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LIFE20 CCM/GR/001642

DEMONSTRATION OF A MOBILE UNIT

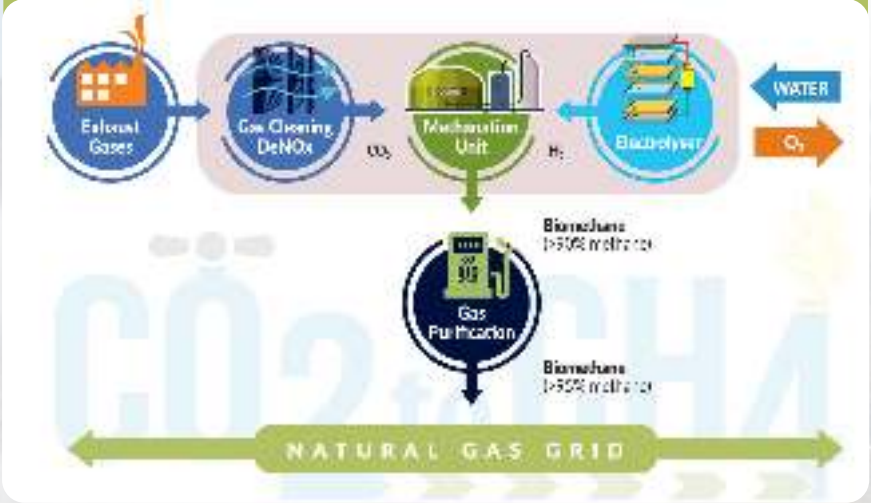
FOR HYDRID ENERGY STORAGE BASED ON CO_2 CAPTURE AND RENEWABLE ENERGY SOURCES

3RD NEWSLETTER 2023

THE PROJECT

LIFE CO2toCH4 aims to develop and demonstrate an innovative, integrated, and sustainable industrial process for simultaneous energy storage and CO_2 capture and utilization (CCU). The ultimate goal of the project is to construct, test and operate (TRL8) a smart mobile unit for hybrid energy storage able to be installed in remote energy systems that commonly have low capacity (e.g. remote areas or islands that are not connected to the central energy grid). The technology innovation relies on the fact that the RES (Renewable Energy Sources) to be used for water electrolysis and subsequently, the produced H_2 will be biologically converted into methane (as a non-fossil biofuel) together with CO_2, which will be captured from exhaust gases with a two-stage membrane separation process.

LIFE CO2toCH4 Mobile Unit for Hybrid Energy Storage



PROJECT BENEFICIARIES

PPC Renewables

ARISTOTLE UNIVERSITY OF THESSALONIKI

ELGO - DIMITRA
HELLENIC AGRICULTURAL ORGANIZATION - DIMITRA

NEVIS

ΔΕΗ

UNIVERSITÀ DEGLI STUDI DI PADOVA

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CLIMATE PROBLEM TARGETED

As part of the European Green Deal, the Commission proposed in September 2020 to raise the 2030 greenhouse gas emission reduction target, including emissions and removals, to at least 55% compared to 1990. Specifically, the key targets for 2030 dictate:

a) At least 40% cuts in greenhouse gas emissions (from 1990 levels), **b)** At least 32% share for renewable energy, and **c)** At least 32.5% improvement in energy efficiency.

Overall, the EU sets out its vision to be climate-neutral by 2050 achieving an economy with net-zero greenhouse gas emissions. This objective is at the heart of the European Green Deal and in line with the EU's commitment to global climate action under the Paris Agreement. To reach these goals, EU member states need to take measures to cut emissions and decarbonise the economy. New rules and updates of EU legislation are available to make the green transition a reality. In specific:

- The **European climate law under the European Green Deal** entered into force, in July, 2021. The climate law sets the framework for the EU countries to progressively reduce emissions, and reach both the 2030 and 2050 climate goals.
- In addition, the Council approved the new **EU strategy focusing on adaptation to climate change by the European Commission**, in June, 2021. The strategy outlines a climate-resilient EU society fully adapted to the unavoidable impacts of climate change, by 2050.
- Moreover, the EU adopted the **'Fit for 55' package**. This plan incorporates a set of proposals for revision of existing legislation and new initiatives. The package includes rules on energy, transport, emissions trading and reductions, land use and forestry.

However, there is no silver bullet for the climate change challenge. In this context, all economic sectors will have to contribute to materialising the objectives of the EU Strategy. To this end, LIFE CO2toCH4 project deals with all the main issues raised in the power sector in regard to carbon dioxide emissions as it will:

Achieve substantial reduction of CO_2 emissions with only one mobile unit for hybrid energy storage using impure CO_2 sources as input material.

Overcome the barrier of the inefficient and expensive storage of excess electricity by using a mobile unit for hybrid energy storage based on CO_2 capture and renewable energy sources.

Tackle the issue of precisely balancing the supply with the electricity grid by using an integrated system that uses impure CO_2 sources, and harnesses microbial consortia for producing biomethane.

Use renewable energy sources for producing electricity without worrying about destabilising the grid since energy is stored in a stable form.

Confront the issue of remote areas and islands concerning the high risk of a power outage by using a competitive procedure for storing energy in a mobile unit.

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SPOTLIGHT ON BIOLOGICAL METHANATION: A PROMISING CCU TECHNOLOGY

Within the vast domain of Carbon Capture Utilization and Storage (CCUS), there's a significant subset dedicated to Carbon Capture and Utilization (CCU) technologies. CCU is not just about capturing CO_2, but it's about transforming this captured carbon dioxide into sustainable and valuable products. One notable example? The production of biofuels such as methane (CH_4) as depicted in *Figure 1*.

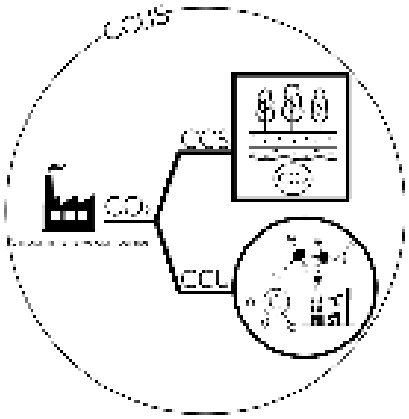

Figure 1. An option often cited as the primary technology for decarbonizing the energy sector and power-intensive industry is the so-called Carbon Capture, Utilization, and Storage (CCUS). In CCU the CO_2 is converted into commercial products, such as CH_4, which is the targeted product of the "LIFE CO2toCH4" project.

A standout method in this CCU sphere is the biological methanation process, also commonly referred to as hydrogenotrophic methanogenesis. This method efficiently recycles collected CO_2. But how does it work? The chemistry is intriguing: it takes two hydrogen (H_2) molecules to transform a single CO_2 molecule into one molecule of methane (CH_4).

Specialized anaerobic hydrogenotrophic methanogens carry out biological methanation. These microorganisms use H_2 as an electron donor, transforming CO_2 into CH_4. When we discuss the process, temperature emerges as a crucial factor. Depending on their temperature preferences, methanogens fall into mesophiles (operating between 30-45°C) and thermophiles (operating between 55-70°C). This classification determines whether the biomethanation systems function in mesophilic or thermophilic conditions. Notably, thermophilic systems often lead the race in CH_4 production, thanks to the accelerated growth rates of methanogenic archaea.

But here's a challenge: how do we ensure a consistent H_2 supply for the process? The sustainability of biomethanation hinges on this. The current strategy ties H_2 supply to renewable energy sources like hydro, wind, and solar. Diving deeper, there are three primary configurations for H_2 supply: in-situ, ex-situ (see *Figure 2*), and hybrid designs.

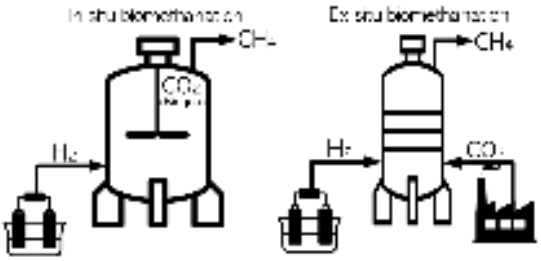

Figure 2. The in-situ and ex-situ biomethanation configurations.

In the in-situ approach, H_2 is introduced directly into a biogas reactor, interacting with the naturally produced CO_2 in the anaerobic digester. Contrastingly, the ex-situ process involves feeding CO_2 from external sources and H_2 into a separate anaerobic reactor, resulting in CH_4 production.

One potential challenge with the in-situ model is the cost; direct H_2 injection can be pricey due to hydrogen's low solubility in water-based environments. This is where the ex-situ method shines. With its external reactor, there's enhanced control over operational conditions (pH, temperature, H_2 mass transfer etc.). Compared to the in-situ approach, this model offers more flexibility and efficiency.

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SPOTLIGHT ON BIOLOGICAL METHANATION: A PROMISING CCU TECHNOLOGY

Regarding ex-situ biological methanation, several reactor designs come into play: from CSTR to fixed bed and bubble column configurations. But standing tall among them is the trickle bed reactor (TBR). What makes TBRs stand out? These reactors feature a column densely packed with material offering a high specific surface area. This design allows microorganisms to immobilise effectively, leading to efficient gas retention and, importantly, optimized conversion of CO_2 to CH_4. The secret? It's all about ensuring a well-timed interaction between the introduced CO_2 and H_2 gases and the biofilm on the packing materials.

Highlighting the practical implementation of this concept in "**LIFE CO2toCH4**" project, a prototype pilot methanation unit has been designed, constructed, and already operating in Hellenic Agricultural Organisation – Dimitra, converting CO_2 and H_2 into CH_4. The project team monitors the unit's daily performance, capturing vital data points, including the output gas composition (CH_4, H_2, CO_2), VFAs concentration, pH levels, and nutrient concentration (as illustrated in *Figure 4*). And the impact? This pilot unit has already made its mark by capturing and reutilising over 80kg of CO_2 into valuable biomethane.

Figure 3. Prototype pilot methanation unit in Hellenic Agricultural Organisation - Dimitra.

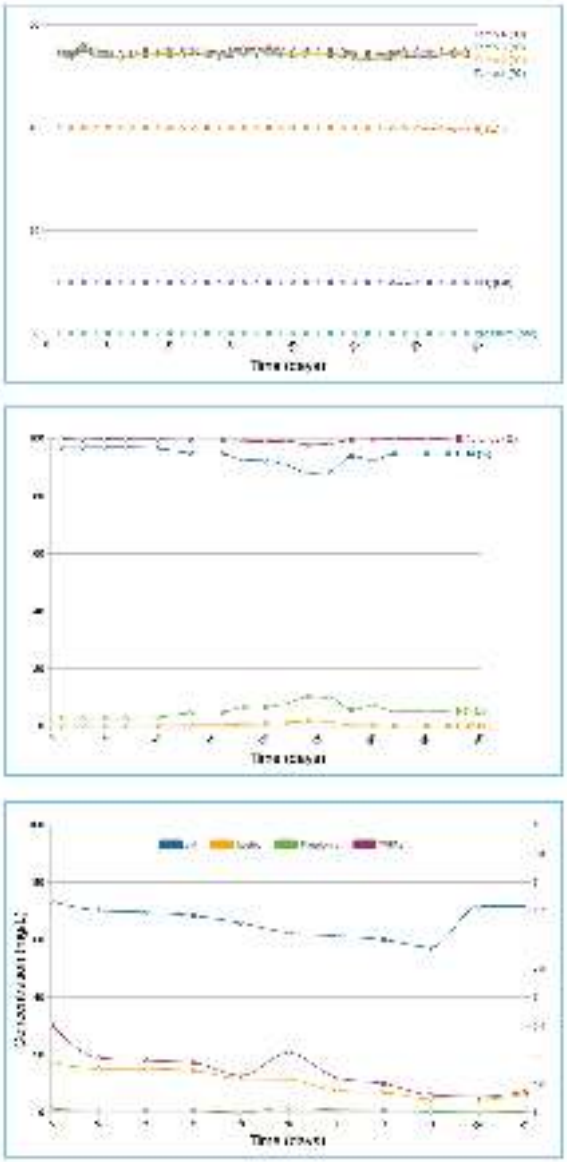

Figure 4. Pilot methanation unit monitoring plots; output gas composition, VFAs concentration, pH value, temperature, and inlet gases (H_2 and CO_2).

As outlined in the project roadmap, a mobile hybrid energy storage system consisting of an array of two reactors will be installed in Agios Dimitrios PPC plant.

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MEETINGS & EVENTS

5TH INTERNATIONAL EXHIBITION OF ENVIRONMENTAL TECHNOLOGIES VERDE.TEC, 17-19 March 2023

The **LIFE CO2toCH4** project (co-funded by the Green Fund) was presented at the LIFE European funding program event organized by **CINEA** - European Climate, Infrastructure and Environment Executive Agency, in partnership with the Green Fund, in the context of the **5th international exhibition Verde.tec** "Environmental Technologies", on Saturday March 18, 2023.

The **LIFE CO2toCH4** project participated in the session entitled: "**LIFE Programme, the EU's funding instrument for environment and climate action**". During the event, speeches were held on the characteristic elements of the **LIFE Programme**, the contribution of LIFE to the national policy framework and the invitation submission of LIFE 2023 proposals. Also, a reference was made to successful examples of LIFE projects, one of which is the **LIFE CO2toCH4**, and to the good practices and results of projects implemented in Greece.

Dr. Apostolos Antoniadis (Project Manager) gave in his speech a brief description of the project and the basic technology that it utilizes as well as the main actions that will be carried out during the project. He also presented the main objectives of the project, the contribution of **LIFE CO2toCH4** to the European and National strategy to tackle climate change, as well as the technical progress of the project up to the moment of the specific event.

After the end of the session, the attending LIFE CO2toCH4 project beneficiaries representatives had the opportunity to interact and develop synergies with other Greek projects in progress, while a poster of the **LIFE CO2toCH4** project was hosted in the LIFE program booth D40a. Informational material (leaflets) of the project was also available during the event.

2ND CIRCULAR ECONOMY FESTIVAL, 7-10 June 2023

Thessaloniki recently hosted the **2nd Circular Economy Festival**, co-organized by the Municipality of Thessaloniki and TIF-Helexpo. Professor Anastasios Zouboulis's presentation on the **LIFE CO2toCH4** project was a key highlight. The festival emphasized Thessaloniki's commitment to sustainable urban waste management and introduced residents to innovative, environmentally friendly practices. This event showcases the city's dedication to merging daily routines with circular economy principles, paving the way for a greener future.

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MEETINGS & EVENTS

2ND MONITORING VISIT, ELGO DIMITRA PREMISES, THESSALONIKI

The 2nd monitoring meeting of the **LIFE CO2toCH4** project took place on 30th of March, 2023 at the **ELGO DIMITRA** premises,Thessaloniki Greece, in hybrid format with the participation of all partners' the participation of Mrs. Sofia Papageorgiou, the Monitoring Expert of the project (NEEMO). The meeting was led by our project coordinator Dr. Apostolos Antoniadis from PPC Renewables, and hosted by Dr. Panagiotis Kougias from ELGO.

Visit to the prototype methanation unit at ELGO-DIMITRA premises and describing of the operation system by Dr. Panagiotis Kougias.

A SUCCESSFUL LAUNCHING EVENT. AN INSPIRING CONFERENCE IN CHANIA!

The **LIFE CO2toCH4** Launching Event took place on Thursday, 22nd June, as a parallel event during the **10th International Conference on Sustainable Solid Waste Management in Chania, Crete, Greece**. The session was opened by Prof. Maria Loizidou from the UNIT OF ENVIRONMENTAL SCIENCE & TECHNOLOGY (UEST) - NTUA, who focused on the rapid advancement towards 4th generation biofuels in support of EU policies.

Dr. Apostolos Antoniadis, our project coordinator, presented the main objectives and scope of the **LIFE CO2toCH4** project, as well as the primary activities of PPC Renewables. Dr. Christos Roumpos emphasized the significance of the project for PPC by giving a description of the environmental policy of PPC and how it aligns with the objectives of the EU Green Deal.

During the event, Prof. Anastasios Zouboulis from Aristotle University of Thessaloniki (AUTH) discussed the main CO_2 capture technologies and the application of membrane separation for separating CO_2 from fuel gases. He also presented his research work and the contribution of his university to the project.

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MEETINGS & EVENTS

Dr. Panagiotis Kougias from ELGO DIMITRA Laboratory in Thessaloniki presented his laboratory work related to the **LIFE CO2toCH4** project. His presentation focused on the technological background of the biological methanation process in trickle bed reactors, the team's work on the prototype pilot methanation unit, and the troubleshooting experience gained over crucial operational parameters.

Our Italian partners, Gabriele Ghiotto and Laura Treu from the University of Padova, presented their research work on the optimization of the Microbial Resource Management process and their contribution to the work of our project.

The project's Launch Event was part of the larger conference, **CHANIA2023 - 10th International Conference on Sustainable Solid Waste Management**, which featured 26 sessions, 550 oral presentations, 215 posters, 11 keynote speakers, and 7 collaborating journals. The conference had a total of 950 participants, both physically and online.

VISIT OF THE MINISTER OF RURAL DEVELOPMENT AND FOOD TO THE LIFE CO2TOCH4 METHANATION PILOT UNIT OF ELGO-DIMITRA

On Thursday 31/8, the Minister of Rural Development and Food, Mr. Avgenakis, the Deputy Minister Mr. Stamenitis and the Secretary General Mr. Baginetas and Mr. Stratakos paid a visit to the modern site of ELGO-DIMITRA, at the campus of Thermi in Thessaloniki. An important stop of the visit was the Waste Management and Bioprocessing Laboratory of the Soil and Water Resources Institute. There, the Minister had the opportunity to be informed about the ongoing research projects and to be thoroughly informed about the **LIFE CO2toCH4** project. At the same time, he was given a demonstration of the pilot CO_2 to methane conversion pilot unit and discussed the prospects for the replication of this technology in further agri-food sectors.

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CO2toCH4 BENEFICIARIES

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CO2toCH4 SUMMARY PROJECT DATA

Total Eligible Project Budget: 3,888,985 Euro
Project Implementation period: 4 years
EU financial contribution requested: 2,138,941 Euro
(= 55.00% of total eligible budget)

The project implementation started in October 2021 and it is expected to be completed by September 2025, in selected regions of Greece and Italy.

CO2toCH4 STAY CONNECTED!!

WEBSITE

> For more news & updates please visit our website:
https://co2toch4.eu/

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The project is co-funded by LIFE, the EU's financial instrument supporting environmental, nature conservation and climate action projects throughout the EU.