

# Study

# “Thermal Processes for Feedstock Recycling of Plastics Waste”

Conducted by

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## Introduction

While all efforts in plastics material recycling showed, despite of all success in the development of new sorting technologies as well as in recycling technologies, that the amount of plastics that can be recycled as high quality material is limited. New approaches are additionally needed to move the idea of a circular economy for plastics to success.

One option for such an approach are technologies, aiming at the breakdown of polymers into small molecules, which are similar to the used feedstock in the chemical industry, and which can substitute fossil based feedstock.

Due to the fact that plastics waste usually is part of complex mixtures of waste streams or even part of complex appliances, the study focuses on technologies which are able to handle those waste streams.

In the past several developments and installations of such technologies took place, but all failed in the market introduction, mostly due to the lack of competitiveness or major errors in engineering.

The economic frame conditions within the EU changed over the last 20 years. Quite a few member states have landfill restrictions for high calorific waste in place. European legislation obliges the industry to achieve for defined products high recovery and recycling rates (e.g. ELV, WEEE, Packaging directive).

Having these challenges in view, BKV GmbH and PlasticsEurope AISBL decided to evaluate the level of technology readiness of pyrolysis and gasification for the treatment of five waste streams relevant for plastics.

In the first step recovery technologies for plastic relevant waste streams were identified, the available technical information reviewed a process for evaluation identified, and their input specifications documented.

In the second step, plastic relevant waste streams were identified and their composition documented. The necessary pretreatment efforts to meet the input specifications were identified.

In the third step, mass and energy balance calculations for the recycling technologies were performed. Based on these results a cost calculation for the whole treatment chain was done.

The study provides an understanding on the technology readiness level of gasification processes as well as pyrolysis processes, identifies weaknesses in the technological development and gives an indication on the competitiveness of these processes.

The report is structured into three parts. Part one describes the whole process chain, starting from the waste and ending with the recycling product. The next two parts give a detailed view on the composition of the chosen waste streams and the necessary pretreatment in order to meet the input specifications.

## Major Results

More than 80 feedstock recycling processes were identified. For four of these processes sufficient data were available for a further evaluation, considering the Technology Readiness Level as well as the basic economics.

Table 1 shows the Technology Readiness Level (TRL) for the valued technology pathways and the combined treatment steps.

Process	Pretreatment Feedstock	Conversion	Upgrading Rawgas / crude	Product utilization
Fixed Bed Gasification (BGL)	9	8	7	MeOH- <sup>1)</sup> Synthesis
Fluidized Bed Gasification (CFB)	9	8 - 9	7	MeOH-Synthesis
Entrained Flow Gasification (EFG)	5 - 6	6	9	MeOH-Synthesis
Pyrolysis	9	5 - 6	3	Steamcracker

The results show:

1. Looking on the treatment chain for all processes, it is shown that there is a lack in the technological development for every process chain.
2. The lack of development occurs on different stages.
3. One of the most interesting technologies – Pyrolysis - shows for the core process as well as the upgrading step, that an elaborate development is still necessary.

The necessary gate fee was calculated as cost to cover all steps along the chain. For the main products (syngas, steamcracker liquid feed), no revenues were included. The results are shown for the different waste streams and the examined process chains.

Process	RHW <sup>2)</sup> [€/t]	ASR <sup>3)</sup> [€/t]	ESR <sup>4)</sup> [€/t]	EPR-SR <sup>5)</sup> [€/t]
BGL	274	275	431	No access to analysis data, calculation not possible.
CFB	212	211	339	
EFG	228	189	292	
Pyrolysis	183	124	181	

1) MeOH – methanol, 2) RHW – residual household waste, 3) ASR – automotive shredder residue, 4) ESR – electro/electronic shredder residue, 5) EPR-SR – extended producer responsibility sorting rest

The results show:

1. Main drivers for the gate fees are the investment and the composition of the waste stream.
2. The necessary gate fee is slightly higher than the gate fee for MSWI<sup>6</sup> as the competing process.
3. Including the revenues for syngas or pyrolysis oil as a replacement for naphtha cost competitiveness compared to MSWI can be expected.

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6) MSWI – municipal solid waste incinerator