Replication strategy assessment related to the 2030 targets for municipal waste and packaging waste in Greece

C. Politi[1], A. Peppas[1], N.A. Zafeiri[1], K. Meletis[2], S. Boutsis[2]

[1] School of Mining and Metallurgical Engineering, National Technical University of Athens (NTUA), Zografou, 15780 Athens, Greece
[2] Directorate of Environment and Spatial Planning, Region of Central Greece, 35132 Lamia, Greece
Keywords: Circular Economy, Recycling, Replication Strategy, Waste Reuse
Presenting author email: chrysapol@metal.ntua.gr

This study aims to address the challenge of Greece to achieve the targets for municipal waste and packaging waste set in EU legislation for 2030 and the 2035 target for landfilling of municipal waste. According to the Waste Framework Directive 2008/98/EC (as amended by Directive (EU) 2018/851) the goal for recycle and prepare for recuse is set to 55 % of municipal waste generated (European Environment Agency, 2022). The Packaging and Packaging Waste Directive (94/62/EC as amended by Directive (EU) 2018/852) and now the Packaging and Packaging Waste Regulation 2025/40 (PPWR) entered into force on 11 February 2025 aims to prevent and reduce packaging waste, including through more reuse and refill systems and make all packaging on the EU market recyclable in an economically viable way by 2030 (European Commission, 2020b). The Landfill Directive (1999/31/EC as amended by Directive (EU) 2018/850) introduces restrictions on landfilling of all waste that is suitable for recycling or other material or energy recovery from 2030 as well as limiting the landfilling of municipal waste to 10 % of the generated municipal waste by 2035 (European Commission, 2020a).
Greece generated about 5,420 thousand tonnes of municipal waste in 2022, and the waste generation has increased by 6.35 % since 2015 (Figure 1). This corresponds to 519 kg/cap in 2022, which is above the (estimated) EU average of 515 kg/cap (Eurostat, 2025a). The country relies heavily on landfilling with a share of about 80.9% in 2022. Respectively, the overall recycling rate has increased slightly by 5.2 percentage points from 15.8 % to 19.1 %, while only 8 thousand tonnes were prepared for reuse and 834 thousand tonnes were recycled in 2022.

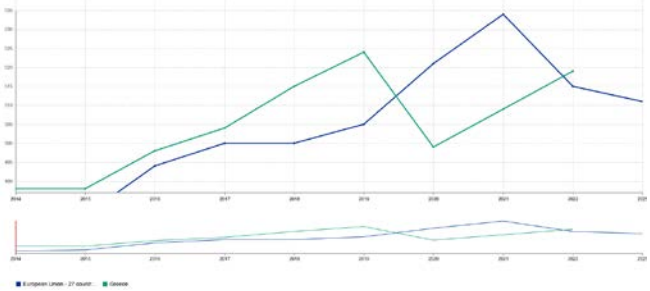

Figure 1 Municipal waste generation and treatment in Greece between 2015 and 2019, in thousand tonnes

To tackle the increasing waste generation and comply with the European Directives, the National Waste Management Plan (Legislation cabinet acts, 2020) of Greece for the period of 2020-2030 was published by the Ministry of Environment and Energy and approved by the Council of Ministers. The targets set in the NWMP are in line with the relevant EU directives. In addition, a target of minimising landfilling to 10 % of MSW generated by 2030 has been set. The NWMP outlines specific measures to enhance separate waste collection and achieve the stated targets. These include introducing separate collection for new waste streams, encouraging waste producers—particularly households—to sort waste at the source, implementing the 'pay-as-you-throw' principle, upgrading and expanding Recycling Material Sorting Centres, and conducting information and awareness campaigns (Ministry of Environment and Energy, 2020). In parallel, packaging waste in Greece reached 75.91 kg/cap in 2018, which is well below the (estimated) EU average of 173.51 kg/cap (Eurostat, 2024b). In addition, the data of packaging previous to 2009 and 2010 is not available. Between 2010 and 2013, total packaging waste generation declined sharply from approximately 83 kg per capita to 68 kg per capita. However, since 2013, an upward trend has emerged. From 2014 onward, waste generation per capita has increased across most packaging categories: paper and cardboard packaging rose from 30 to 36 kg/cap, plastic packaging from 17 to 21 kg/cap, wooden packaging from 4 to 6 kg/cap, and glass packaging from 9 to 10 kg/cap.
The replication and adoption of novel technologies can facilitate the development of waste reduction in terms of recycling and reuse to achieve the European targets of 2030. In this framework, the European Funded Project FRONTSH1P aims at ensuring green and just transition towards decarbonization and territorial regeneration through demonstration of highly replicable regenerative Circular Systemic Solutions (CSS) that address the current challenges and needs Circular Economy, transforming them into opportunities for economic growth, social inclusion, decarbonisation of systems of production and consumption. The CSSs are demonstrated in the Lodzkie Region as the foundation of a successful and ambitious circular bio-economy transformation. The main targets are

to reduce the transition timing, allowing for secondary raw materials and wastewater to be fully exploited and increasing the decarbonization targets, while ensuring citizens engagement and proactive participation. In the frame of this study, the replication of Circular Systemic Solution 1, concerning the valorisation of wood packaging waste, and Circular Systemic Solution 2 involving the valorisation of food and feed waste are analysed. The implementation refers to the Region of Central Greece and the municipality of Levadia.

The Circular Systemic Solution 1 (CSS1) focuses on the sustainable management of wood packaging waste through end-of-life disposal, reuse, and recycling. From the perspective of the sustainable use of raw wood through a circular economy approach, it is important to properly manage the wood waste generated at each stage of the value chain. The classification of wood waste varies depending on the adopted subdivision criterion. There are three main groups of wood waste. The first one is waste from forest management, such as residues from maintenance works. The second group is wood waste from industry (generated in the production process of the final goods). Industrial wood waste is generated in the production of goods from wood raw material and can be in the form of particles, shavings, sawdust, wood dust, wood chips or bark. The third group of waste is post-consumer waste (from the consumption of the final goods). This group of waste includes, among others, wood from demolition, furniture, windows and doors, packaging, e.g., pallets or panelling and flooring (Laskowska et al., 2020). To this purpose, CSS1 integrates new solutions to improve sustainability and efficiency. In the project, CSS1 system introduces a polygeneration scheme for treating wood wastes and for simultaneous production of bio-energy, bio-syngas, biogenic CO_2 as well as char. FRONTSH1P is integrating gasification technology not only for the poly-generation potential in three basic energy streams but also to valorise all potential by-products as part of the circular economy and take advantage of flexibility of gasification technology.

The CSS2 focuses on the utilization of biodegradable waste from urban and industry to produce bioenergy, compost, and bioplastics. Bio-waste – mostly food and garden waste – is the key stream of waste with great valorisation potential, contributing to the creation of a circular economy. It provides valuable materials that improve the properties of soil and fertilizer, and biogas that is a source of renewable energy. With a share of 34%, bio-waste is the largest homogeneous component of municipal waste in the European Union. Depending on the source of biodegradable waste and the place it is produced, it can be classified as municipal or non-municipal waste. Industrial and production waste, meaning non-municipal waste, includes: (1) Agricultural and food waste, (2) Forest economy and industry waste, energy crop waste, (3) Sewage sludge from sewage treatment plants. Industrial waste also includes the biodegradable fraction from the process of mechanical treatment of mixed municipal waste. The CSS2 aims at obtaining Free Fatty Acids (FFAs) as a component for foaming biomaterials through the pre-treatment of agro-industrial waste combined with biotechnological treatments. It also aims to establish innovative oil crops cultivations in marginal and abandoned agricultural areas to obtain vegetable oils that can be transformed in biodegradable bio lubricants, and locally available animal feed supplement formulations. The production of biobased building blocks (diols and dicarboxylic acids) from second generation feedstock (from regional agro-industrial waste rich in sugars) for the formulation of new compostable bioplastics (compostable bags for OFMSW collection) is also an objective. A regional roadmap is developed to define the next steps for its deployment. A framework for sustainable products is created that can provide new opportunities and tackle potential barriers to the integration of reuse and recycling technologies in Greece. In addition, the national regulation framework for fostering local economy and financing SMEs development in the region is assessed and policy measures will be recommended.

European Environment Agency. (2022, June). *Early warning assessment related to the 2025 targets for municipal waste and packaging waste*. https://www.eea.europa.eu/publications/many-eu-member-states/early-warning-assessment-related-to

European Commission. (2020a). *Landfill waste*. https://environment.ec.europa.eu/topics/waste-and-recycling/landfill-waste_en

Laskowska, A., Maminski, M., Laskowska, A., & Maminski, M. (2020). The properties of particles produced from waste plywood by shredding in a single-shaft shredder. *Maderas. Ciencia y Tecnología*, *22*(2), 197–204. https://doi.org/10.4067/S0718-221X2020005000206

Legislation cabinet acts. (2020, September 29). *Government Gazette Issue (FEK) A 185/2020*. https://search.et.gr/el/fek/?fekId=605485

European Commission. (2020b). *Packaging waste*. https://environment.ec.europa.eu/topics/waste-and-recycling/packaging-waste_en

Ministry of Environment and Energy. (2020). *Solid Waste*. https://ypen.gov.gr/diacheirisi-apovliton/sterea-apovlita/

Eurostat. (2025a). *Statistics | Eurostat*. https://ec.europa.eu/eurostat/databrowser/view/ENV_WASMUN/default/table

Eurostat. (2024b). *Statistics | Eurostat*. https://ec.europa.eu/eurostat/databrowser/view/ENV_WASPAC__custom_842634/default/table?lang=en