

PLASTICE

New technologies to integrate PLASTIC waste in the Circular Economy

Training materials

Module 2: Testing the technologies

Unit 2.1: Microwave-assisted thermochemical processing: prospects and scalability



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement n° 101058540.

MODULE 2 Overview

This module is composed of four units, each showcasing innovative approaches to plastic and textile waste recovery. The units present real-world demonstrations of how emerging technologies can support a circular economy through scalable and sustainable solutions. These include:

- **Unit 2.1: Demo-sites for gasification and chemical post-treatment: enabling innovation in circular plastic technologies**
- Unit 2.2: Pilot-scale plant for Microwave-Assisted pyrolysis of plastics for oil obtention
- Unit 2.3: Enzymatic hydrolysis: Demonstrating mixed textile-waste recycling at pilot scale
- Unit 2.4: Demo-sites as innovation hubs for startups and academic entrepreneurs

These technologies have been developed and validated within the framework of the **PLASTICE project**, funded by the European Commission, which aims to promote circular solutions for plastic waste valorisation through **chemical recycling**.



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Unit 2.1

Demo-sites for gasification and chemical post-treatment: enabling innovation in circular plastic technologies

*The PLASTICE demo-site for plastic **waste gasification** and **chemical post-treatment** provides a key enabler platform for testing, validating, and scaling up innovative recycling processes. It allows startups and academic entrepreneurs to develop syngas-to-DME (Dimethyl Ether) and DME-to-olefins conversions, ensuring technological advancements to reach industrial applications.*

Key points of Unit 2.1

- **Solid Recovered Fuel (SRF)** can be reused through the gasification process and post-chemical treatments, which convert plastic waste into valuable products.
- The Italian **demo-plant permits startups to test syngas to DME and DME to olefins conversion processes** under various conditions.
- **Syngas to olefins conversion** is achieved through a catalytic process, enabling flexibility in future industrial applications.



Introduction

Gasification is a suitable solution for highly contaminated streams, as the process is less affected by the feedstock impurities, and it produces a more **homogenous outcome** (syngas). However, the storage and transport of the syngas is a barrier to the gasification process. Therefore, PLASTICE will demonstrate a symbiotic operation of a gasifier with a **chemical reactor** for the syngas post-treatment. In this way, it is possible to obtain valuable products (i.e. ethylene and olefins) on a single and autothermic process.

Process operation at the PLASTICE Italian demo site

In the European project PLASTICE, the demo-site for gasification and chemical post-treatment is one of the methods used to produce dimethyl ether, which will then be processed to produce **olefins**. This complex process can serve as a platform to foster innovation and entrepreneurship in the waste valorisation sector by converting plastic waste into valuable chemical products.

The process begins with the selection of plastic waste to produce Solid Recovered Fuel (SRF). Ensuring a **stable treatment system** is critical to maintaining the characteristics of the SRF constant. The SRF has been characterised through **specific measurements** (density, moisture, proximate, and ultimate analysis) to determine its suitability for conversion. Ultimate and ash analysis have been performed to evaluate the content of both the main elements and minor elements (such as S, Cl), which can be considered **catalyst poisons** at a certain level. The results of the analysis showed that the metal content in the ashes was mainly represented by Pb, Zn, and Cu. These elements must be minimised because they cause the possible formation of eutectic systems, which can modify the composition of the catalyst by reducing its active surface. Consequently, the gasifier reactor will be equipped with a **plasma torch** and a **gas washer** to respectively remove fly ashes and heavy metals in the syngas.

The gasification process represents the first step in converting SRF into high-value products. The demo site gasifier (CE-RKR), with a maximum capacity of 1,5 tonne/h, operates at temperatures up to 900 °C, using gas torches. The generated syngas, after a wet gas cleaning and iron filtering system, will be sent to the ZEB reactor, made up of a multifunctional hybrid catalyst to complete the first



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conversion step (from syngas to DME). The clean syngas will be pumped into the ZEB reactor via a compressor, which will bring the gas to a pressure of 50 bar. The ZEB reactor was designed to treat up to 300 m³ of syngas, being a modular membrane reactor that requires minimum maintenance and can process syngas continuously without downtime.

The second conversion step is represented by the process transforming the DME into the light olefins, which represent the main building blocks to produce bio-polymers able to **close the loop of the plastics chain in a sustainable way**. Lab-scale experiments indicate a complete DME conversion at 300 °C and atmospheric pressure, achieving a 35% yield of light olefins.



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Conclusion

Italian demo-site as Innovation Hub

Italian demo-site provides a controlled environment for startups and academic entrepreneurs to test and optimize waste valorisation technologies. They reduce the gap between research and industrial application, accelerating the development of sustainable solutions.

◇ Recommendation: support the creation and funding of demo-sites to facilitate technology validation and foster entrepreneurship in circular economy sectors.

Advancing Gasification and Chemical Recycling

Gasification combined with chemical post-treatment enables the conversion of plastic waste into valuable products such as DME and olefins. Proper process design, including feedstock characterization and reactor optimization, ensures efficiency and repeatability.

◇ Recommendation: establish regulatory frameworks that encourage the adoption of advanced waste valorisation technologies and promote investment in research-driven pilot projects.

Standardization and Quality Control

Ensuring adequate quality of Solid Recovered Fuel (SRF) is critical for efficient conversion processes. Feedstock stability, ash composition, and catalyst protection influence process efficiency and environmental impact.

◇ Recommendation: develop standardised protocols for SRF characterization and implement certification schemes to improve process reliability and market confidence.

Industrial-Startup Collaborations

Collaboration between industries and startups accelerates the commercialization of innovative technologies. Demo-sites act as meeting points where emerging companies can refine their solutions and industries can integrate new approaches.

◇ Recommendation: promote public-private partnerships to enhance knowledge exchange and facilitate access to demo-site infrastructure for emerging businesses.



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NEXT

UNIT 2.2

Pilot-scale plant for Microwave-Assisted pyrolysis of plastics for oil obtention



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