptance, feedstock & product flexibility, greenhouse gas emissions, efficiency, and safety. On the other hand, *pyrolysis* has lower air emissions and medium public acceptance. The *incineration* process is relatively better as it requires minimum land area and the process is noiseless and odorless but it has higher capital and operation & maintenance (O&M) costs with lower public acceptance.

Conclusions

This research paper investigates a variety of *thermochemical conversion technologies* of *non-recyclable plastic waste*, showing that the *gasification* process provides a significant improvement in energy recovery rates and minimizes prospective greenhouse gas emissions. With high contents of carbon and hydrogen in *non-recyclable plastic waste*, thermal degradation processes at an elevated temperature can lead to the production of value-added electricity, hydrocarbon fuels, and chemical products.

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