CO2toCH4 Life

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

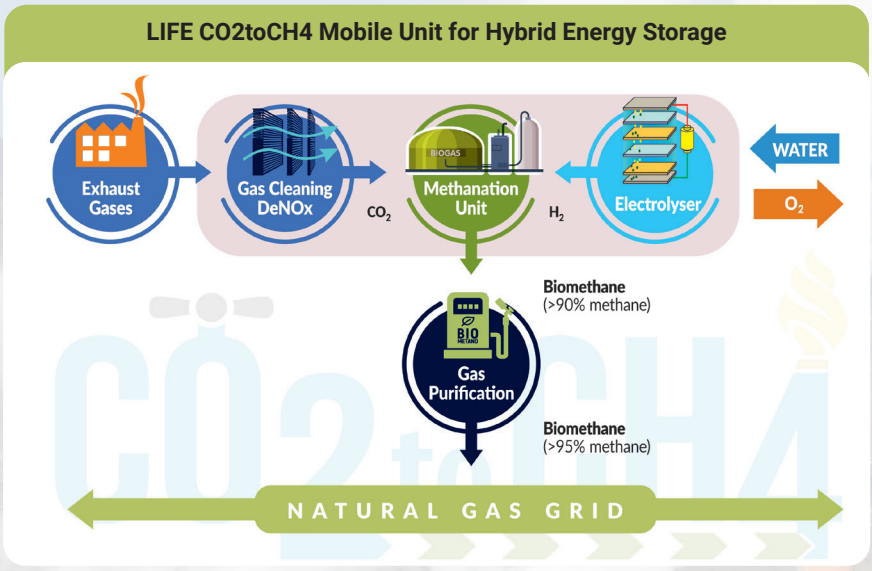
DEMONSTRATION OF A MOBILE UNIT

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

2ND 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 from exhaust gasses.

PROJECT BENEFICIARIES

PPC Renewables

ARISTOTLE UNIVERSITY OF THESSALONIKI

ELGO - DIMITRA
HELLENIC AGRICULTURAL ORGANIZATION - DIMITRA

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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. As it is clearly visible the transition to the EU's climate strategy is passing through all sectors, including increased energy efficiency and renewable energy. Thus, EU starts the process of making detailed legislative proposals by June 2021 to implement and achieve the increased ambition. Furthermore, the EU aims to be climate-neutral by 2050 – 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.

Since there is no silver bullet for the climate change challenge, 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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TECHNICAL PROJECT PROGRESS UP TO DATE

THE IMPORTANCE OF CCUS APPROACH

In the context of the effort to reduce CO_2 emissions, especially those created during the incineration of mineral fuels for energy production, there is an urgent need for the creation of a holistic approach, including legislation initiatives. EU climate change relevant policy was initially developed back in the 1980s. Ultimate goal of this effort was to achieve the stabilization of major greenhouse gases' concentrations in the atmosphere at a sufficiently lower level that would prevent the expected dangerous anthropogenic interference with the climate. By reducing the greenhouse gases' emissions means generally to get rid of carbon. Phasing out the CO_2 emissions, is often referred as decarbonization.

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 relation to this general term, Carbon Capture and Storage (CCS) and Carbon Capture and Utilization (CCU) technologies should be particularly mentioned. The difference between CCS and CCU lies in the destination of the captured CO_2. In CCS, the captured CO_2 is transported to a suitable site for long-term storage, while in CCU the captured CO_2 is reutilized by conversion into commercial products, such as CH_4 (used as alternative fuel), which actually is the desired product of "CO2toCH4" LIFE project. In general, the concept of CCU is indeed more attractive. Instead e.g. of burying CO_2 underground, hoping to its further geological mineralization process, CO_2 can be used as raw material, for the production of valuable commercial products, such as bio-plastics and/or bio/fuels.

The main CO_2 capture technologies that can be applied to isolate CO_2 from the exhaust gases waste streams are absorption, adsorption, cryogenic separation and membrane separation. Membrane processes have seen a considerable transformation in the past forty years, going gradually from a rather insufficient technological state towards a viable 2nd generation technical solution with numerous new applications in the separation science and technology field. This advancement was made possible by the coordinated, synergistic research on customized membrane materials and on relevant process design studies. Although there are still several obstacles to overcome and problems to be resolved, it is projected that membrane processes will undoubtedly play an important part in the overall framework for carbon capture, either as a separate system or through the application of hybrid processes. The membrane-based technologies present a series of interesting advantages in comparison with the other relevant carbon capture technologies, such as lower cost, simpler operation etc., and they are considered as environmentally more friendly, since no chemicals' use is demanded, when compared e.g. to amine scrubbing treatment system, where significant quantities of mono-ethanol-amine solutions are periodically required. In the "CO2toCH4" project specific polymeric membranes will be employed in a two-stage pilot-scale system for separating gas mixtures, aiming to provide the final bio-methanation (bio-transformation) unit with relatively cleaner CO_2 stream of higher concentration.

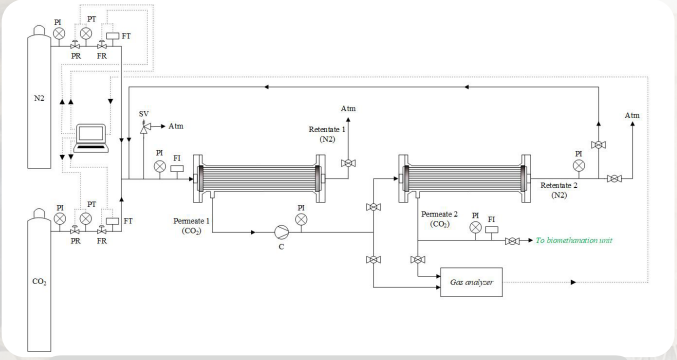

Figure 1. Two-stage membrane separation process for CO_2 capture from the flue gases.

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TECHNICAL PROJECT PROGRESS UP TO DATE

THE MICROBIAL RESOURCE MANAGEMENT

The production of adapted microbial hydrogenotrophic consortia has begun, and a preliminary aliquots have been delivered to ELGO as an inoculum for the pilot reactor. Several experiments have been initiated to explore the potential of the existing hydrogenotrophic inoculum derived from agricultural waste. A novel inoculum has been developed at ELGO from activated sludge, and samples from both the liquid phase and biofilm have been periodically collected and sent to UniPD for monitoring the microbial community composition and defining population dynamics. Moreover, the biofilm developed on the diffusion devices of biogas upgrading reactors is under investigation using genome-centric metagenomics. These studies aim to evaluate and utilize the network of interactions in mixed microbial consortia for optimizing the process by addressing shifts in microbial composition and tuning working parameters (see Figure). These studies have been presented at conferences and published in international scientific journals; additional measures for monitoring microbial communities and optimizing the process are currently being implemented.

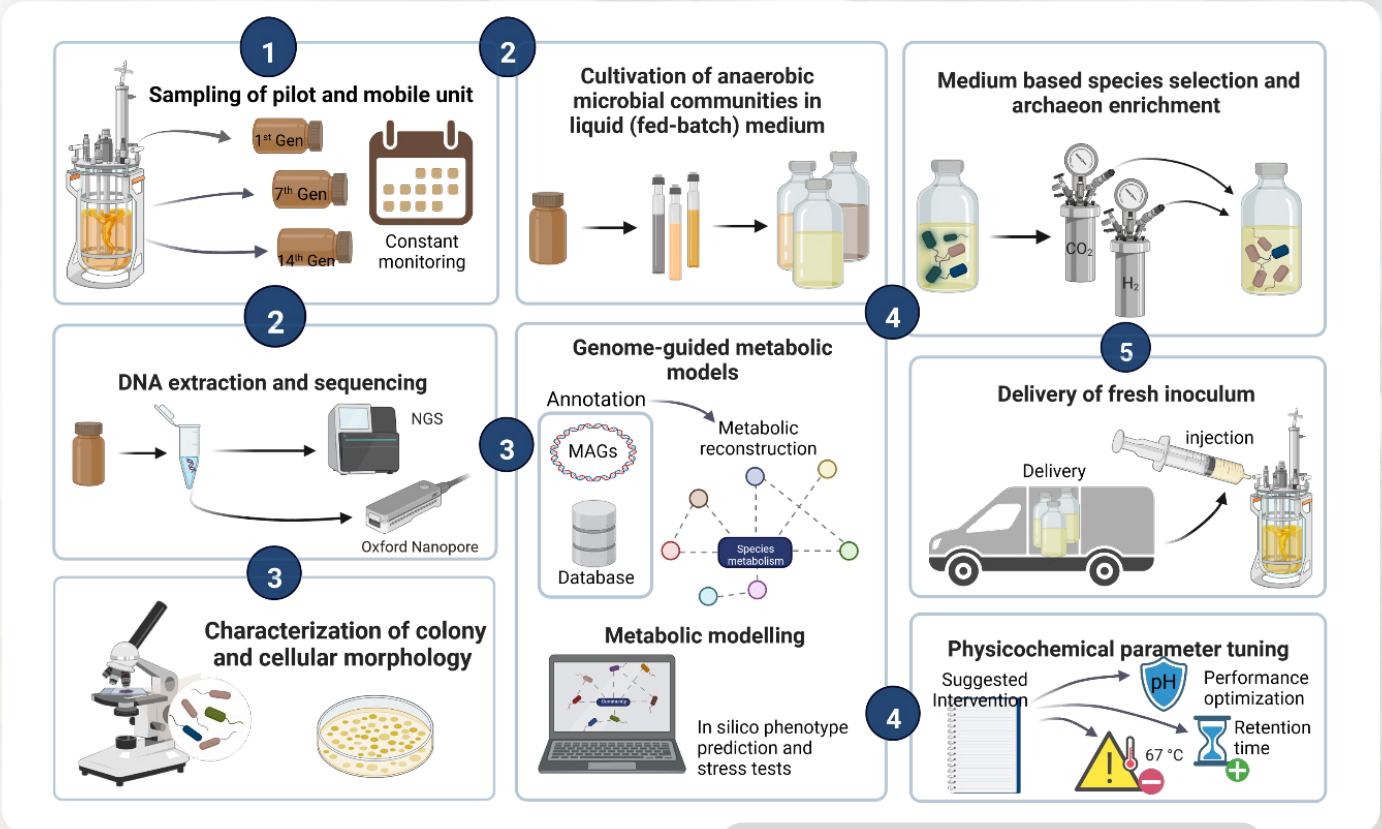

Figure 2. Schematic workflow for microbial resource management of UNIPD.

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POLICY RELEVANCE

POLICY	LIFE CO2toCH4 POLICY RELEVANCE
COM/2015/080 final, A framework strategy for a resilient energy union with a forward-looking climate change policy.	The key priorities of this policy refer to the development of a fully integrated internal energy market and the reduction of energy imports, thus improving energy efficiency. In addition, this policy supports breakthroughs in low-carbon and clean energy technologies by prioritizing research and innovation for decarbonizing the economy. LIFE CO2toCH4 contributes to the implementation of the policy by proposing an innovative technology that uses CO_2 from exhaust gases for the production of biomethane.
2018/2001/EU, Renewable Energy Directive REDII	Directive (EU) 2018/2001 is a recast of the Fuel Quality Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amends Directives 2001/77/EC and 2003/30/EC (RED I). In this context, the Directive establishes an overall policy for the production and promotion of energy from renewable sources in the EU. LIFE CO2toCH4 produces biomethane based on CO_2 from exhaust gases and H_2 using RES.
Renewable Energy Directive (RED II) Directive (EU) 2018/2001 and its amendments	The amendment of REDII resulted in a series of revised documents, such as the Amendment of the Fuel Quality Directive (EU) 2015/1513, namely the iLUC Directive. The key element of the amendment is that the contribution of biofuels produced from 'food' crops (to the 10% renewables in transport target) is capped at 7%. The other 3% will come from a variety of multiple-counted alternatives. The technology of CO2toCH4 project relies on using H_2 from RES that will be biologically converted into methane together with CO_2 from exhaust gasses.

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POLICY RELEVANCE

POLICY	LIFE CO2toCH4 POLICY RELEVANCE
European Climate Law Regulation (EU) 2021/1119	The Regulation (EU) 2021/1119 enshrines into law the EU's climate-neutrality objective, ensuring that all EU actions and policies contribute to it in a socially fair and cost-efficient manner incorporating all societal and economic sectors. In this context, the LIFE CO2toCH4 project can achieve a reduction of CO_2 in carbon-intensive industries thus contributing to the reduction of greenhouse gas emissions target of the law.
COM (2011) 112, A Roadmap for moving to a competitive low carbon economy in 2050	LIFE CO2toCH4 focuses on the use of CO_2 from the exhaust gases of energy-intensive industries. Therefore, it contributes to the reduction of greenhouse gas emissions as foreseen in the Roadmap.
DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on industrial emissions (integrated pollution prevention and control)	LIFE CO2toCH4 contributes to the prevention and control of CO_2 industrial emissions.
Regulation (EC) No 166/2006 on the establisment of a European Pollutant Release and Transfer Register	The reduced CO_2 emissions achieved with the LIFE CO2toCH4 project are visible at the official data registries.
COM(2022) 672 Final Regulation of the European Parliament and of the Council establishing a Union certification framework for carbon removals	The project, relying on deploying innovative carbon removal technologies and sustainable carbon farming solutions, provides a voluntary set of rules for certifying high-quality carbon removals. Energy-intensive industries using CCUS technologies, like the technology proposed with the LIFE CO2toCH4 project, ensure high-quality EU-certified carbon removals, through this transparent and credible governance framework.

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MEETINGS & EVENTS

FORTHCOMING HIGHLIGHT EVENT LAUNCHING EVENT

The project's Launching event will be held physically and virtually on **Thursday, 22nd June,** during the **10th International Conference on Sustainable Solid Waste Management, Room 4, SESSION XII**. Join us to participate to this event and vivid discussion and find out more about LIFE CO2toCH4 (https://chania2023.uest.gr/).

PARTICIPATION TO ECOMONDO 2022, 25TH EDITION, 8-11 NOVEMBER 2022

University of Padova LIFE CO2toCH4 project team members participated to **Ecomondo**, a European level event regarding advances and new perspectives in circular economy. In particular, Prof. Lorenzo Favaro and the BTS company, a long lasting partner of the UNIPD, which has expressed his interest for the LIFE Programme's project participated to this event which is a reference event in Europe for the ecological transition and the new models of circular and regenerative economy and attracts stakeholders globally.

PARTICIPATION TO COBRA CONFERENCE 28-30 SEPTEMBER 2022

LIFE CO2toCH4 landed a spot at the prestigious **8th Conference on Constraint-Based Reconstruction and Analysis (COBRA 2022)** September 28 - 30, 2022, held in Galway, Ireland.

Post-doctoral researcher Esteban Orellana, member of the UNIPD team, presented his results regarding flux balance analysis applied to the microbial community of anaerobic digestion. The syntrophies revealed by his research will effectively drive the project forward. Thanks to this participation, the whole LIFE Programme initiative gained visibility at an international level.

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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.