The potential of Waste-to-Energy Plant in Central Macedonia in the Context of Circular Economy

D. Geroliolios, M. Batsioula*, S. Skoutida*, L. Melas*, C. Karkanias*, A. Malamakis*, S. Patsios**, G. F. Banias* and N. Mousiopoulos****

**Laboratory for Environmental Engineering & Sustainability, Institute for Bio-Economy and Agri-Technology, CERTH, 10th km Thermi – Thesniki, Rd., 57001 Thessaloniki, Greece*
(E-mail: d.geroliolios@certh.gr)

*** Natural Resources & Renewable Energies Laboratory, Chemical Process & Energy Resources Institute, CERTH, 6th km Charilaou-Thermi Rd., 57001 Thessaloniki, Greece*

****Sustainability Engineering Laboratory, Mechanical Engineering Department, Aristotle University Thessaloniki, Greece*

Introduction

Greece's heavy reliance on landfilling as a waste management technique is in stark contrast to the European Union's (EU) guidelines to limit landfilling to only 10% of total waste production by 2030. The EU's ambitious targets are aligned with the principles of the circular economy, which prioritize the reduction, reuse, and recycling of waste, as well as resource recovery. The circular economy aims to minimize waste generation and reduce the dependence on landfills, which pose significant environmental and health risks. The European Green Deal, which sets out the EU's vision for a sustainable, carbon-neutral future, places a strong emphasis on waste reduction and the transition towards a circular economy. As such, Greece's heavy reliance on landfilling is not in line with the EU's long-term goals for sustainable waste management and may hinder the country's progress towards a more circular, sustainable economy.

Figure 1: Waste-to-Energy plant in Copenhagen

Waste-to-energy (WtE) technologies can play a crucial role in aligning Greece's waste management practices with the EU's guidelines for sustainable waste management. WtE technologies can convert waste into energy, reducing the dependence on fossil fuels and mitigating greenhouse gas emissions.
This study presents an analysis of the waste management system in the Central Macedonia region. Through data collection from various sources such as LSWMP, NSWMP, and RSWMP, the current status of solid waste production is evaluated. A regression analysis is used to generate a forecast of solid waste production for the period of 2020-2030. Based on the projected waste production, three different scenarios are examined to determine the feasibility of implementing a Waste-to-Energy plant to achieve the target of limiting landfilling to 10%

Results & Discussion

Data obtained by sources such as LSWMP, NSWMP and RSWMP were used το predict waste production in the region of Central Macedonia using regression analysis. The data cover the years 2011-2019 and the prediction is for 2020-2030. The prediction was done on a regional unit level (Thessaloniki, Imathia, Kilkis, Pella, Pieria, Serres and Chalkidiki). The regression analysis was done using the SPSS software to calculate the curve estimation that best describes each regional unit. The curve estimation was selected based on the coefficient of correlation R^2.

Regional Unit	Curve estimation	Equation	R^2
Thessaloniki	Linear	$y = 2.425{,}24x + 465.821{,}73$	0,413
Imathia	Third-degree polynomial	$y = 54.064{,}79 - 165{,}72x + 22{,}48x^2 + 0{,}26x^3$	0,893
Kilkis	Second-degree polynomial	$y = 27.922{,}2 + 236{,}02x - 1{,}27x^2$	0,843
Pella	Second-degree polynomial	$y = 55.755{,}59 - 1.218{,}29x + 108{,}95x^2$	0,587
Pieria	Linear	$y = 651{,}64x + 62.472{,}51$	0,860
Serres	Second-degree polynomial	$y = 68.323{,}64 - 593{,}60x + 53{,}36x^2$	0,801
Chalkidiki	Second-degree polynomial	$y = 93.691{,}78 + 1.731{,}80x - 51{,}96x^2$	0,804

Figure 2: Curve estimation for regional units.

Using the above curve estimations for each regional unit, the waste production for 2020-2030 was calculated for every regional unit. With the waste production for each regional unit known, the waste production for the entire region of Central Macedonia was calculated.

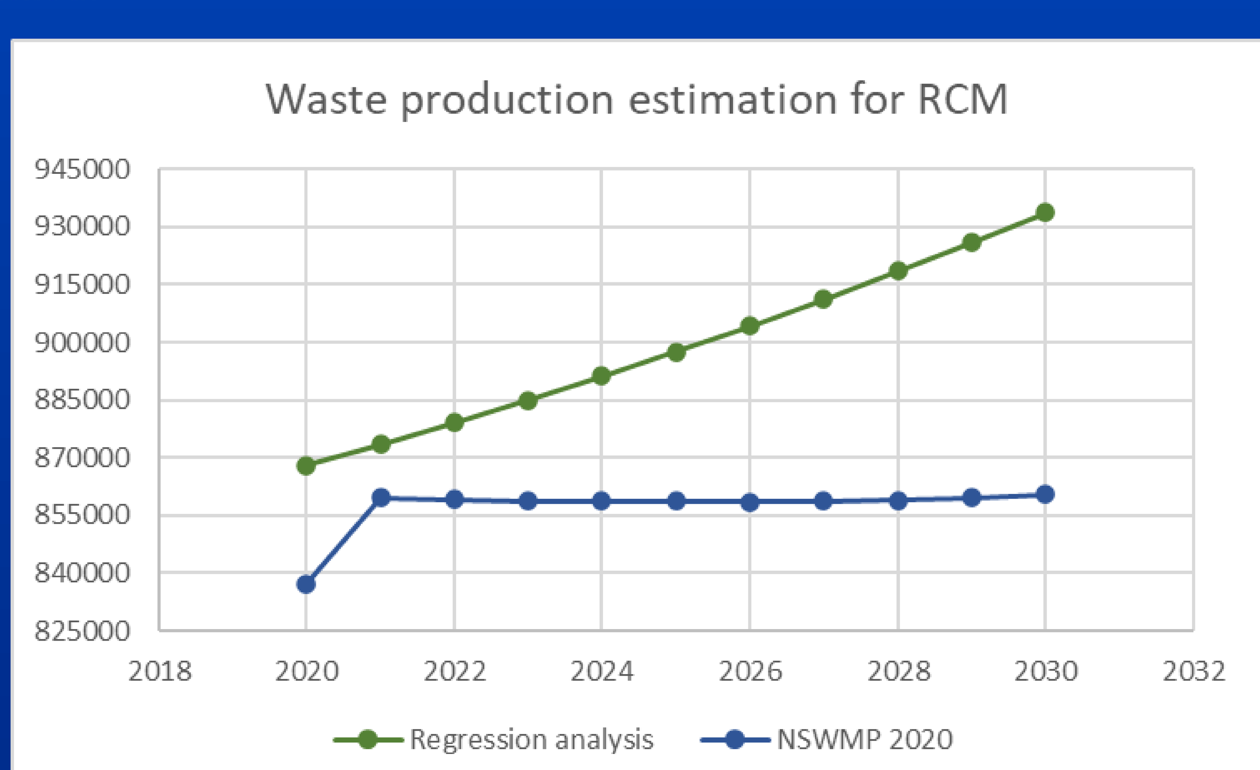

Figure 3: Waste production for RCM in tonnes.

The comparison of the results of the regression analysis with the data obtained from the NSWMP of 2020 show a divergence that can be explained based on the assumption of the NSWMP that waste prevention measures will be implemented in the next decade to maintain waste production to 2019 levels. Overall, the yearly divergence between the two models is between 3,66% and 8,53% (<10%).
Three scenarios are examined based on the level of implementation of waste treatment facilities (Serres – 46.400 t/year, East Sector – 129.300 t/year, West Sector – 261.600 t/year).

	%	Quantity (t)
Waste production	100%	933.763
Landfill target	10%	93.376
Source separation	35%	326.817
Organic waste (brown bin)	15%	140.064
Waste to WTF	50%	466.881,5

Figure 4: Assumptions

All scenarios assume that mixed Municipal Solid Waste (MSW) are treated in Waste Treatment Facilities (WTF). Only residue from WTF is feeded in Waste-to-Energy plants (WtE). The residue from WtE plants is then landfilled with MSW that is not treated in WTFs due to capacity restraints. The WTF removal efficiency is 65% and the WtE removal efficiency is 85%. The three scenarios are the following:

1. Base scenario- Only Serres WTF facility available
2. Scenario I – All WTFs available
3. Scenario II – WTFs in Serres and East Sector available

Quantity	Base scenario	Scenario I	Scenario II
WTF capacity (t)	46.400	437.300	175.700
MSW not treated (t)	420.481,5	29.581,5	291.181,5
WTF output – WtE input	16.240	153.055	61.495
WtE output	2.436	22.958,2	9.224
Landfilling (t)	422.917,5	40.836,5	300.405,7
% landfilling	45,3	5,6	32,1

Figure 5: Results for each scenario.

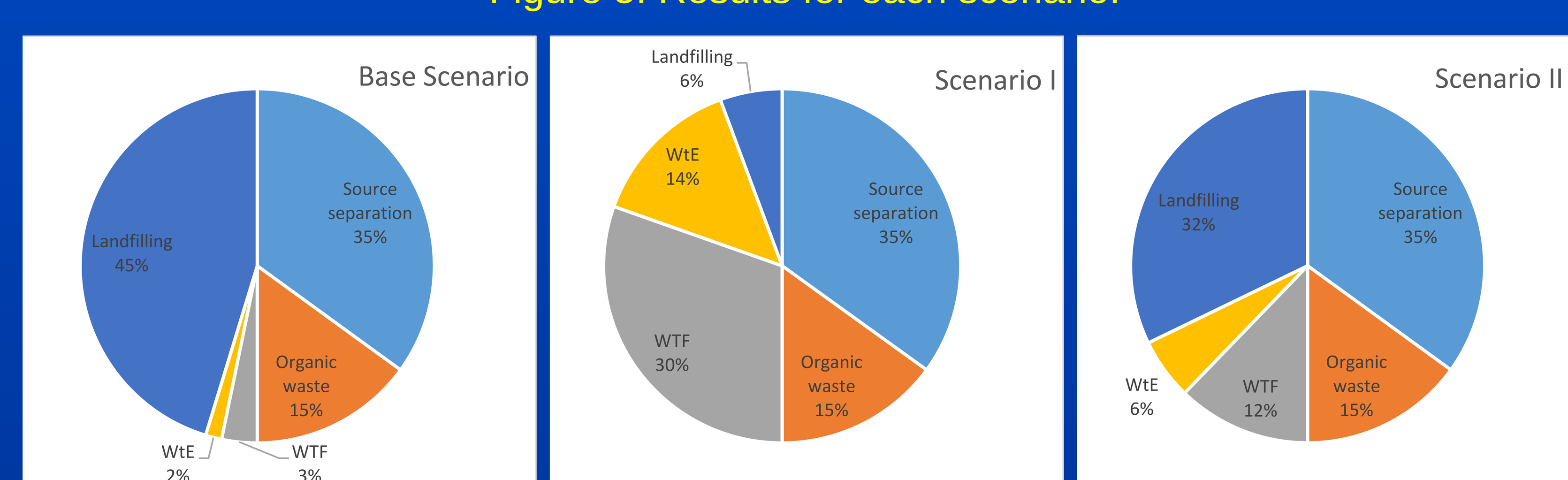

Figure 6: Waste distribution for each scenario.

Figure 6 showcases the necessity of implementing all three WTFs that have been scheduled from FODSA, as all other scenarios fail to achieve the landfilling target.
Only in scenario I is the landfilling target achieved, highlighting the need to implement the WTFs together with WtE plant in the context of an integrated waste management system. The study found that without WtE plants, the landfilling target cannot be achieved by just implementing the WTFs.

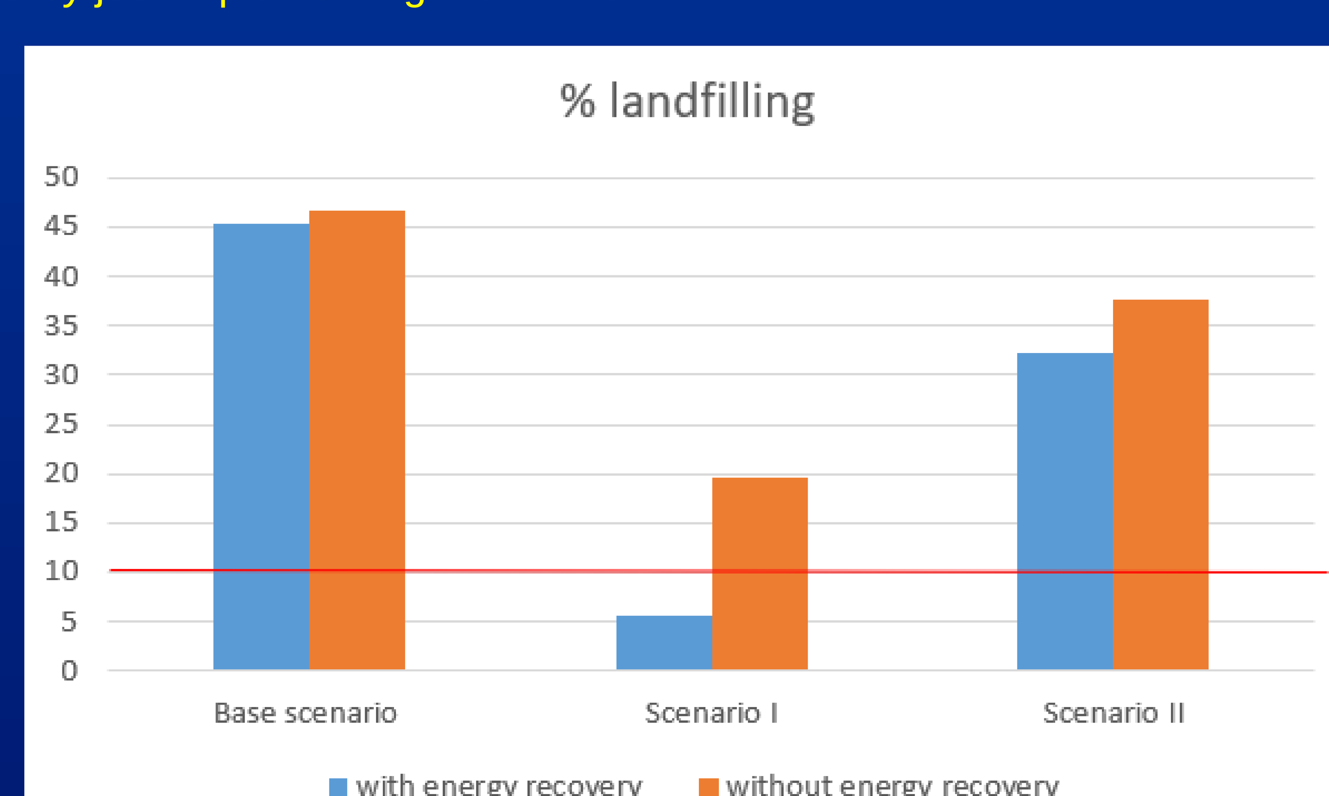

Figure 8: Landfilling % with and without energy recovery

Conclusions

This study highlights the importance of leveraging all available technologies, including waste treatment and Waste-to-Energy (WtE) plants, to design an integrated waste management system that aligns with the principles of the circular economy. he findings of the study suggest that an integrated approach that incorporates waste reduction, recycling, and WtE is necessary to achieve the targets set by the EU and the European Green Deal. The findings of the study can provide valuable insights for policymakers, waste management practitioners, and other stakeholders in designing effective waste management strategies that prioritize the principles of the circular economy.