# SYMSITES-EcoSites Implementation for Industrial-Urban Symbiosis through Social and Technological Solutions

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**Abstract**

The SYMSITES project aims at implemeting the Industrial - Urban Symbiosis (I-US) concept by newly developed technologies and solutions for wastewater treatment and reuse supported by an IT Management system, while applying a digital and circular economy. This will be achieved with local and regional collaborations i.e., Municipalities, Universities and research centers, Large and Small Enterprises. The project output will enhance the sustainability and environment in the specific region.
The implementation of the regional I-US will be proven in four European regions, different in geographic, socioeconomic, and environmental aspects. The co-treatment of wastewater and other urban and industrial waste in each of the four EcoSites will allow the recovery of energy, water, and high-value-added products.

**Keywords**

AnMBR, industrial waste, regional development, wastewater, water reuse

## INTRODUCTION

Municipal wastewater (WW) and solid waste (BW) volume from domestic activities is dramatically increasing due to the increment in the worldwide population and activities in urban areas. Water pollution and overproduction of waste, lead to shortages in natural resources, thus innovations are required in waste treatment. These innovations must be based on a new paradigm: from waste management to a resource management philosophy. Through energy and material retrieval, wastes are a resource that can and must be drawn upon - this is the concept of waste recovery and recycling.

Transitioning into a digital circular economy as a strategy for sustainable regional development requires the development of multidisciplinary approaches. Wastewater treatment can be a source of renewable energy proven by SYMSITES. In parallel, water reclamation and reuse for industrial purposes should be facilitated. These changes require the engagement of the policymakers, governing bodies, and industries acting at key stages in this transition, improving on-source waste separation for a further I-US.

This project aims to develop

complementary technologies to apply advanced anaerobic membrane bioreactor (AnMBR) treatment of urban and industrial wastes in four European regions, different in geographic, socioeconomic, and environmental aspects, from the north of Denmark, through the centre of Austria and the south of Spain and Greece, thus allowing the transition towards a digital circular economy. The technologies will include: an advanced AnMBR for the co-treatment of waste and wastewater, coupled with ii) a tertiary treatment based on an adsorption column (AC)-based with antibacterial and antiviral activated carbon; iii) a pyrolysis system to convert non-recyclable wastes into platform molecules and activated carbon for the adsorption column, iv) a newly developed IT-based Regional Management Platform including novel IoTs, artificial intelligence and a Social Decision Support System to manage the I-US efficiently.

## MATERIALS AND METHODS

- **The Spanish EcoSite**

The main objective of the Spanish EcoSite is to treat industrial and urban WW from the municipality of Alcoy together with organic solid waste from the town of Muro de Alcoy to produce green $H_2$, high-quality reclaimed water and high-value new resources (HVNR) through AnMBR with a magnetic vibration membrane (MVM) and tertiary treatment.

The predominant industries in the Alcoy area are the textile and the cosmetics industries, both need water supply for their industrial processes. Currently, both industries produce waste that is difficult to treat sustainably. The cosmetics industry produces WW from reactor cleaning with high COD and low biodegradability (30%). On the other hand, the textile industry generates non-recyclable textile waste that ends up in landfills, as well as transfer paper waste from the printing process, highly difficult to manage due to the traces of silicone and printing paste in the cellulose-based material.

The EcoSite installation will treat between 2.00 and 4.00 $m^3$/day of wastewater, and up to 50 kg/week of solid organic waste, allowing four streams of new HVNR to be obtained as output:

- Platform molecules: Benzoic acid will be produced from pyrolysis and used in the cosmetics industry for cleaning equipment.
- Charcoal: from transfer paper.
- Green hydrogen: $CH_4$ from AnMBR will be reformed into $H_2$.
- Treated water: The treated wastewater will be tested for reuse in relevant industrial processes to replace all or part of the virgin water.

- **Austrian EcoSite**

The main objective of the Austrian EcoSite is to treat WW and organic residues from a meat processing company (Fleischwaren Berger GmbH (BER)) producing biomethane ($CH_4$), clean water and a high-value fertilizer.

The meat industry processes ham and sausages. They have a wastewater volume of around 600 $m^3$/ day and an organic waste amount of around 5.00 tons/ day. The local wastewater treatment plant (Gemeindeabwasserverband Südöstliches Tullnerfeld (GST)) has reached the limits of its capacity, thus BER should reduce the quantity of organics going to the sewer system. Additionally, they need a large quantities of water for their ham production; however, the existing well will soon no

longer be able to supply the necessary quantities of water.

The EcoSite installation will treat up to 5.00 $m^3$/day of WW and up to 50 kg/week of solid organic waste, thus providing the following HVNR streams:

- High-value bio-fertilizer (mixed from organic + inorganic) for the nearby farmers.
- Char for the AC from selected pig bones.
- Treated water for cooling

- **Danish EcoSite**

The main objective of the Danish EcoSite is to treat industrial (brewery) and urban WW together with municipal organic solid waste from the town of Svaneke to produce green $CH_4$ and high-quality reclaimed water by the AnMBR and the AC.

The three waste sources to be used at the Danish EcoSite will be:

- WW from a brewery (Svaneke Bryghus (BRYG).
- Municipal organic solid waste.
- Urban WW from the municipal WWTP of the town of Svaneke.

The EcoSite installation will treat up to 4.00 $m^3$/day of WW and up to 50 kg/week of organic solid waste, resulting in three streams of HVNR:

- Char: from the pyrolysis of beer mash waste.
- Biogas rich in methane: $CH_4$ from AnMBR will be used to apply heat in the brewery or as electricity to be used for heating the AnMBR process.
- Treated water: Treated water produced will be used for irrigation.

- **Greek EcoSite**

The main objective of the Greek EcoSite is to treat industrial and urban WW as well as fermentable solid household waste (FHW) originated and collected from the municipality of West Achaia via a brown bin collection network.

The FHW will be dried and shredded to produce dehydrated biomass, namely FORBI (solid phase), as well as a liquid fraction (condensate, up to 0.24 $m^3$/d). FORBI has 1/4 to 1/5 the weight of the initial biowaste due to its low-moisture content and may be stored for prolonged periods without deterioration. It does not have any odours and may be used for fuel production, energy, and others. The liquid condensate, along with the WW from the olive oil industry, Elaiourgikes Epiheiriseis Patron S.A. (EEP) and Municipality of Western Achaia (MWA), will be treated for gaseous biofuel production and hydrogen.

The EcoSite installation will treat up to 2.00 $m^3$/day of wastewater and up to 120 kg/week of FHW, thus providing the following HVNR streams:

- Methane via AnMBR.
- Hydrogen and bioplastics via dark fermentation.
- Char for AC: The remaining fraction from the urban selective collection.
- Treated water: to be used for irrigation.

The whole operation of the Greek EcoSite is determined by the waste availability of the three waste sources described above, but mostly from the one originated by the industrial partner (EEP). In particular, the latter follows the seasonal harvesting of the olive trees. At the same time, the amount of solid waste collected by the brown bin network is affected by the population variation in the area of the EcoSite. The MWA, in addition to being a rural area, is also a tourist area due to its proximity to the sea

(Patras Gulf) as well as to the third larger city of Greece (City of Patras).

## RESULTS AND DISCUSSION

A General EcoSite diagram is shown in Figure 1.

SYMSITES will demonstrate the joint treatment of BW and WW through an anaerobic process as an alternative for the reduction of the organic waste, as required by Directive 1999/31/CE, valuing the residue as methane, an energy source. In addition, greenhouse gas emissions into the atmosphere will be reduced since the biogas is recovered in a closed system.

Finally, a wet treatment of the organic fraction of solid urban waste would unify the management methodologies of both residual currents and, therefore, a reduction in the volume and management of landfills, a reduction in transport and costs in parallel with a decrease in use of fossil fuels while saving in facilities and resources. For all these reasons, the joint anaerobic treatment of WW and BW is a highly applicable option in future urban spaces with a greater environmental commitment.

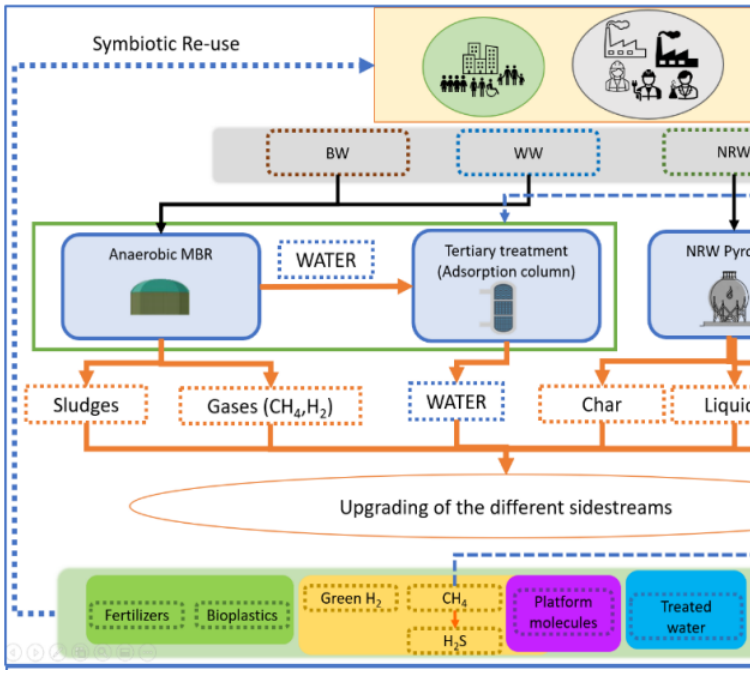


**Figure 1.** EcoSites diagram with different symbiosis strategies for industrial-urban application. BW: biowastes, WW: wastewater; NRW: non-renewable waste; HVNR: high-value non-renewable wastes.

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