Pilot site in Greece

CERTH - BLAG

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Workshop

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innovations in the BIOMETHANE uniVERSE

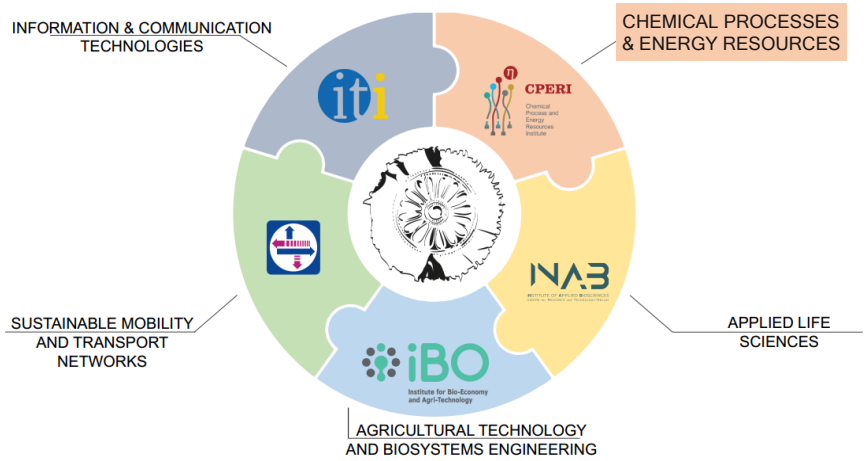
CERTH at a glance

- Foundation: 2000
- Legal entity governed by private law under the auspices of the General Secretariat for Research & Innovation of the Ministry of Development & Investment
- Personnel: > 1500
- Annual Revenues: > 50 M€
  - 77% from competitive research projects through open call for proposals
  - 13% from bilateral industrial research contracts
  - 10% from government institutional funding
- Numerous distinctions & awards
  - Descartes Prize
  - ERC Advanced Grant
  - Trading Agent Competition Award, etc.

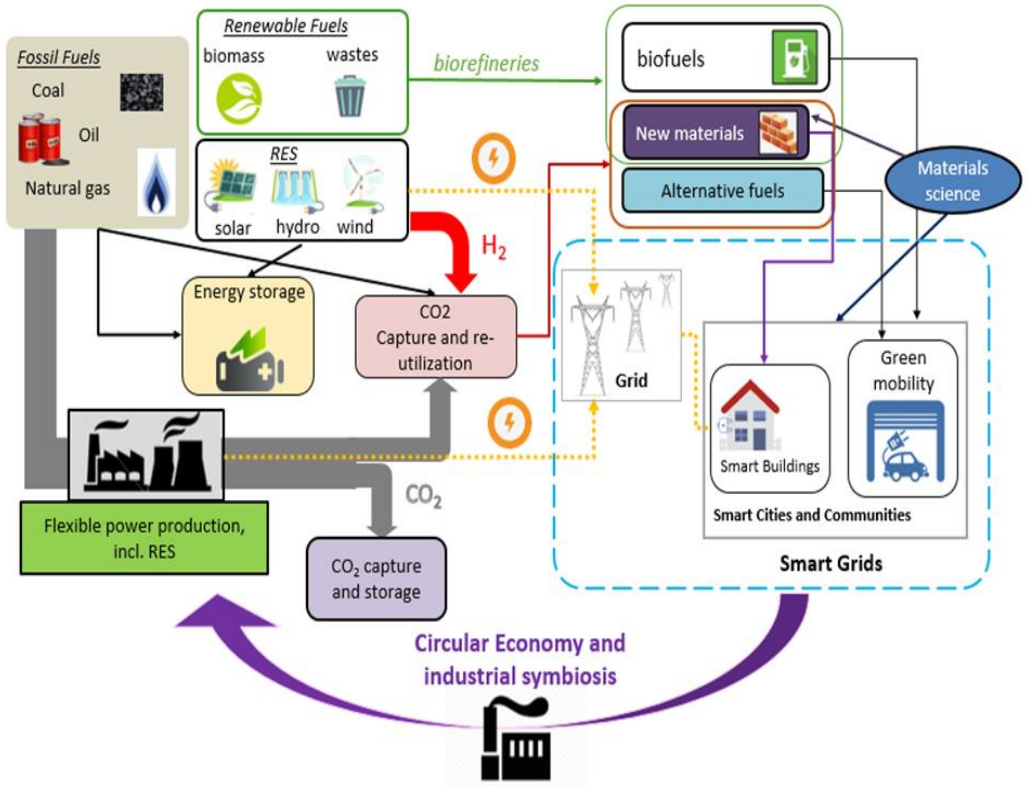
14th place among all Research Organisations participating in H2020

Innovative research facilities and modern laboratory equipment worth > 47 million €

5 Institutes



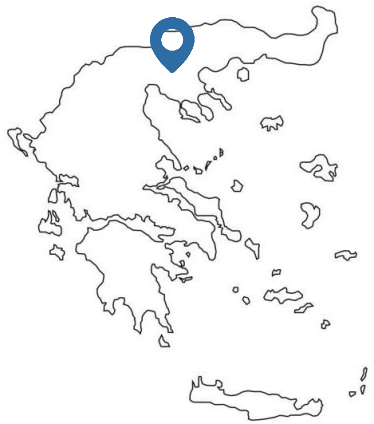
Our group's vision



BLAG plant at a glance

The **Biogas Lagadas S.A. (BLAG)** plant is located in Kolchiko – Lagadas, in Central Macedonia Region.

It was established in 2011 and operates since 2016.



Key technical characteristics

- Exploitation of around **80,000 tonnes** of livestock waste per year
- Production of **8,400 MWh** of electricity
- Production of **75,000 tonnes** of digestate, suitable for fertilizing 5,000 acres of agricultural land
- Capacity of **290 m³ CH_4/h**.
- 2 fermenters with **4,500 m³** active volume for biomass (each one) and 10,000 m³ of biogas buffer capacity.
- The total flow is **500 Nm³/h** at 100 mbar.
- The capacity of CHP generator is **1 MW_e**.

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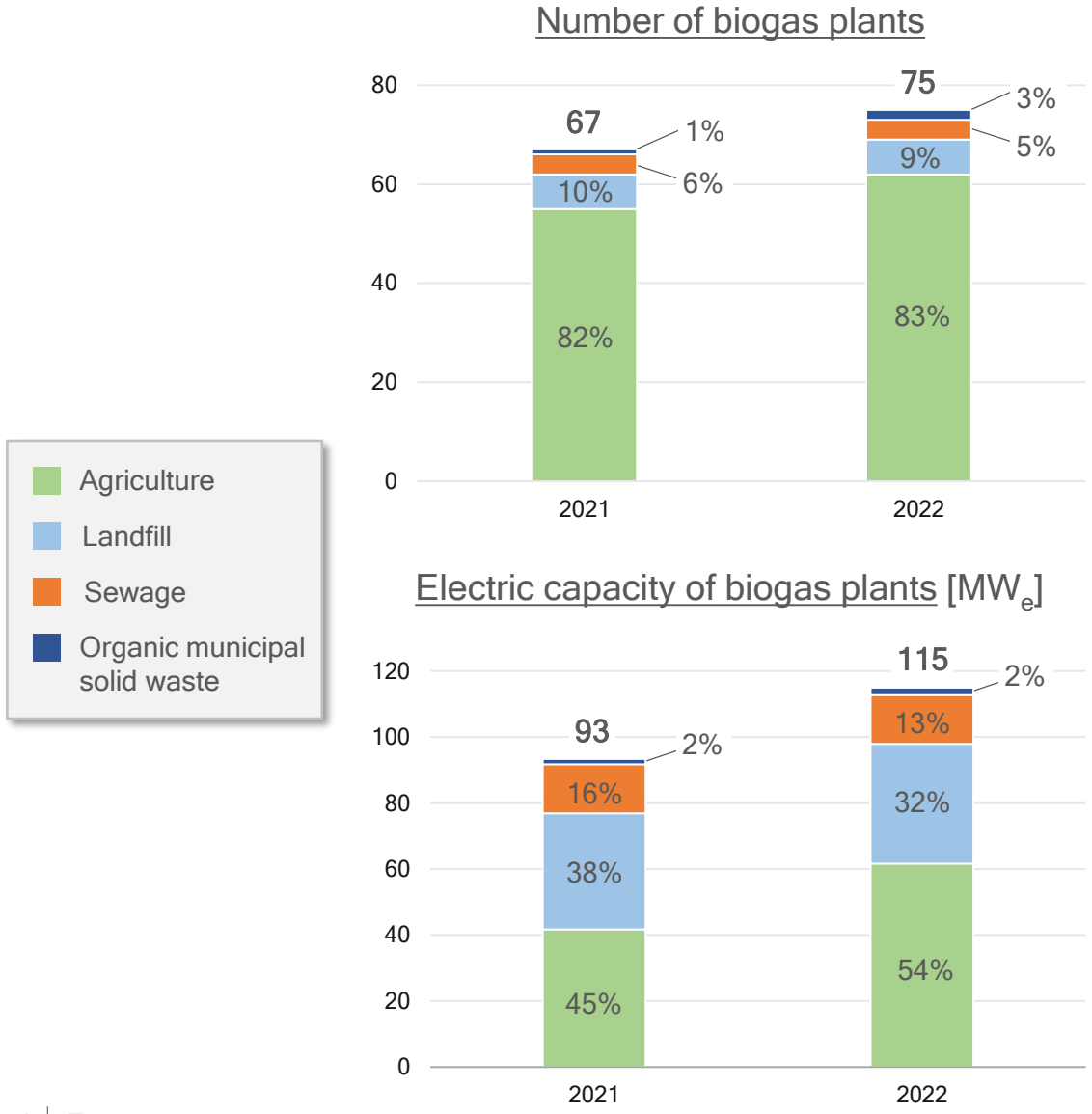
Biogas and biomethane sector in Greece

- ✓ Greece has been gradually increasing its focus on **renewable energy** (the share of renewables and biofuels in the total primary production has increased from 22% in 2012 to 71% in 2021)
- ✓ Biomethane is a **mature and competitive technology** that can help Greece in its **energy transition**
- ✓ In Greece today, **only biogas** is produced and there is **no biomethane market**. In our country, **75 units** operate with a total capacity of 115 megawatts. It is indicative that only 50% of the 115 megawatts of installed capacity is used.
- ✓ The two defining **problems** in Greece today are the **absence of legal framework** on the one hand and the **lack of raw material on the other**. A policy to organize the gathering of raw material has not been applied yet and for this the Ministry of Rural Development must take action.
- ✓ A positive milestone in this direction is that the Ministry of Energy stated that there will be a **law on biomethane** at the beginning of 2024.
- ✓ In order to achieve the EU's target by 2030 (35 bcm annually) → biomethane production in Greece has to reach 600 million cubic meters (approx. 150 plants will be needed)



Sources: https://energypress.gr/ https://habio.gr/ | Eurostat EBA Statistical Report 2022 EBA Statistical Report 2023

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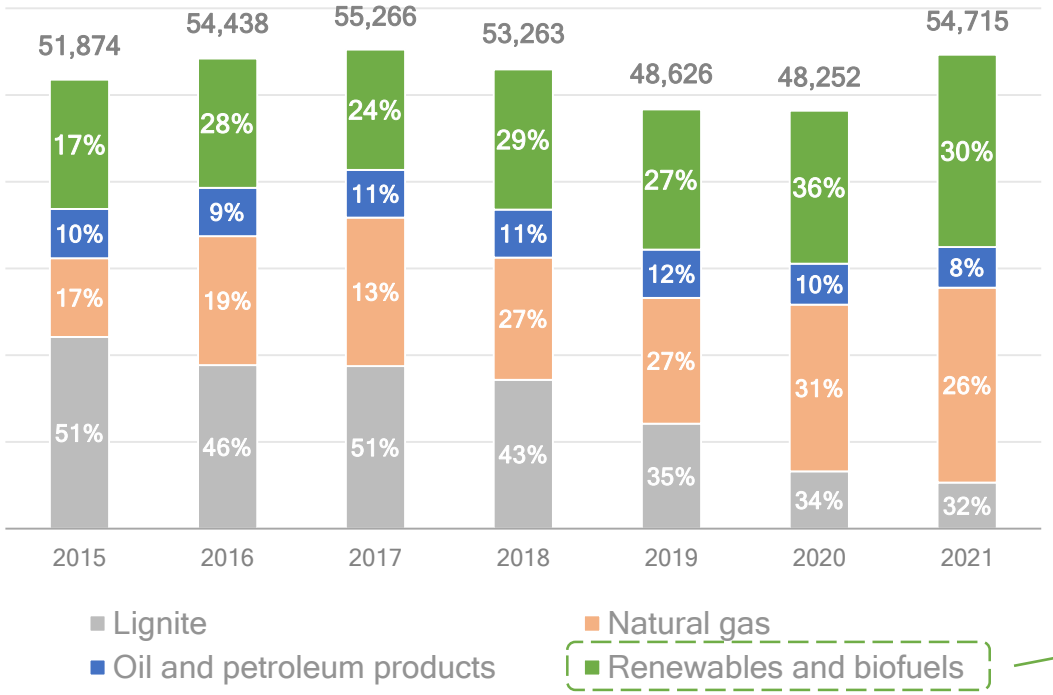
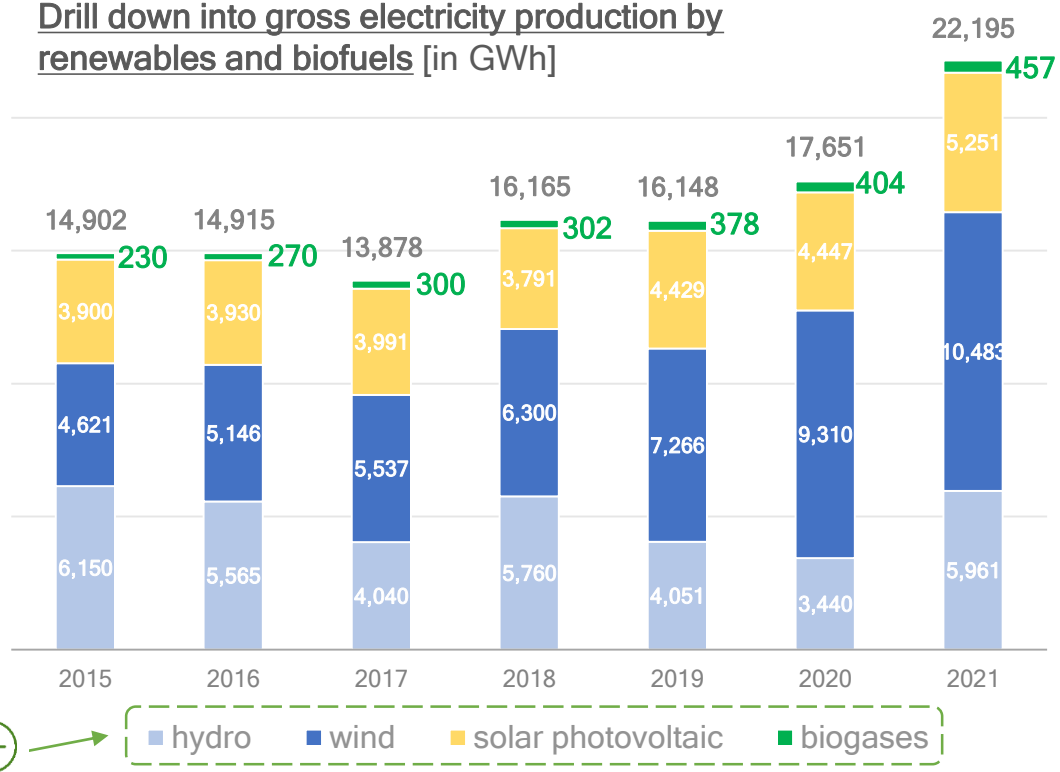
Contribution in the electricity production in Greece

- ✓ The share of **renewables** in the electricity mix of the country has increased significantly (25% in 2017 → 41% in 2021)
- ✓ However, the **contribution of biogas** still remains low as other forms of renewables (mostly wind and solar) were mainly promoted during the last decade.
- ✓ **Biogas and Biomethane sectors** are expected to rise drastically in the next few years

Gross electricity production by type of fuel
[Total in GWh and fuel shares in %]



Drill down into gross electricity production by renewables and biofuels [in GWh]



Source: Eurostat

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National policies for biomethane production and scale up

The establishment of a **Biomethane support scheme** is currently **in progress** and it is expected to be finalized in 2024. Preparatory studies that include financial funding mechanisms have already been conducted.

The Ministry of Environment and Energy is going to establish a law that will provide **incentives for the production and use of biomethane** that can be **distributed through the existing natural gas network** and used by consumers.

Indicative directions for the upcoming **Biomethane support scheme**:

- Definition of support **reference prices** in correlation to the current electricity equivalent.
- **Priority** to substrates of manure, **agricultural** waste and organic fraction of **municipal** solid waste.
- **Extra incentives for connection to the gas grids** and for the conversion of existing electricity generating plants to move to biomethane production.

The new development law (**4887/February 2022**) is more specific about the **support of renewable energy production**. As for the biogas / CHP, the relevant provisions of the Law briefly state:

- Investment support shall be granted only to **newly installed or refurbished generation capacity**. Eligible costs shall be additional investment costs in equipment that the installation needs to operate as a high-efficiency cogeneration installation
- The intensity of the support shall be set at a rate of **45% of the expenditure**. The support may be increased by 20 percentage points for small enterprises and by 10 percentage points for medium-sized enterprises.

This new provision may constitute <u>additional incentive</u>, especially for investments in the areas and industry sectors supported by the development law.

Source: Support Schemes for Biogas and Biomethane production in Greece, EBE, March 2022

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What is the innovation in our technology?

The individual stages of the whole process include:

1. **Purifying and compressing biogas** (the reaction takes place at high pressure and temperature)
2. **Catalytic methanation reaction** (innovative thermocatalytic process)
3. **Dehumidification** of the final biomethane stream

Sabatier reaction

$$CO_2 + 4H_2 \xrightarrow{pressure + catalyst} CH_4 + 2H_2O \qquad (\Delta H = -165\ kJ/kmol)$$

The CO_2 contained in the biogas is converted to biomethane through its reaction with **renewable H_2**

The catalytic reactor can handle a mixture of CH_4 and CO_2 thus, **no separation of the biogas is required** before conversion

The final product is biomethane already reaching pipeline quality gas standards (**96-98 vol% CH_4**), thus no further upgrading is necessary

The technology is based on well-proven equipment, i.e., fixed bed reactors and tube heat exchangers.

It has been combined with coal gasification and there have been as well conceptual designs for bio-syngas.

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Further description of the demonstrated technology

State of the art of the demonstrated technology

- Thorough review of relevant literature on case studies and applications for **syngas**
- The technology **has not yet been demonstrated on biogas**. Hence, the technology starts from **TRL5**.

Ambition and progress beyond the state of the art

- The examined technology will be transferred **for the first time to the biogas application** at **TRL7**.
- A catalytic technology will be integrated into the industrial **LAGADA biogas plant**.
- **The most attractive configuration for the methanation section is currently identified** taking into consideration several factors, including but not limited to heat exchange, catalyst type, process temperature and pressure.

Expected outcomes

1. Production of a total of **15,000 m^3** of biomethane.
2. Operation of the pilot plant for a total of **6,000 hours**.
3. Increase the methane content from **60%** in the input stream towards more than **95%** in the output stream
4. The target for the **total energy efficiency of the process** is set to **61%**
   (defined as the energy content of the biomethane divided by the electricity consumption for renewable hydrogen production)
5. **Reduction of biomethane production cost by 20% - 25%** compared to conventional technologies
6. Potential **replicability of the demonstrated technology** to other biogas plants

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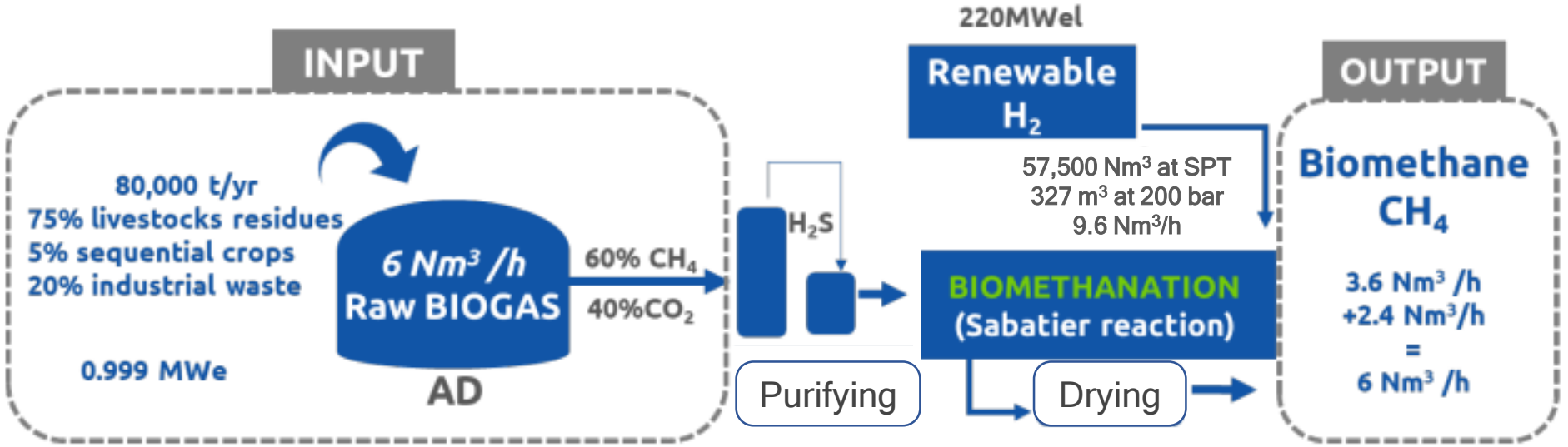
Simplified Block Flow Diagram (BFD)

Input biogas flow: **6 Nm³/h**

Composition:
60% CH_4 and 40% CO2

The CH_4 contained in biogas stream (60% x 6 = **3.5 Nm³/h**) will be **incorporated into the output flow**

The output flow will yield an additional **2.4 Nm³/h biomethane** corresponding to the conversion of the CO_2 stream into biogas stream



In the pilot unit the methanation will conducted in 3 successive steps to achieve the final desired composition

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The challenges we face…

Essential aspects which must be considered for the Greek demo site include:

Catalyst deterioration and contamination	The catalyst has been extensively studied regarding the characterization of its **composition** and the optimal **conditions** for the process performance
Safe **distribution of H_2** to the pilot unit, **storage** and tank replenishment	**Safety study** for the hydrogen storage at biogas plant facilities, distribution through piping system to the upgrading pilot unit and the blending stage based on dangerous goods legislation and safety standards regarding compressed gases
Appropriate **automation** with the respective controller unit	Key operation parameters, such as **temperature**, **pressure** and biogas **composition** will be controlled at specific points during the demo activities
Successful **operation** of the catalyst	The process will be evaluated during the demo activities so as to **recognize any deviations** (lower biomethane yield, lack of H_2, no ideal conditions for the catalyst)

During the BIOMETHAVERSE project, **all the aforementioned measures will be investigated** to identify possible edge effects at **pilot scale** for the **transition of the biogas Lagada** plant to a **full scale** biomethane production plant.

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Further exploitation of the pilot unit

Exploitation steps

- Basic **design of the biomethane plant** with necessary engineering and operational specifications
- **Construction and full integration** of the pilot plant into biogas industrial plant
- Conduction of **Factory Acceptance Test (FAT)** and **Site Acceptance Test (SAT)**
- **Operation** of the pilot plant to produce **15,000 m^3** of biomethane
- Further commercial exploitation by BLAG and policy exploitation by CERTH

Policy perspective

- Contribution to the **biomethane penetration** and the establishment of a **legislative framework** for biomethane production in Greece.
- Policy working groups with key stakeholders (Ministry, HABIO, gas distribution network operator, gas transmission operator)
- **Location planning and dimensioning of new biomethane plants**, including the BIOMETHAVERSE technologies
- Technical specifications for the integration of the project results within existing plants in Greece

Business perspective

- **Scale-up studies** based on the pilot campaigns results (different composition of biogas, range of feedstock, catalysts)
- Promotion of a relevant legislative framework to provide **financial initiatives** for relevant activities
- BLAG stakeholders are also interested to proceed to **similar retrofitting activities in Nigrita biogas plant**

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