



INDUSTRIAL URBAN SYMBIOSIS:

A Solution to Transform
Waste into Resources

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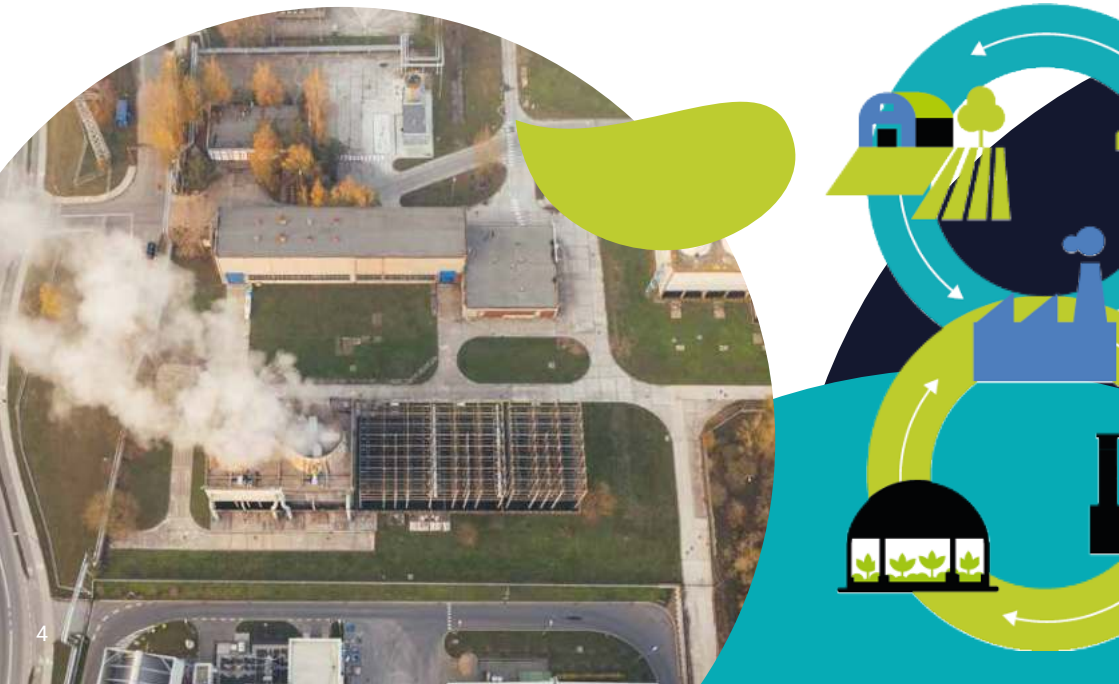
INTRODUCTION

Population growth and urbanisation are causing a dramatic increase both in municipal wastewater and in the volume of solid waste from domestic activities.

To answer the problem and face shortages in natural resources, waste treatment should embrace a new paradigm that moves **from waste management to resource management**. 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.

Innovations based on this philosophy are required, and Industrial and Urban Symbiosis is one of the solutions.

Industrial-Urban Symbiosis (I-US) is a strategic way to increase resource productivity through collaboration. In Industrial Symbiosis, industries from different sectors cooperate to exchange resources, materials, and energy. I-US adds the urban component, encouraging the involvement of municipalities and other relevant actors from urban areas.



The strategy, based on long-term cooperation, has several benefits:

- STRENGTHENS REGIONAL DEVELOPMENT
- IMPROVES THE COMPETITIVENESS OF COMPANIES
- PROMOTES ENVIRONMENTAL INNOVATION
- INCREASES THE VALUE OF UNDERUTILIZED RESOURCES
- REDUCES EMISSIONS AND THE USE OF PRIMARY AND FOSSIL RESOURCES

SYMSITES solutions are based on industrial-urban symbiosis as they transform waste and by-products into green value products.

SYMSITES will test novel technologies, methodologies, and stakeholder engagement strategies in four European **EcoSites**, each differing in socioeconomic and environmental aspects, ranging from the north (Denmark), through the mid-region (Austria), and southward to Spain and Greece.





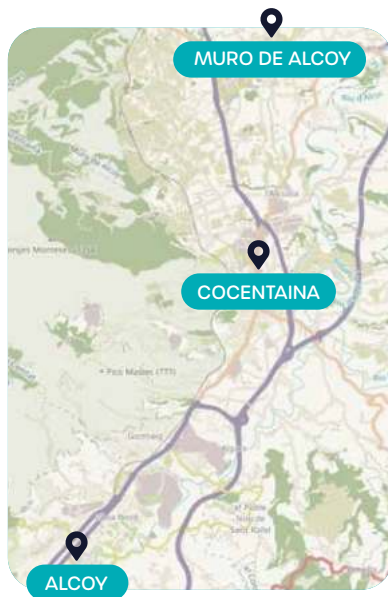


SPANISH ECOSITE



OVERVIEW

The Spanish EcoSite is located at the wastewater treatment plant (WWTP) in Alcoy, within the Valencian Community. However, the urban-industrial symbiosis covers a bigger area of approximately 8 km², spanning the municipalities of **Muro de Alcoy, Alcoy and Cocentaina** in the province of Alicante.



At the pilot-scale plant, urban and industrial wastewater is treated along with organic waste from urban areas and waste from sectors such as textiles, with the participation of the following **partners**

SOCIEDAD DE FOMENTO AGRICOLA CASTELLONENSE, S.A. (FACSA)

Manager of the EcoSite

FOMENTO VALENCIA MEDIOAMBIENTE SL (FOVASA)

Waste collection company

ASOCIACIÓN DE INVESTIGACIÓN DE LA INDUSTRIA TEXTIL Y COSMÉTICA (AITEK)

Manager of the project

FRANCISCO JOVER SA (JOV)

Textile industry

GERMAINE DE CAPUCCINI SAU (GERM)

Cosmetics industry

KATHOLIEKE UNIVERSITEIT LEUVEN (KUL)

MMV system builder

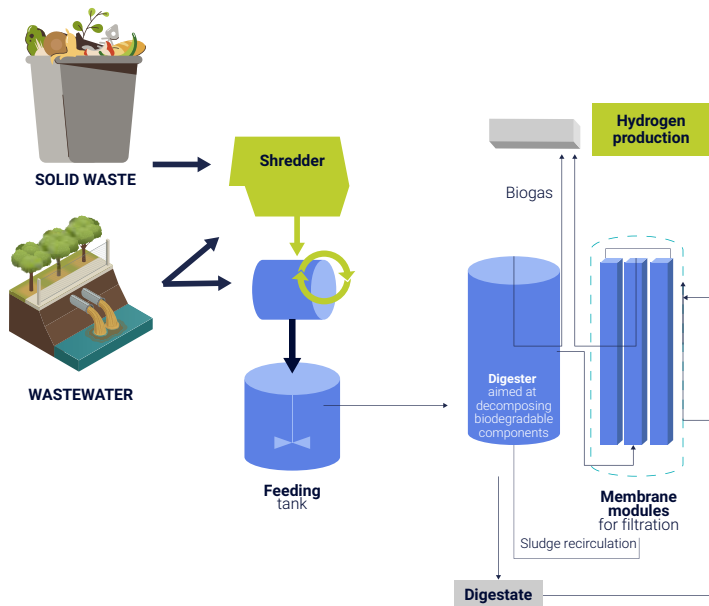
LOCAL CHALLENGES

The Valencian Community faces significant **water scarcity** due to a combination of factors, including its climate, irregular rainfall patterns, and increasing demands from agriculture, tourism, and urban and industrial development. Additionally, climate change is expected to intensify these challenges, making sustainable water management crucial for the region's future.

The predominant industries in the Alcoy area are textile and cosmetics, both requiring a reliable water supply for their industrial processes. Currently, both industries produce waste that is difficult to treat in a sustainable way. The cosmetics industry discharges reactor cleaning streams with a high organic load and low biodegradability (30%). Meanwhile, the textile industry generates non-recyclable textile waste that ends up in landfills, as well as transfers paper waste from the printing process, which is highly difficult to manage due to the traces of silicone and printing paste in the cellulose-based material.



THE ECOSITE SOLUTIONS



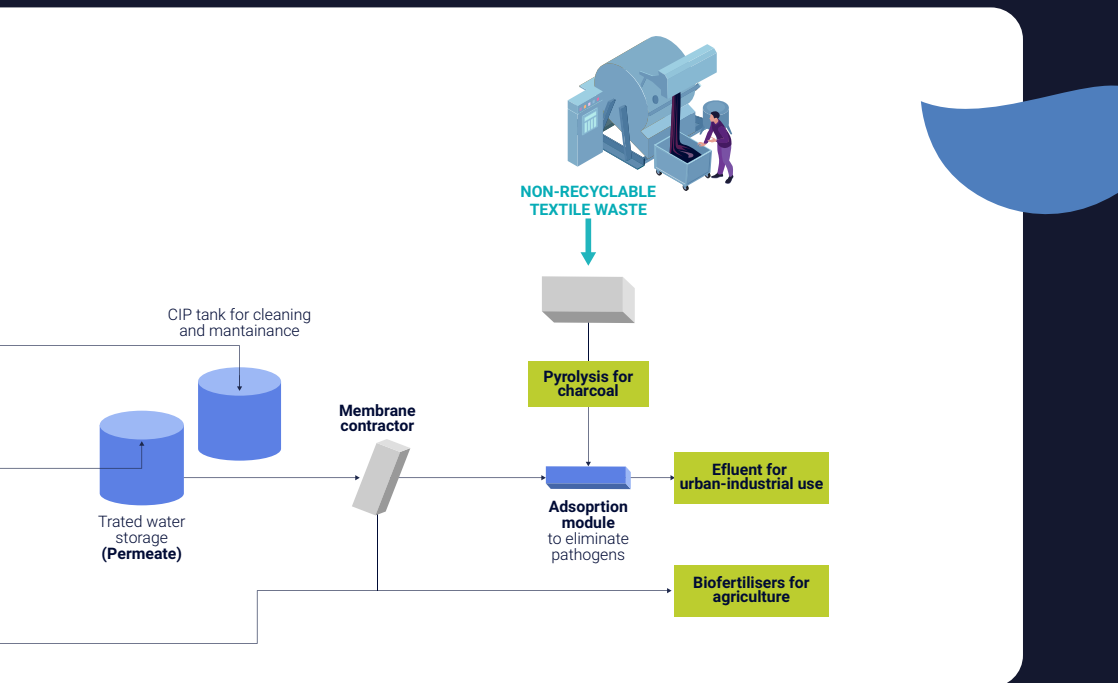
The main **objective** of the Spanish EcoSite is to treat industrial and urban wastewater (WW) from the municipality of Alcoy together with urban organic solid waste from the town of Muro de Alcoy to produce green hydrogen, high-quality reclaimed water and added-value products, through an anaerobic membrane bioreactor (AnMBR) with a magnetic membrane vibration system (MMV) innovation and tertiary treatment.

The three **sources of waste** in the Spanish EcoSite are:

- Urban organic solid waste generated and collected in the municipality of Muro de Alcoy;
- Urban and industrial WW from the municipal Alcoy WWTP;
- Non-recyclable solid waste produced in the textile industry.

The Spanish EcoSite will treat between 2-4 m³/day of WW, and up to 50 - 100 kg/week of urban organic solid waste, allowing five streams of new **added-value** products to be obtained as output:

- Platform molecules: Benzoic or acetic acid will be produced



from the liquid fraction of the pyrolysis treatment and will be used in industry.

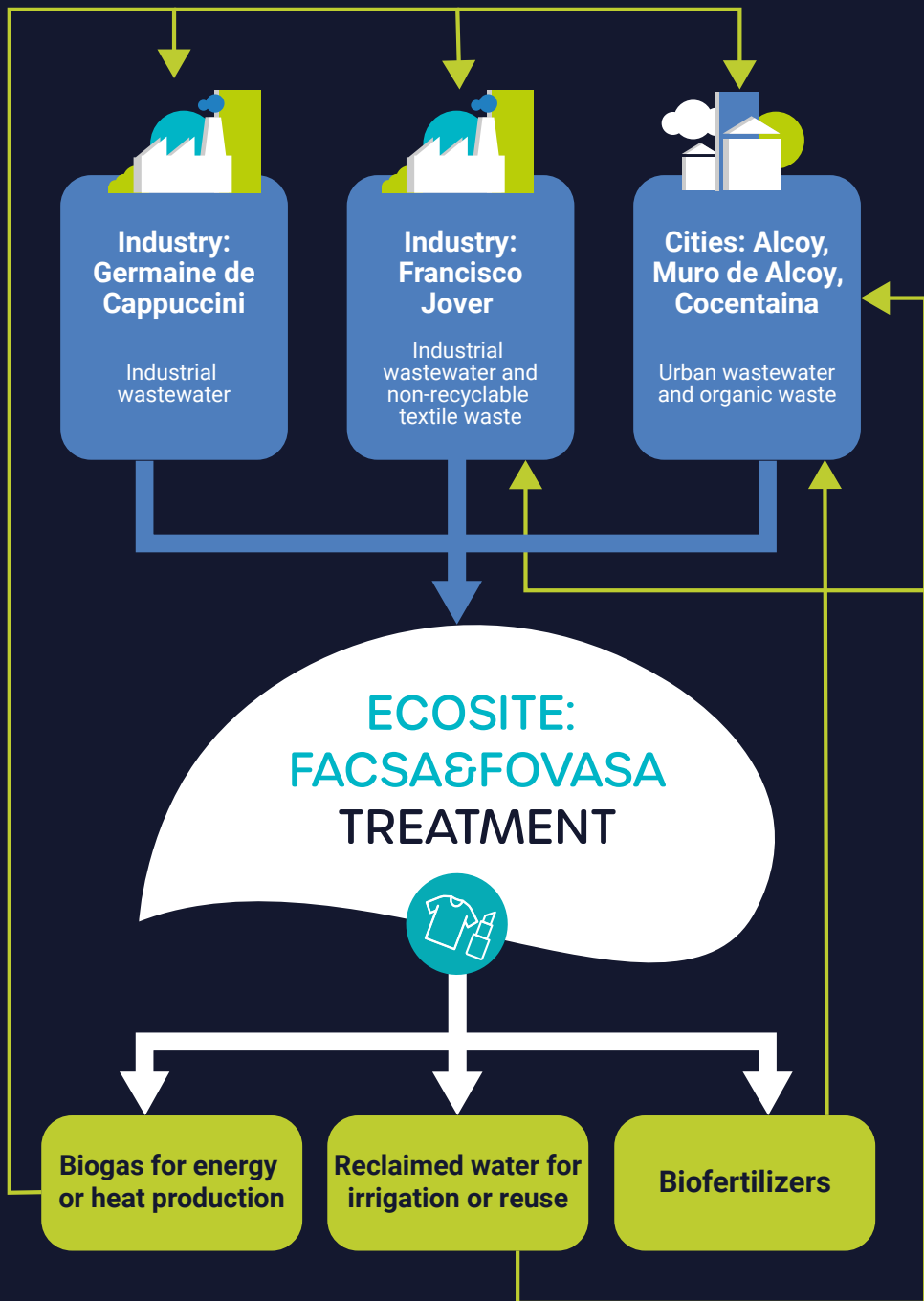
- **Charcoal:** from pyrolysis of textile waste and transfer paper from the printing process stamps. Adsorption capacity tests will be carried out after and before activation to assess its removal capacity.
- **Digested sludge:** 9.9 kg biomass/m³ of treated water will be produced and tested for application as fertiliser.
- **Green hydrogen:** CH₄ from AnMBR will be reformed into H₂

for use by urban and industrial users.

- **Treated water:** The treated water produced will be tested in industrial processes to replace all or part of the water employed conventionally.

BENEFITS OF THE SYMBIOSIS

- **EFFICIENT WASTE MANAGEMENT:** Organic waste from urban areas can be seen as a valuable resource rather than being disposed of in landfills. This reduces the environmental impact and extends the lifespan of existing landfill sites. Additionally, by diverting organic waste from traditional waste streams to bioenergy production facilities, municipalities and industries can save on disposal costs.
- **ENERGY PRODUCTION:** Organic waste can be processed in the AnMBR to produce biogas, a renewable energy source. This biogas can be used to generate electricity, heat, or be upgraded to other biofuels such as biohydrogen. The continuous supply of organic waste ensures a steady production of biogas, contributing to a reliable and sustainable energy source.
- **ENVIRONMENTAL BENEFITS:** Anaerobic digestion of organic waste reduces methane emissions from landfills and decreases reliance on fossil fuels, thus lowering greenhouse gas emissions. Additionally, the digestate, a by-product of anaerobic digestion, can be used as a biofertilizer, returning valuable nutrients to the soil and reducing the need for chemical fertilizers.
- **SUSTAINABLE DEVELOPMENT:** Integrating waste treatment and bioenergy production into urban planning fosters resilient infrastructure capable of adapting to population growth and industrialisation. This fact encourages the circular economy where waste is minimised, water is reused and citizens are aware of the main environmental goals, contributing to the sustainability of the area.





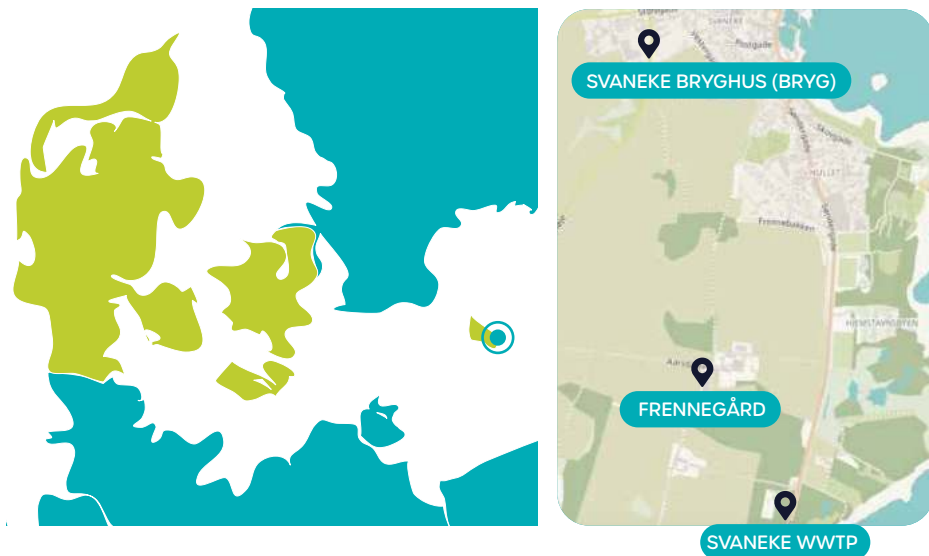


DANISH ECOSITE



OVERVIEW

The Danish EcoSite is located on the island of **Bornholm** in the Baltic Sea, in and around the small town of **Svaneke**. The town has a population of 1,100 people and covers an area of about 6 km². The island of Bornholm is a unique test platform with a solid foundation of data in a secluded energy system, with a large production of renewable energy, up to 1% of all of Denmark.



The EcoSite treats municipal wastewater and organic waste with waste from **the brewing industry**, and involves the following public and private actors:

BEOF

The island's multi-utility company operating the wastewater treatment plant

SVANEKE BRYGHUS (BRYG)

A local brewery

FINN HARILD (GARD)

A local farmer from Frennegård

BOFA

The municipal waste handling company

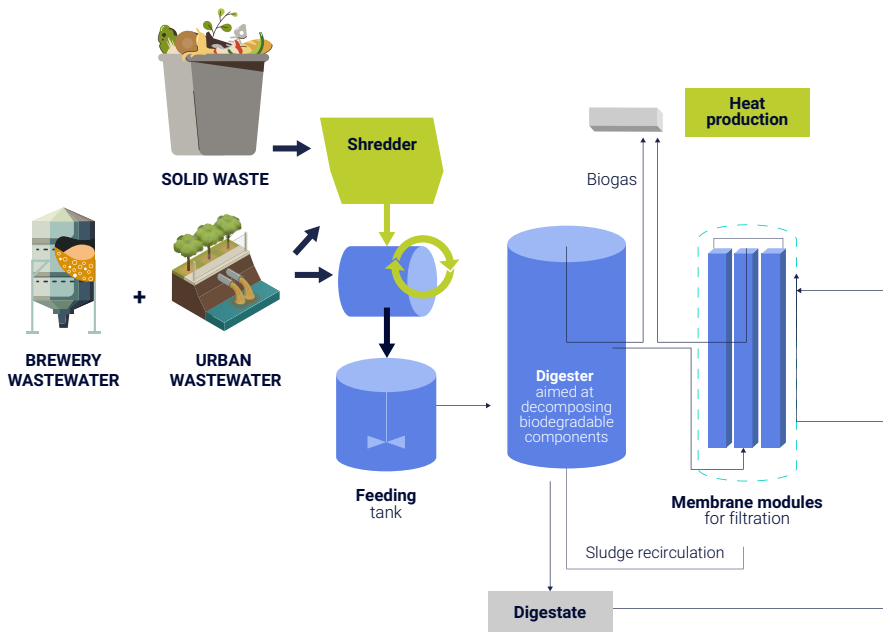
For the past 16 years, Bornholms Energi & Forsyning has been a pioneer when it comes to analysis, tests, demonstrations and data within future energy and utility technology. The multi-utility company is located in Bornholm and has participated in international innovation projects with a total budget of approximately 161 million EUR.

LOCAL CHALLENGES

Svaneke is a small village in the municipality of Bornholm, mainly known for agriculture and its brewing industry. While the brewing industry produces **large volumes of wastewater** and solid waste, the large presence of agriculture requires high volumes of water to meet the **demand for irrigation**.



THE ECOSITE SOLUTIONS

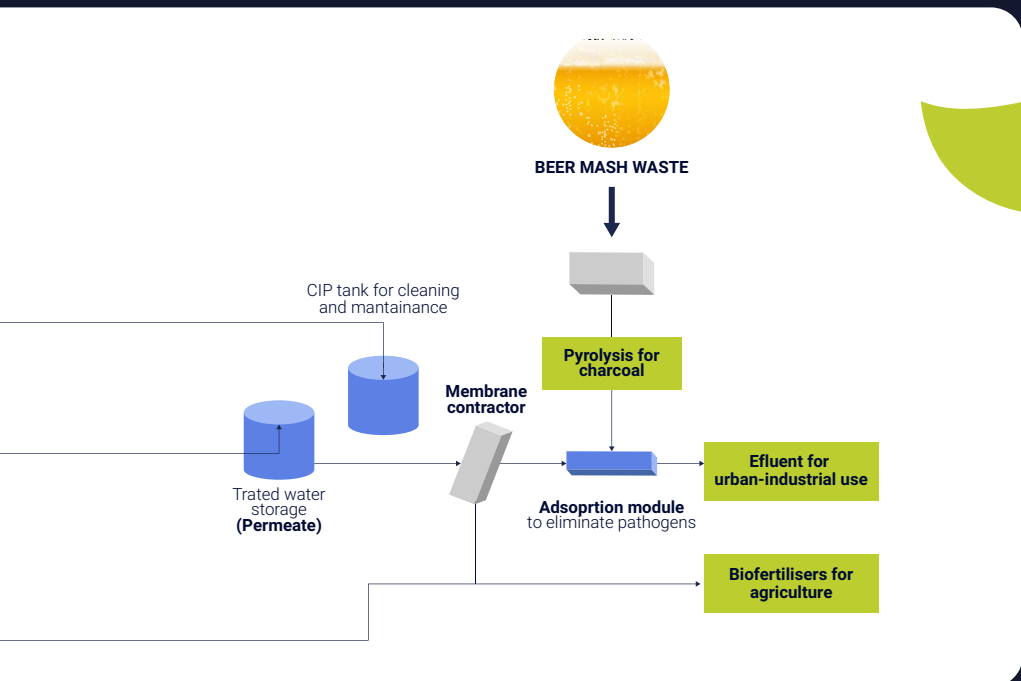


The pilot facility (demo plant) was put in operation in May 2024 and its **objective** is to investigate the prospects of biogas production for industrial use and filtered wastewater for agricultural irrigation, in particular:

- Up to 4 m³ of wastewater daily from the Wastewater Treatment Plant run by BEOF and from the brewery BRYG are treated by the Anaerobic Membrane BioReactor (AnMBR).

- Up to 50 kg of municipal solid biowaste is provided by BOFA every week.

The wastewater comes from Svaneke Brewery and the nearby town of Svaneke. The ground food waste, collected by BOFA, is added to increase the volume of biogas. Quality checks of the produced biogas determine potential industrial applications, including a future source to process heat at Svaneke Bryghus. Due to extremely small amounts, the biogas is finally discharged.



The filtered wastewater is analysed to determine its applicability to agricultural irrigation at Frennegård, in accordance with the EU regulation on minimum requirements for wastewater reuse. Sludge from the test facility is used as fertiliser at Frennegård if the quality is suitable according to the Sludge Order.

The advanced wastewater treatment pilot facility consists of multiple interrelated processes:

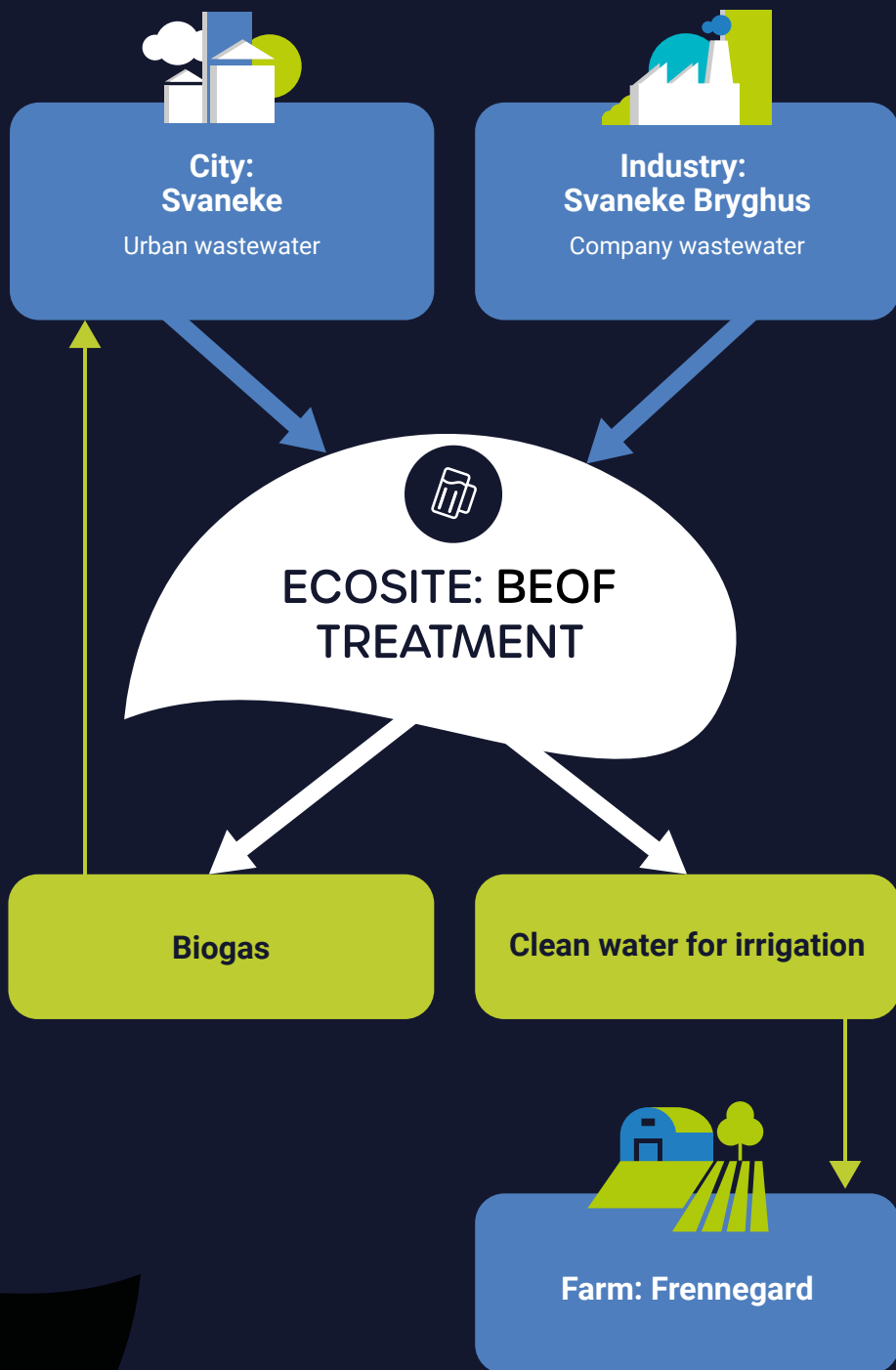
- Pre-treatment: grinder, agitators, dosing pumps, and drum filter.
- Bioreactor to produce biogas and sludge.
- Membrane unit to produce filtered water.

As a result, High-Value New Resources are available:

- Treated wastewater for irrigation
- Digested sludge for fertiliser
- Biogas rich in methane
- Char from the Beer mash

BENEFITS OF THE SYMBIOSIS

- **CIRCULAR VALUE CHAINS BETWEEN INDUSTRY, CITIES, AND CITIZENS:** waste streams are processed and upgraded into new products using technology. Thus, waste and residual products from one area can be turned into a useful resource in another area.
- **PRODUCTION OF BIOGAS AND WASTEWATER:** while biogas converts into energy and heat, purified wastewater can be used for agricultural irrigation as well as irrigation of gardens, trees or parks.
- **SOCIAL COHESION:** cooperation between industry, cities, and citizens.







AUSTRIAN ECOSITE



OVERVIEW

The Austrian EcoSite is located at the production facilities of Fleischwaren Berger GesmbH in the town of **Sieghartskirchen**, within the south-eastern Tullnerfeld area. The local wastewater treatment plant (GST) is located in Tullnerfeld, covering the wastewater (WW) of an area of 131km² including the municipalities of Sieghartskirchen, Michelhausen, Judenau-Baumgarten and Lagenrohr.



The Austrian EcoSite was developed under the scientific direction of IFA Tulln in cooperation with the following partners:

IFA TULLN, BOKU UNIVERSITY (BOKU)
Manager of the EcoSite

FLEISCHWAREN BERGER GESMBH (BER)
Meat processing industry

GEMEINDEABWASSERVERBAND SÜDÖSTLICHES TULLNERFELD (GST)
Wastewater treatment

SPITZER GESMBH
Membrane technology

AAT ABWASSER AND ABFALLTECHNIK GMBH
Biogas pilot plant installation

LOCAL CHALLENGES

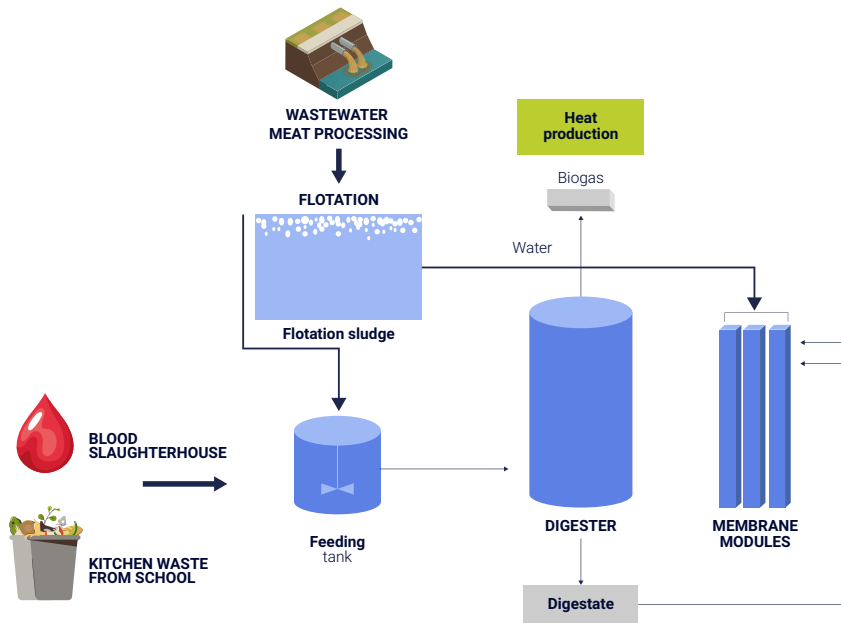
In the area many residential development projects are realised and the wastewater treatment plant capacities will not be sufficient in the near future. The wastewater volume from Berger can reach up to 630 m³/day and represents a significant share of the treatment plant's volume. From this follows that a reduction of the input to the WWTP by the meat industry is of high importance, to free capacities for the treatment of municipal wastewater from the surrounding communities/ households. In addition, the meat industry consumes **large volumes of water** that could be reused with appropriate technologies. Especially in view of the fact that there is a lot of agriculture in the area and with the increase in drought risk due to global warming the importance of water security is increasing.

The meat processing industry is the only large operation in the area and provides many job opportunities as well as tax income for the municipality. The company is essential for the regional development despite its high water consumption and wastewater volume. The wastewater contains many organics, mostly fats, but also high amounts of detergents from cleaning and salts from the production.

Another factor is the treatment of other residues from the meat processing and slaughter house, which are difficult and costly in their disposal, like blood.



THE ECOSITE SOLUTIONS

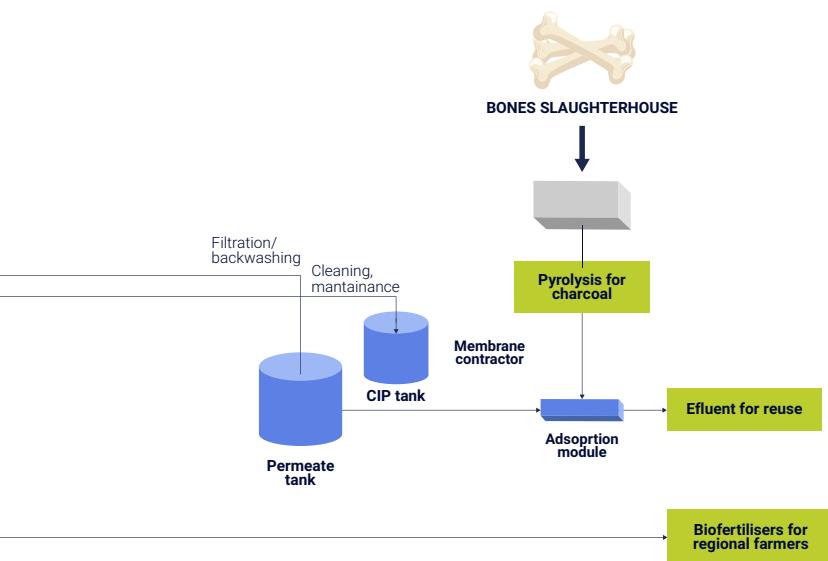


The Austrian EcoSite focuses on the treatment of the wastewater from the meat processing industry and blood waste from the slaughterhouse as well as food waste from the school and kindergarten supplied by the companies catering.

The industry WW contains a higher organic load than municipal wastewater and is used for **biogas production**. After a flotation process that reduces the volume of the primary stream, the flotation

sludge is fed into the biogas reactor. The treated water is further cleaned with ultrafiltration and nanofiltration membranes to produce **purified water** for reuse as process water at the company or potentially as irrigation water in the future.

As a co-substrate, waste from the associated slaughterhouse is used, resulting in high levels of ammonium and hydrogen sulphide from protein degradation. The ammonium in the outflow can be recovered by extraction with



sulfuric acid, which is produced by desulfurization bacteria in a desulfurization column from the hydrogen sulphide contained in the biogas. This process forms the valuable **fertilizer** ammonium sulphate. The fertilizer can be used in regional agriculture, thereby keeping the nutrients in a loop.

The **sources of waste** in the Austrian EcoSite are:

- Meat processing wastewater
- Slaughterhouse waste: blood, bones, intestines

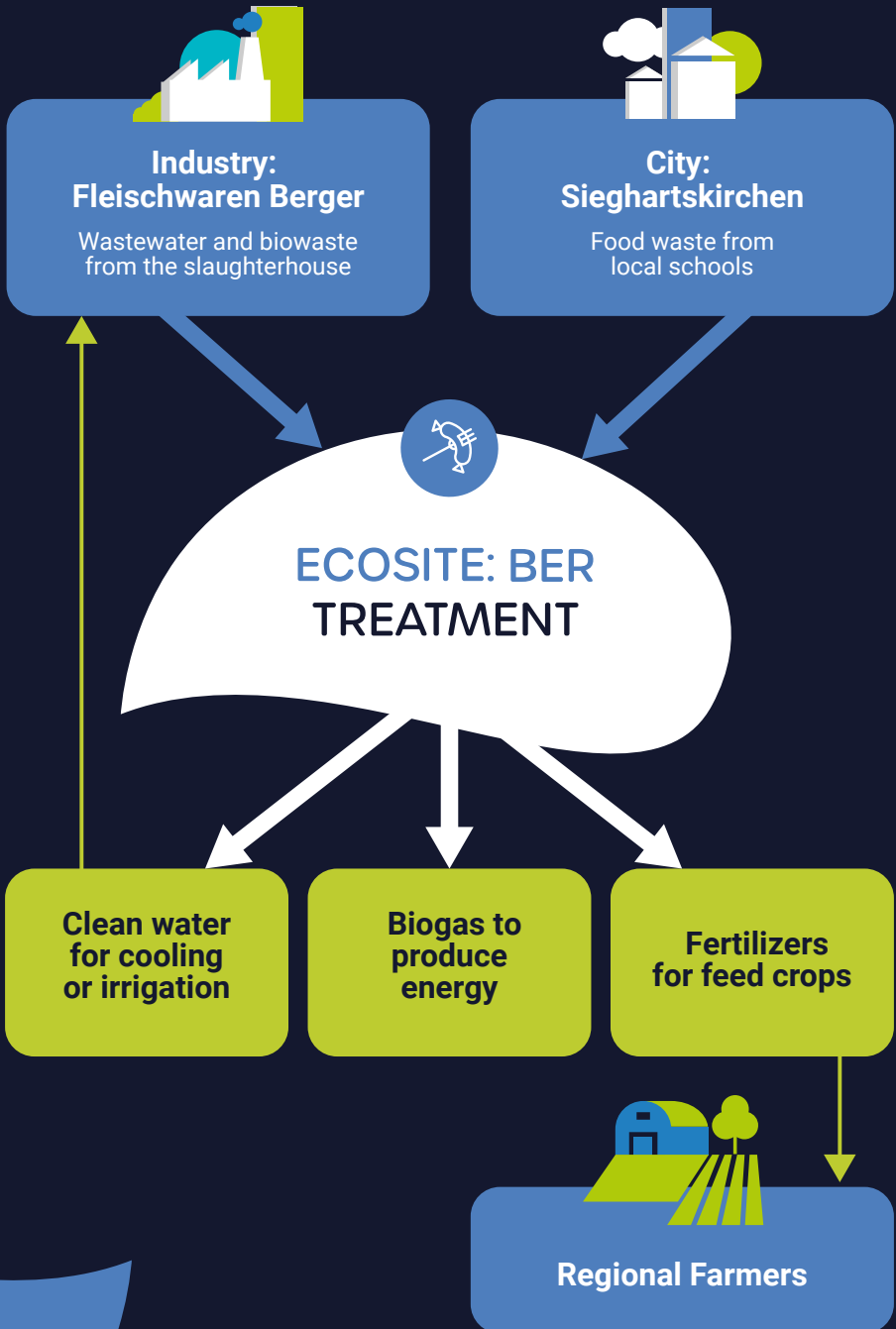
- Food waste from school canteens

The aim of the Austrian EcoSite is to treat 4 m³ of wastewater per day and 50 kg of biowaste per week, resulting in a daily maximum biogas yield of 6 m³ and additional streams of new **added-value products**:

- Cleaned water for cooling or irrigation, instead of using ground water
- Biogas for energetic use
- Fertilizer for the surrounding farmers

BENEFITS OF THE SYMBIOSIS

- **USE OF SLAUGHTERHOUSE WASTE:** Organic waste from slaughterhouses can be used as a valuable resource rather than a hazardous waste. This reduces the environmental impact and effort for transport and treatment. Additionally, the company can save disposal costs.
- **ENERGY PRODUCTION:** The wastewater can be used to generate energy instead of energy-intensive treatment processes. The additional treated organic waste can increase the biogas production. The produced biogas can be used as a renewable energy source for the generation of electricity and heat. The continuous supply of wastewater and organic waste ensures a steady production of biogas.
- **ENVIRONMENTAL BENEFITS:** The treatment of wastewater and biowaste in a close proximity decreases the environmental impact of infrastructure and traffic. The treatment of the wastewater combining a flotation and anaerobic digestion requires less space and can thereby reduce the land consumption. By combining desulfurization with a membrane contactor, a valuable fertilizer can be produced and distributed locally keeping the nutrients in a regional loop and counteracting dependency on international fertilizer suppliers.
- **SUSTAINABLE DEVELOPMENT:** The integration of the wastewater treatment with biowaste for energy production allows the company to grow sustainably with less negative effects for the municipality and the community. Instead, the local groundwater consumption can be reduced and the farmers benefit from valuable fertilizer.





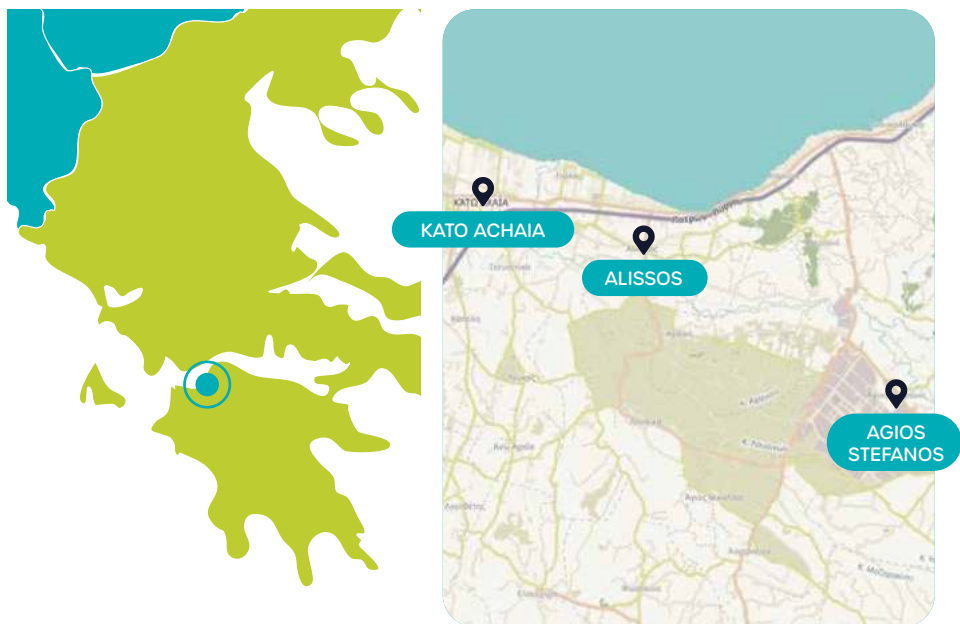


GREEK ECOSITE



OVERVIEW

The Greek Ecosite is located at the wastewater treatment plant (WWTP) in the municipality of Western Achaia. This **urban-industrial symbiosis** extends over a larger area of approximately 13.5 km², encompassing Ano Alissos, the industrial zone, and the WWTP. The Ecosite focuses on **waste from olive oil production** and is designed to treat industrial and urban wastewater (WW) as well as food waste (FW).



The project involves the following partners:

NATIONAL TECHNICAL UNIVERSITY
OF ATHENS (NTUA)
Manager of the EcoSite

SIRMET S.A. (SIRMET)
Developer of the Ecosite

MUNICIPALITY OF WESTERN
ACHAIA (MWA)
Operator of the WWTP

ELAIOURGIKES
EPIHEIRISEIS PATRON S.A.
(EEP)
Partner from the olive oil industry

LOCAL CHALLENGES

The region faces significant challenges due to the diverse sources and types of waste generated, necessitating a comprehensive and integrated solution.

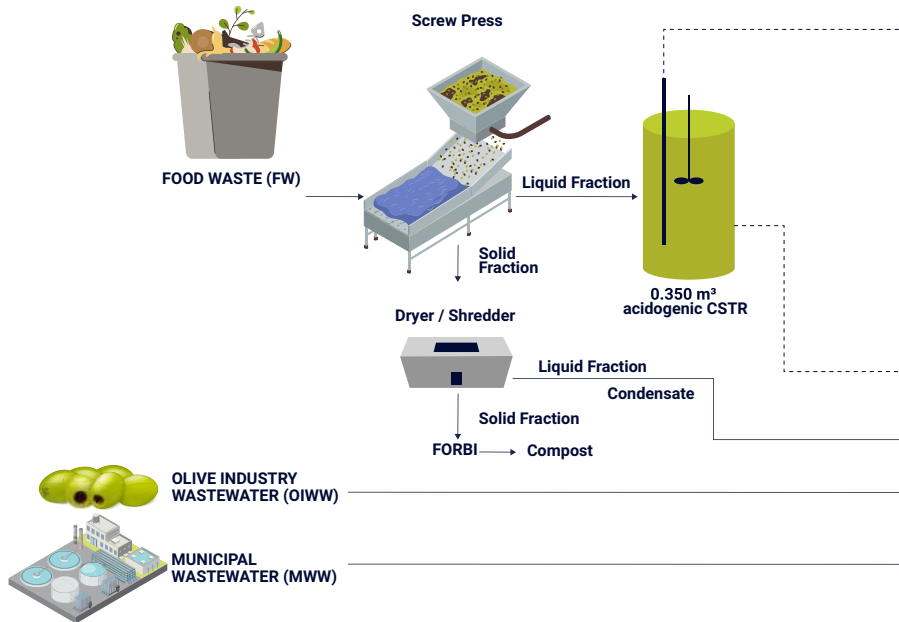
In particular, the olive oil industry produces substantial amounts of wastewater and solid waste. Key challenges include:

- **High Organic Load:** Olive oil wastewater contains high concentrations of organic matter, complicating treatment with conventional methods.
- **Seasonal Production:** The seasonal nature of olive oil production causes fluctuations in waste volume, challenging capacity planning for waste management facilities.
- **Solid Waste Disposal:** Olive pomace, the primary solid waste, poses disposal issues due to its volume and environmental impact.

Additionally, there is a critical need to treat urban wastes to prevent environmental degradation and improve public health. The Ecosite leverages sustainable waste treatment processes to address these issues, mitigating environmental impacts and enhancing the overall waste management system in the region.



THE ECOSITE SOLUTIONS



The main objective of the Greek EcoSite is to treat industrial and urban wastewater (WW) from the municipality of Western Achaia, along with urban organic solid waste from the village of Ano Alissos. This treatment process aims to produce hydrogen, methane in AnMBR, compost, and clean water.

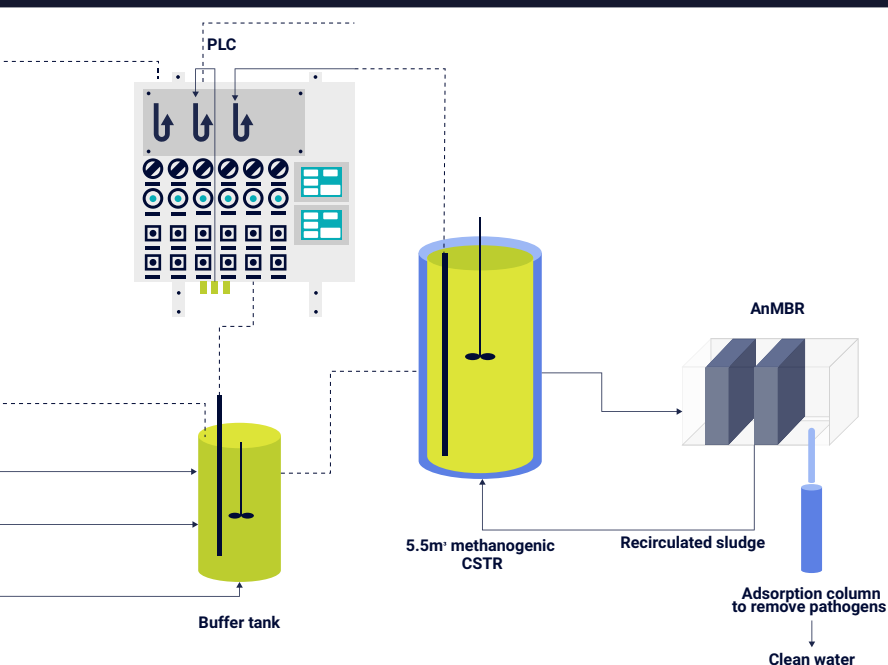
The three sources of waste at the Greek EcoSite are:

- Urban organic solid waste from the village of Ano Alissos
- Urban WW from the area of Kato Achaia (WWTP)

- Industrial wastewater from Elaïourgikes Epiheiriseis Patron S.A. (EEP)

The Greek EcoSite will treat between 2-4 m³/day of urban and industrial WW, and up to 100-200 kg/day of urban organic solid waste.

This process will produce gaseous biofuels (hydrogen and methane) and other valuable products. The advanced wastewater treatment pilot facility consists of multiple interrelated processes:



- **Pre-treatment of food waste:** Using a screw press for hydrogen production and drying shredding for methane production, the biomass (FORBI, Food Residue Biomass) generated from the drying/shredding will be led for composting.
- **Bioreactors:** A 0.350 m³ acidogenic CSTR for hydrogen production and a 5.5 m³ methanogenic CSTR in tandem with anaerobic membrane system (AnMBR) for methane production.

- **Membrane unit:** For producing filtered water.

As a result, high-value new resources will be available:

- Biogas rich in methane
- Hydrogen production
- PHAs (lab scale)
- Treated wastewater for irrigation
- Compost from the solid phase after pre-treatment (FORBI) along with the digestate

BENEFITS OF THE SYMBIOSIS

The Greek EcoSite, located in Western Achaia, exemplifies the benefits of industrial-urban symbiosis (I-US) through its innovative waste treatment processes and integrated approach. By promoting collaboration between industries and urban areas, the EcoSite optimizes resource use and minimizes waste, addressing critical waste management challenges in the region.

In brief the benefits arising from this symbiosis are:

- **RESOURCE RECOVERY AND RECYCLING:** Collaboration between SIRMET S.A., EEP, NTUA, and MWA results in a pilot system for treating industrial wastewater, municipal household waste, and urban wastewater using anaerobic technology and solids drying. This system not only treats waste but also recovers biogas and biohydrogen, addressing green power challenges.
- **UTILIZATION OF BY-PRODUCTS:** EEP provides wastewater and dry olive heartwood, exploring their potential uses. Treated wastewater enhances biogas production, while olive heartwood's antimicrobial properties are investigated for use as filtering media in tertiary wastewater treatment, turning waste into resources.
- **STAKEHOLDER ENGAGEMENT:** Forming stakeholder forums involving local communities, food processing industries, universities, and government organizations ensures the integration of advanced waste exploitation knowledge into local practices and addresses community needs.
- **TESTING AND OPTIMIZATION:** The Greek EcoSite pilot tests various wastewaters, optimizing waste treatment processes. By addressing challenges such as high organic load, industrial waste inhibitors, energy production through anaerobic technology, and stakeholder involvement, the project becomes a model for innovative waste management.

Through industrial-urban symbiosis, the Greek EcoSite not only addresses waste management challenges but also promotes sustainability, resource efficiency, and environmental stewardship in Western Achaia, setting a precedent for similar initiatives globally.



Discover more about the project

www.symsites.eu



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