

Valorization of urban sewage sludge and used cooking oils into bio-H₂ or bio-methane alternative transport fuels for municipal garbage trucks

N. Ntavos^{1,*}, E. Papista^{1,2}, A. Lampropoulos^{1,2}, G. Varvoutis^{1,2}, Y. Fallas¹, G.E. Marnellos^{1,2,3}

¹ Cluster of Bioeconomy and Environment of Western Macedonia, Greece

² Department of Mechanical Engineering, University of Western Macedonia, Greece

³ Chemical Process & Energy Resources Institute, Centre for Research & Technology Hellas, Greece

* Corresponding Author: n.ntavos@clube.gr; Tel.: +30-2461056652

Abstract

The climate change and EU dependence on energy imports are major threats for the prosperity of the continent and its citizens, as spotted out in the Green Deal strategy and REPowerEU plan announced recently by the European Commission ¹. Both plans contain ambitious targets to decouple the European economy from carbon emissions by vastly increasing the shares of variable renewables and alternative fuels, such as hydrogen and biogas, in the EU energy mix, enabling in parallel the effective mitigation of the greenhouse effect and EU independence on fossil fuel imports. In this context, the European coal regions, such as the Western Macedonia Region (WMR) in Greece, which its economy was for more than six decades traditionally dependent on lignite mining and power production activities, are forced to phase out of coal and effectively bridge the gap between the current “grey” economy to a greener, sustainable and prosperous future by investing in diversified economic activities securing at the same time a smooth and just transition for local communities ². Toward this direction, the local regional and municipal authorities are planning to deploy an integrated system, as schematically illustrated in **Figure 1**, to convert sewage sludge and used cooking oils (UCOs) from all 13 municipalities in the Region of Western Macedonia, into biogas through anaerobic digestion, which will then be converted to bio-H₂ or bio-CH₄ to fuel municipal garbage trucks. This circular approach will not only partially compensate the current sewage sludge disposal problems and costs, but it will make WMR a lighthouse example in the northeastern part of Europe by promoting and establishing relevant infrastructure to deploy bio-H₂ and bio-CH₄ as alternative fuels for the transportation sector.

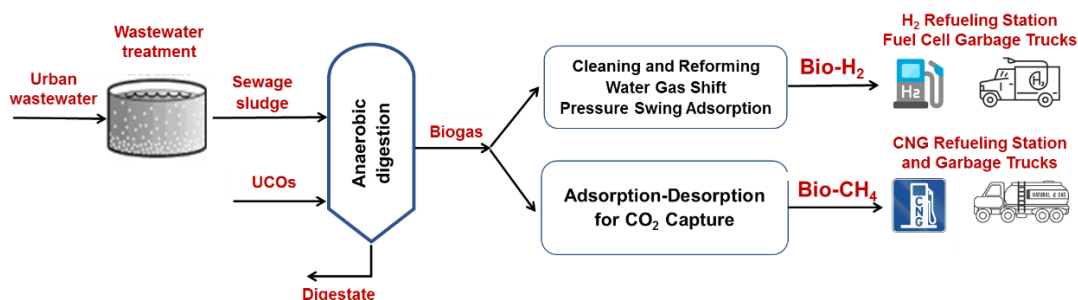


Figure 1. Schematic illustration of the valorization of sewage sludge and UCOs for bio-H₂ or bio-CH₄ production and deployment as fuel for municipal garbage trucks

The high content of energy-containing carbonaceous molecules such as polysaccharides, proteins and lipids, has rendered sewage sludge into an abundant source for sustainable energy conversion ³. Instead of aerobic digestion to produce compost, landfilling and incineration, anaerobic digestion is an environmentally friendlier solution that produces biogas (CH₄ + CO₂) and stabilizes organic waste into a digested biomass suitable for fertilizers or soil reclamation. Compared to biogas, which is also regarded as a renewable and carbon-neutral energy vector, both hydrogen and methane have higher heating values and are considered as very promising clean fuels for several sectors including transportation ^{4,5}. To this end, the present work aims to assess the feasibility, environmental and financial benefits of the proposed pathways to convert locally available sewage sludge and UCOs into bio-H₂ or bio-CH₄ to fuel through dedicated refueling stations municipal garbage trucks that are currently operating on fossil diesel.

References

1. European Commission. *REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition.* (2022).

2. Karasmanaki, E., Ioannou, K., Katsaounis, K. & Tsantopoulos, G. The attitude of the local community towards investments in lignite before transitioning to the post-lignite era: The case of Western Macedonia, Greece. *Resour. Policy* **68**, 101781 (2020).
3. Mitraka, G.-C. *et al.* A Comprehensive Review on Pretreatment Methods for Enhanced Biogas Production from Sewage Sludge. *Energies* **15**, 6536 (2022).
4. Khan, M. U. *et al.* Current status of biogas upgrading for direct biomethane use: A review. *Renew. Sustain. Energy Rev.* **149**, 111343 (2021).
5. Kumar, R., Kumar, A. & Pal, A. Overview of hydrogen production from biogas reforming: Technological advancement. *Int. J. Hydrogen Energy* (2022)
doi:10.1016/j.ijhydene.2022.08.059.