With the contribution of the LIFE Programme
of the European Union
LIFE20 CCM/GR/001642

CO2toCH4 SUMMARY PROJECT DATA

The project implementation started in October 2021 and it is expected to be completed by June 2026, in selected regions of Greece and Italy.

Total Eligible Project Budget:
3,888,985 Euro

Project Implementation period:
57 months

EU financial contribution requested:
2,138,941 Euro
(= 55.00% of total eligible budget)

PROJECT PARTNERS

- PPC Renewables
- ΔΕΗ
- ELGO - DIMITRA HELLENIC AGRICULTURAL ORGANIZATION - DIMITRA
- NEVIS INNOVATE WITH US
- ARISTOTLE UNIVERSITY OF THESSALONIKI
- 800 1222-2022 ANNI — Università degli Studi di Padova

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CO2toCH4 Life

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DEMONSTRATION OF AN INNOVATIVE, INTEGRATED AND SUSTAINABLE INDUSTRIAL PROCESS

FOR THE SIMULTANEOUS STORAGE OF ENERGY AND THE CAPTURE AND UTILIZATION OF CO_2

The LIFE CO2toCH4 project is co-funded by the European Union and develops and demonstrates an innovative method of renewable energy storage, while also helping to reduce carbon dioxide (CO_2) emissions. The project focuses on capturing CO_2 from industrial flue gases and, in combination with hydrogen (H_2), which is produced from renewable electricity, aims to produce biomethane (CH_4), a renewable, non-fossil fuel.

This innovative technology utilizes the surplus electricity from renewable sources to electrolysis water and produce hydrogen. The hydrogen is then combined with carbon dioxide from exhaust gases and, through a biological process, converted into methane, which is a renewable, non-fossil fuel.

By converting surplus renewable electricity into a stable fuel, the LIFE CO2toCH4 project helps address both the challenges of energy storage and the impacts of climate change.

INSTALLATION & OPERATION OF THE LIFECO2toCH4 MOBILE UNIT

INSTALLATION OF THE MOBILE UNIT

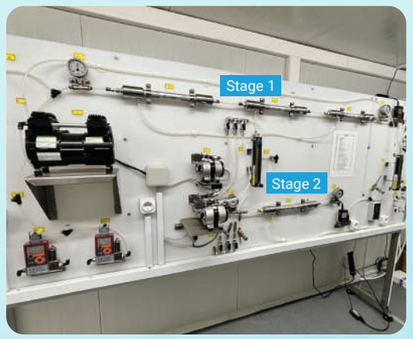
The autonomous mobile unit for hybrid energy storage LIFE CO2toCH4 constitutes the core technology of the project and demonstrates, under real-world conditions, the potential for energy storage and CO_2 utilization. It was installed at the PPC S.A. Agios Dimitrios Power Plant in Kozani and placed in a specially designed container (Isobox), where the trial operation and its optimization phase were successfully completed.

CO_2 MEMBRANE SEPARATION UNIT

A two-stage membrane system (4 units, 3+1) that processes gas streams and produces high-purity CO_2, suitable for feeding the biological process.

FEATURES:

- Hollow fiber (HF) polyimide membranes with a capacity of up to 10 L/min of gas flow per unit.
- Dimensions approximately 1.8 × 3.0 m with an integrated programmable logic controller (PLC)



H_2 PRODUCTION SYSTEM (PEM ELECTROLYZER)

A PEM electrolyzer that produces high-purity hydrogen (up to 99.999%) from deionized water, providing the necessary reducing agent for biological methanation.

BIOMETHANATION SYSTEM (TRICKLE BED REACTORS)

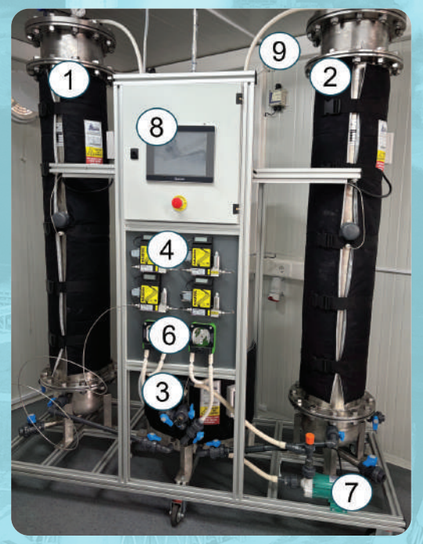
Two stainless steel reactors (TBR), with a total active volume of ~200 L, where CO_2 is converted to biomethane (CH_4) by hydrogenotrophic methanogenic microorganisms under thermophilic conditions (55 ± 2°C).

FEATURES:

- CO_2 and H_2 flow control via Mass Flow Controllers
- Maximum flow rate: 3.84 m³/d (H_2) & 0.96 m³/d (CO_2)
- Sequestration capacity: 8.6 kg CO_2 per m³ of reactor

1 - 2 Reactors, 3 Nutrient solution tank,
4 - 5 H_2 and CO_2 flow regulators, respectively,
6 - 7 Recirculation and stirring pumps, respectively,
8 PLC display, 9 Gas leak detector.

The three subsystems operate in combination, forming an integrated process for CO_2 capture and utilization to produce renewable fuel.



SAFETY & OPERATIONAL MONITORING

The safe and uninterrupted operation of the mobile unit is ensured through the implementation of a specific safety protocol and compliance to standard operating procedures (SOPs). Operation and control are carried out via a fully automated control system (PLC), which supports the membrane and methanation subsystems, providing continuous logging of critical parameters and remote management capabilities.

At the same time, data logging, on-site sampling, and measurements of gases and liquids are performed, as well as gas chromatography (GC) are conducted twice a week by specialized scientists from Aristotle University of Thessaloniki (AUTH) and ELGO-DIMITRA, who are responsible for the operation and monitoring of the unit, as well as by the project team from PPC and PPC Renewables.

PERFORMANCE IN CONTINUOUS AND INTERMITTENT OPERATION

The mobile unit was evaluated in both continuous and intermittent (start–stop) operation, confirming the system's stability, efficiency, and flexibility under various operating conditions.

CONTINUOUS OPERATION

- Stable CH_4 purity >95% at most Gas Retention Time (GRT) levels (GRT)
- Methane production rate (MPR): 4.42 m³ CH_4/(m³·d) and CO_2 sequestration: 8.47 kg/m³·d
- Stable operation for 5 months
- Temporary increase in Volatile Fatty Acids (VFAs) with full recovery of stability following optimization of the nutrient solutions.

INTERMITTENT OPERATION (START–STOP)

- Successful start-stop cycles.
- After restart, CH4 concentration (>90%) was restored within 24-48 hours, confirming strong microbial resilience.
- During idle phases, VFA levels remained low despite reduced H_2 supply.
- pH remained above 7, indicating sufficient buffering capacity despite temporary acidification.

RESULTS & TECHNOLOGICAL READINESS

The operation of the mobile unit fully validated the project's technical and operational objectives, demonstrating the stability, efficiency, and industrial applicability of the integrated CO_2 capture and utilization process.

CO_2 purity >93% via the membrane system.

- Production of SNG-grade biomethane (>90% CH_4).
- Capability for continuous and intermittent operation without loss of performance.
- Zero microbial inhibition and limited VFA accumulation.
- Demonstration of technological maturity and suitability for CCU applications under varying feed conditions.
- The integrated gas purification and biological methanation process proved to be efficient and operationally stable, confirming its potential for application not only in pilot-scale but also in industrial settings.