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Chemical Process and Energy Resources Institute (CPERI)

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CO_2 Capture to Utilization

A Technological and Sustainable Perspective

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Workshop IENE: "The Economics of CCUS Applications"
Technical Chamber of Greece (TGB), 12/03/2025

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Vision for Energy Transition and Environment

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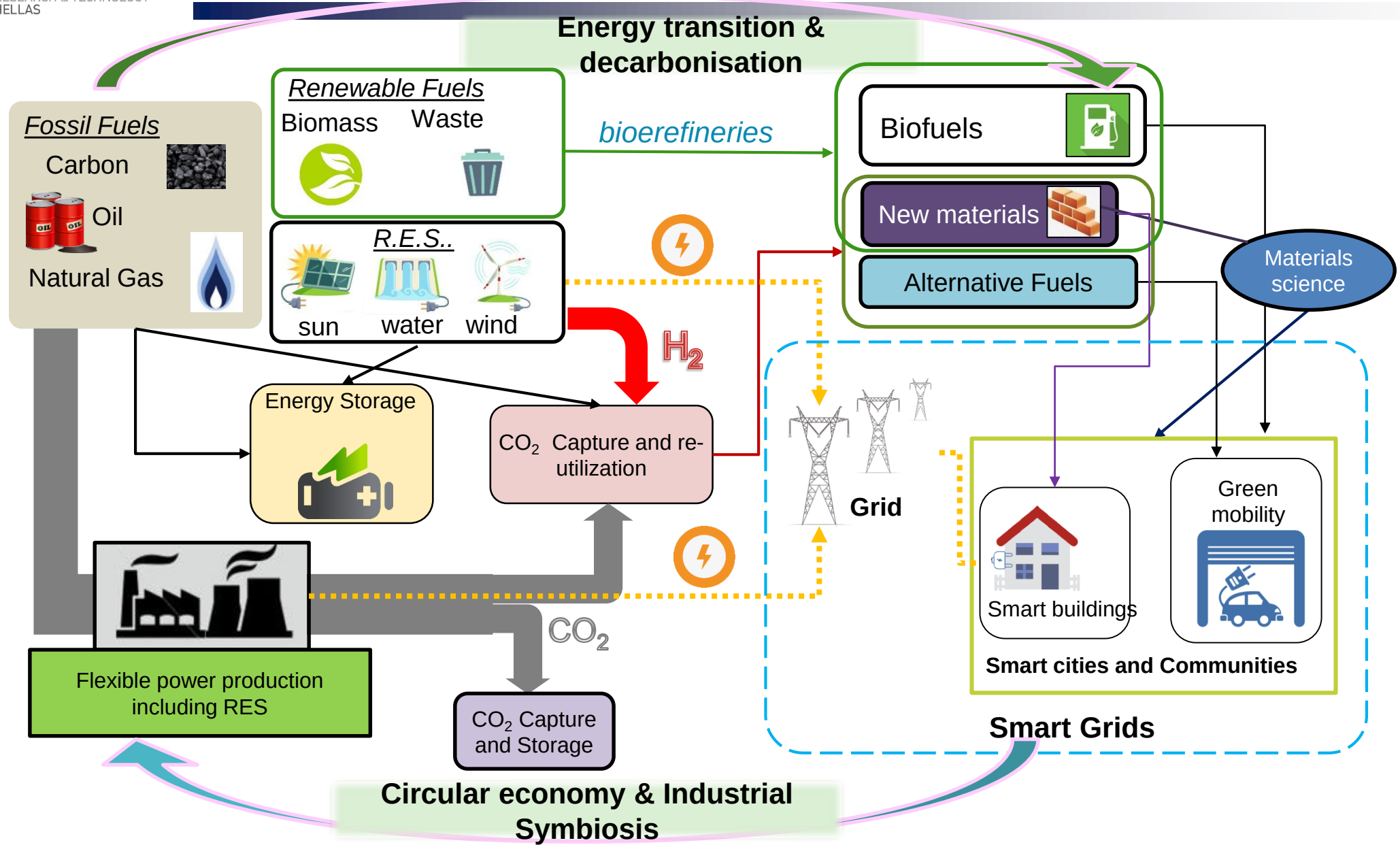
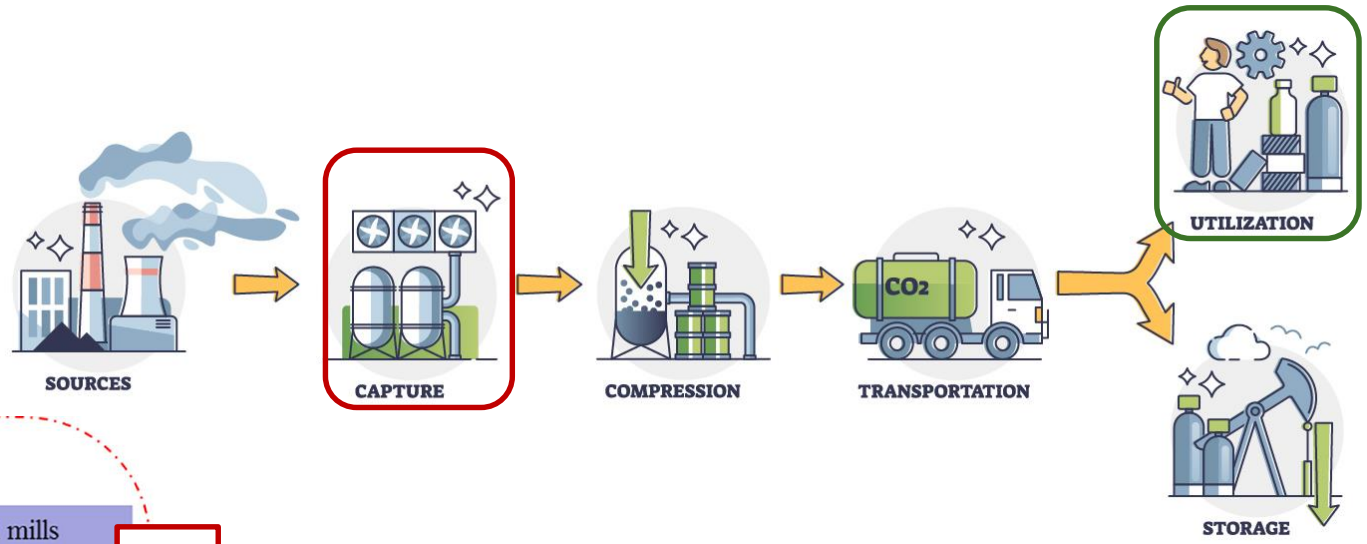
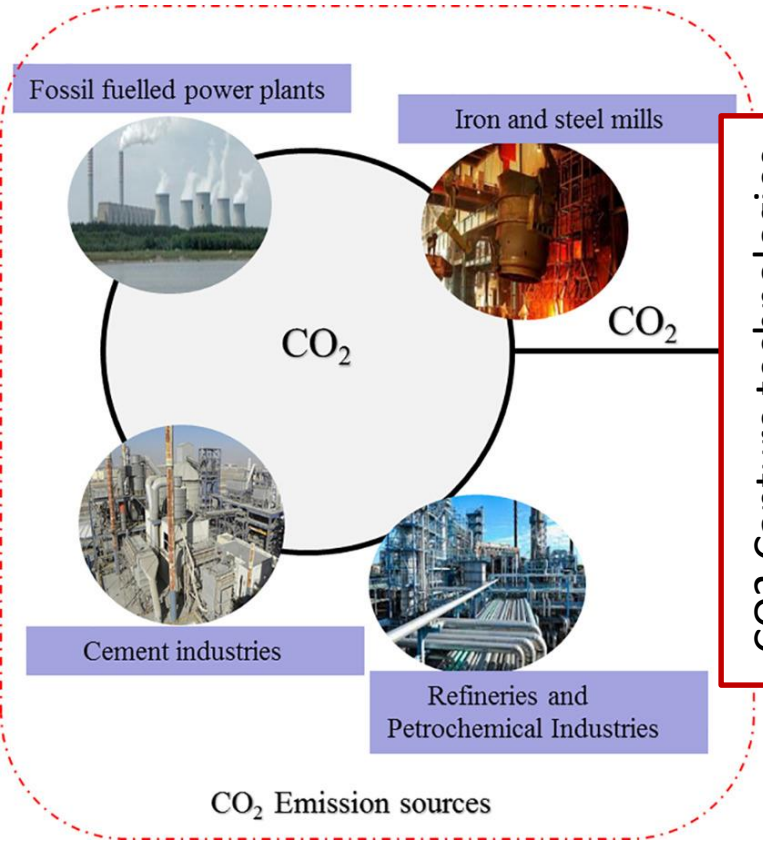


CO2 Capture Technologies





CO2 Capture technologies

- **Pre-Combustion** → Removes or separates CO_2 from a fuel gas before the combustion process.
- **Post-Combustion** → Separate or removes CO_2 from a flue gas containing CO_2 mixed with other gases, after the combustion process. (power plants, cement industries)
- **Oxy-fuel** → Utilizes pure O_2 instead of air, producing flue gas mainly CO_2 & H_2O, which is easily separated.

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Research projects on CCU Technologies

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COCCUS

CO2SMOS
Solutions for a circular biobased industry

SCaRLET

LOUISE

AC²OCem
Accelerating Carbon Capture using Oxyfuel technology in Cement production

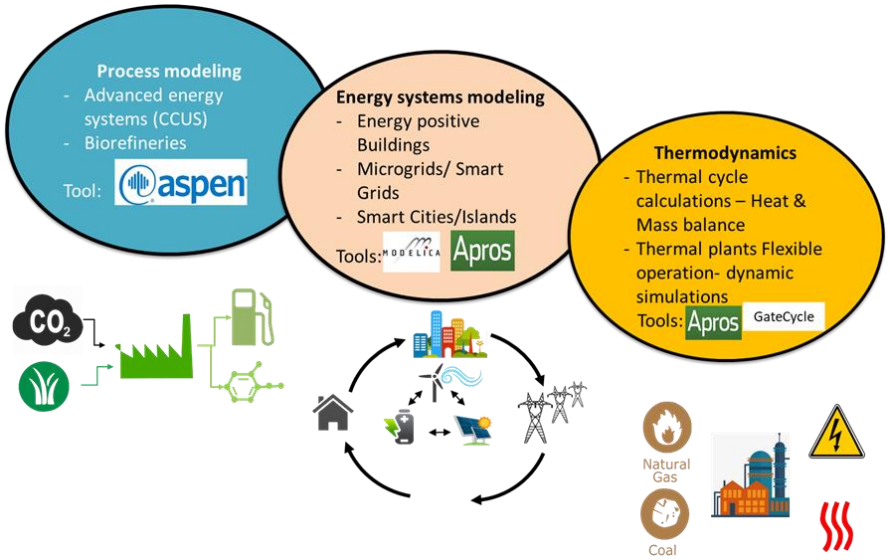
FUELPHORIA

BioTheRoS

H2-HUB project

Technologies

- Calcium Carbonate Looping & Chemical Looping
- Oxy-combustion (oxygen-enriched environment combustion)
- Novel system using enzyme boosted K_2CO_3 Solvents
- Synthetic Fuels by CO_2 & ***Green H_2***
- Chemicals production from industrial CO_2 emissions



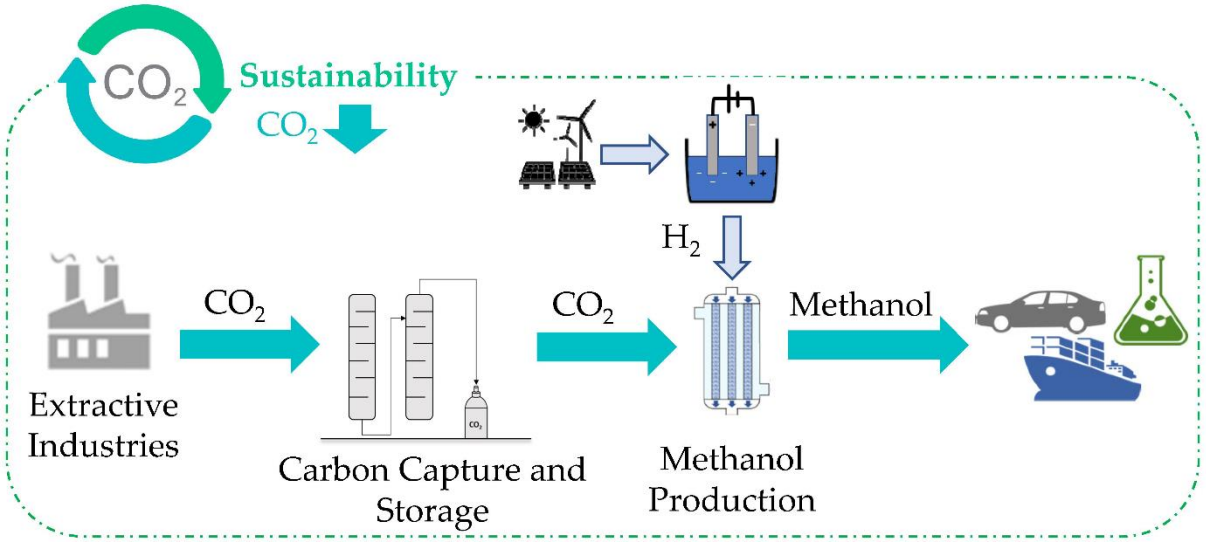
Main Competences

- Computer model libraries for CO_2 capture & separation technologies
- Modeling of Chemical Processes via AspenPlusTM and IPSEproTM
- 3-D Fluid models (CFD) via ANSYS / FLUENT
- Fluid mechanics and heat transfer calculations in CO_2 capture technologies, for mass and energy balances
- Lab scale equipment for CO_2 capture

CoCCUS Scope

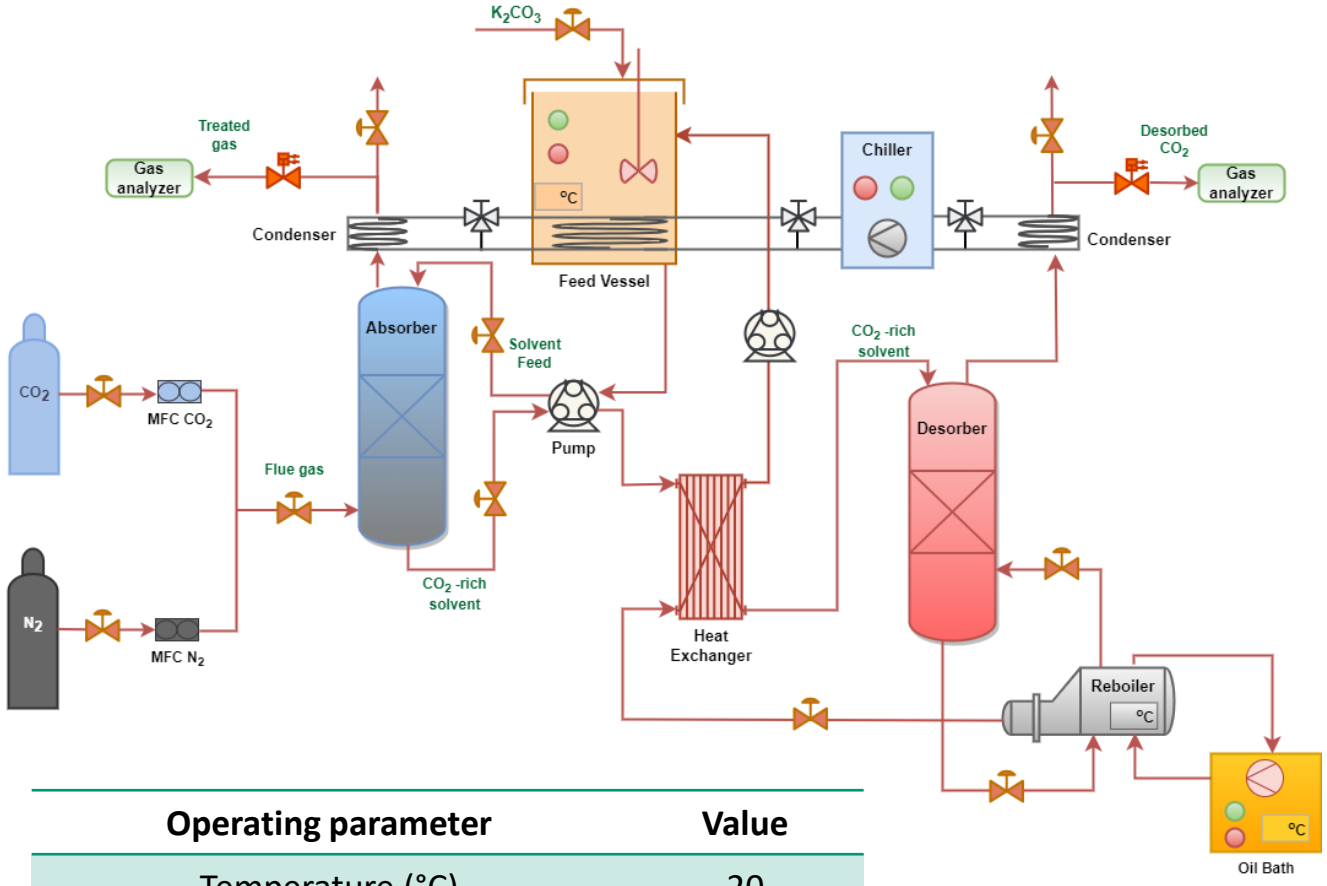
Development of an innovative CO_2 capture technology from flue gases of energy-intensive industries with process-inherent CO_2 emissions

The capture is achieved using a **K_2CO_3 solution** and a **novel thermostable carbonic anhydrase enzymes (CA)**



Production of **high-value-added products**, contributing to sustainability and circular economy applications.

CO2 capture laboratory unit

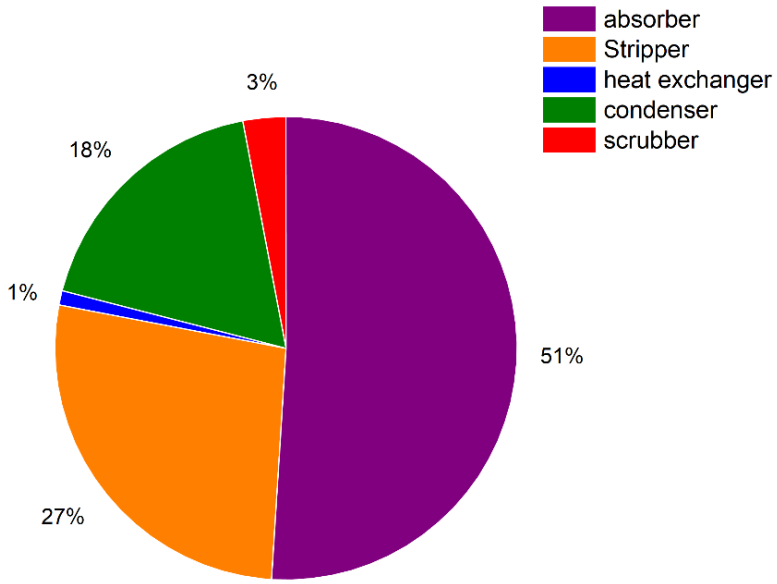


Operating parameter	Value
Temperature (°C)	20
Pressure (barg)	0.8-0.9
L/G (L/m^3)	15
K_2CO_3 concentration (wt.%)	20
Inlet gas CO_2 concentration (vol.%)	20

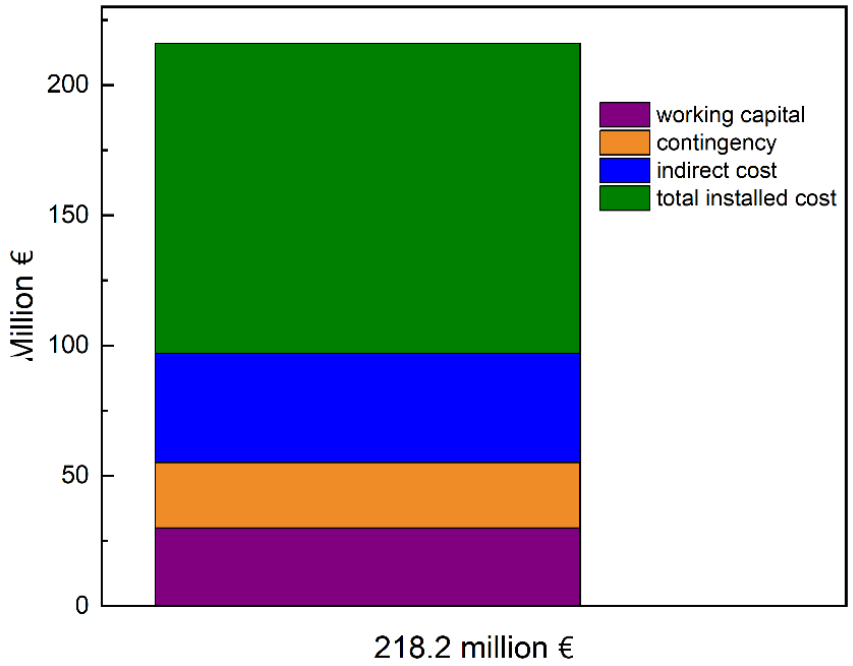
Techno-economic analysis of industrial cases

CO_2 capture cost ranges from 31 to 48 €/tn, including CAPEX and OPEX

- Increased CO_2 molar fraction leads to decreased energy demand and cost



TPEC cost break-down for cement industry



Total Capital Investment Cost break-down for cement industry

Impact of Enzyme Cost on Process Economics

Enzyme replacement cost influences CO_2 capture expenses.

Cost sensitivity analysis:

- 0-3% enzyme replenishment scenarios analyzed
- Potential future enzyme **price reduction by 10-20%** (from 485 €/kg to 430 €/kg).

Lower enzyme costs can significantly improve process feasibility.

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FUELPHORIA project

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Upgrading

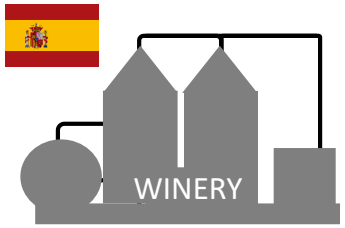
CO_2

2-step fermentation

Microbial oil

Hydrogenation

Hydrotreated oil



Ethanol fermentation

CO_2

Hydrogenation

Methane

CNG, LNG

Ethanol fermentation

CO_2

Hydrogenation

Methanol, Ethanol

CERTH's role:

- Coordination
- Demo runs supervision
- Pilots process modeling
- System design and upgrading at industrial scale

FUELPHORIA

Chemical Looping Combustion for Waste-to-Energy applications: the LOUISE project

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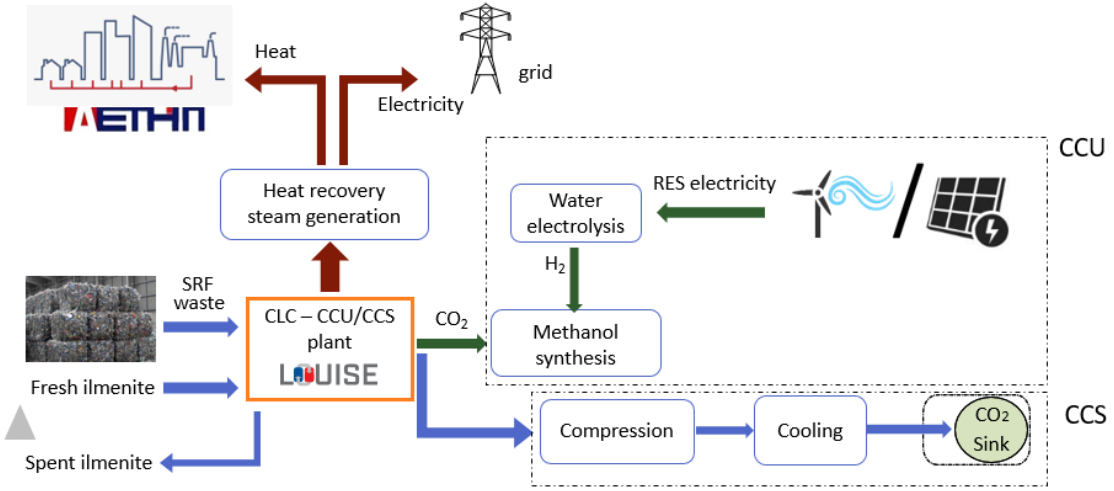
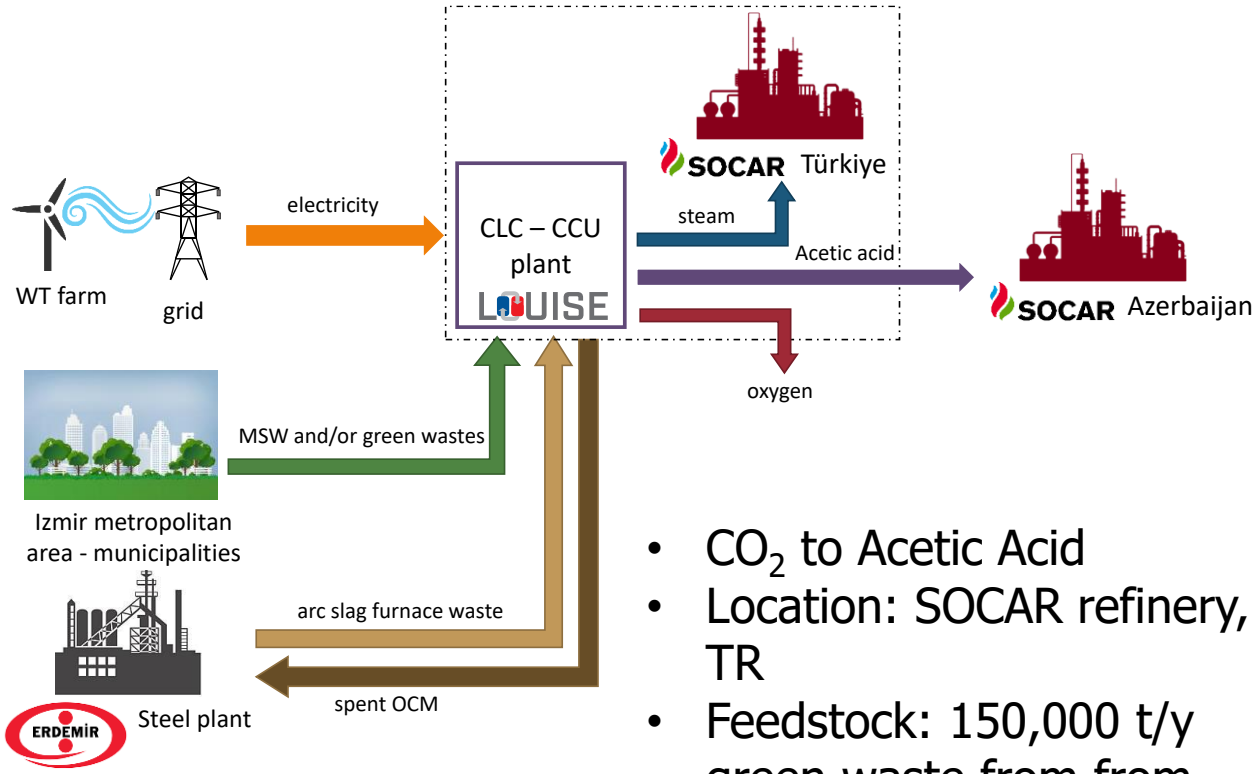
Greek case study



- CO_2 to Methanol
- Location: Western Macedonia
- Feedstock supply: SRF from Thessaloniki & Kozani
- Capacity: **30 MW_{th}**

CO_2 cost	**30.76**	**€/t_{CO2}**
Methanol cost	**1000-1100**	**€/t_{MeOH}**

Turkish case study



- CO_2 to Acetic Acid
- Location: SOCAR refinery, TR
- Feedstock: 150,000 t/y green waste from from Izmir metropolitan area
- Capacity: **100 MW_{th}**

CO_2 cost	**24.05**	**€/t_{CO2}**
Acetic acid cost	**811-910**	**€/t_{AA}**

LOUISE

CO2SMOS: Advanced chemicals production from biogenic CO2 emissions for circular bio-based industries

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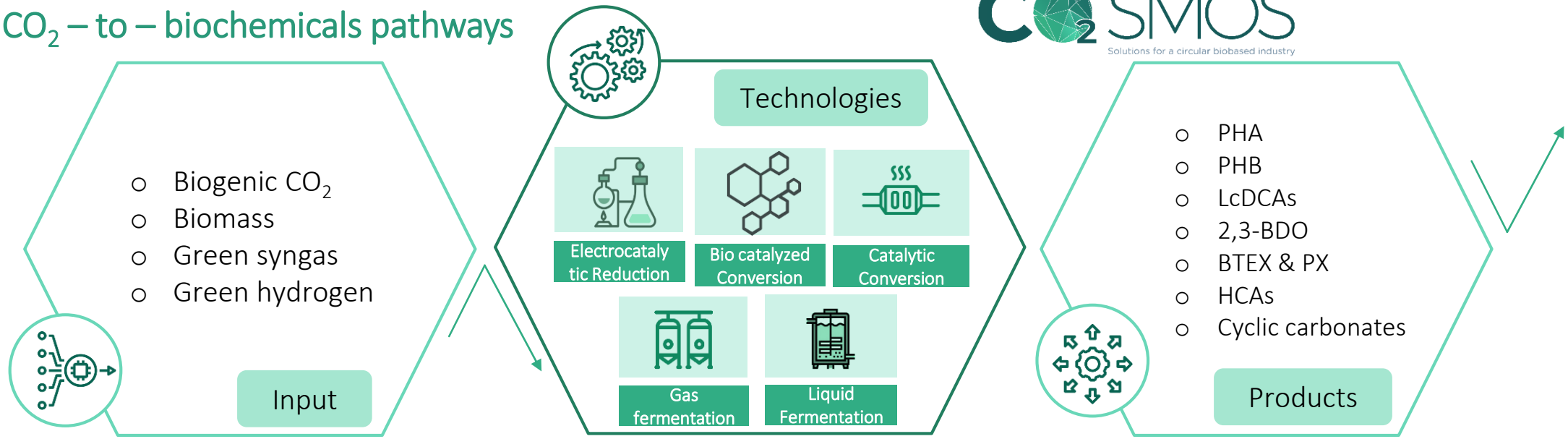
CO2SMOS
Solutions for a circular biobased industry

Biogenic CO_2 – to – biochemicals pathways



CO_2SMOS targets

- 5 Conversion technologies
- 7 Bio-based chemicals
- 60% CO_2 emissions reduction
- 40% Production cost reduction

CO_2SMOS technologies target at negative emissions. CO2SMOS empowers industries to assess sustainability, optimize costs, and choose the most eco-efficient production pathways.

H2 innovation Hub in West Macedonia/Ptolemaida

H2-HUB project

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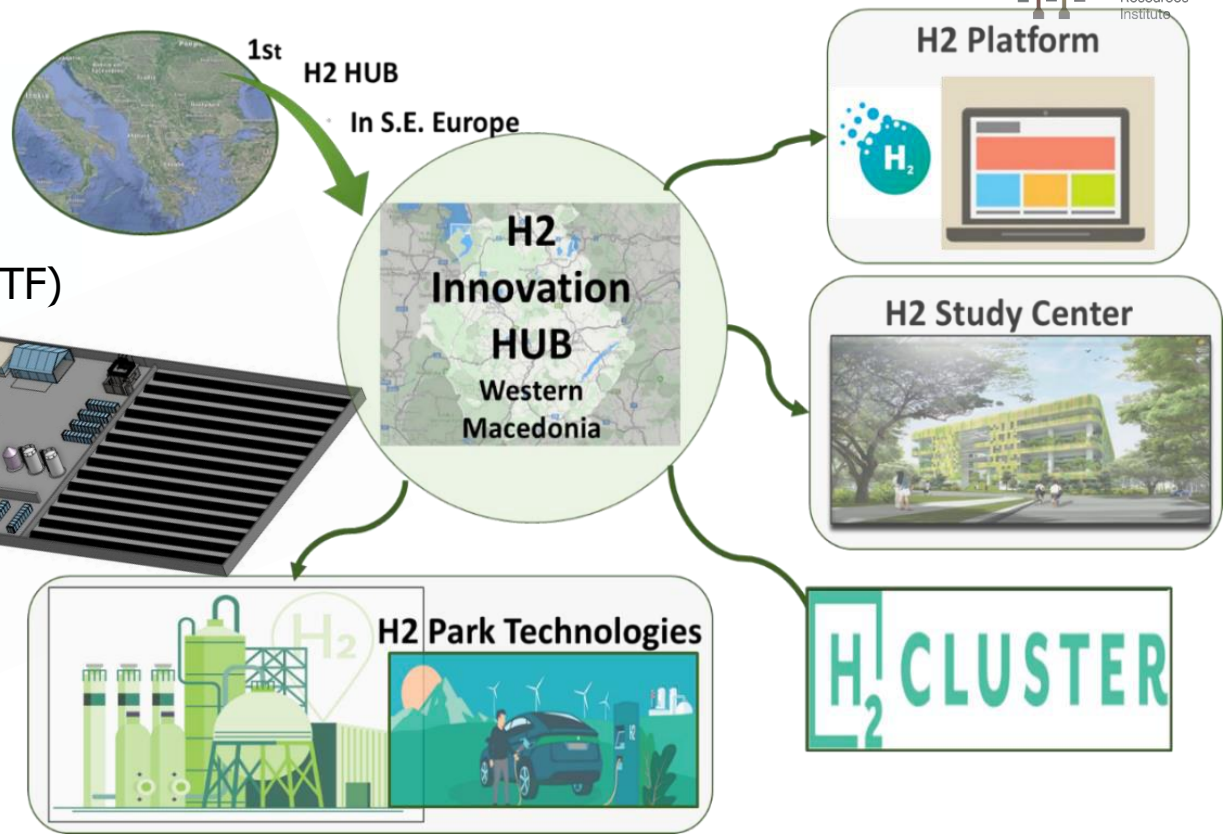
Duration: expected to start operation by middle 2026

(operation of 36 Months)

Budget/ EU contribution: €19,800,000.00 (funded by JTF)

Coordinator: CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS



ΣΧΕΔΙΟ ΔΙΚΑΙΗΣ ΑΝΑΠΤΥΞΙΑΚΗΣ ΜΕΤΑΒΑΣΗΣ

ΠΡΑΣΙΝΟ ΤΑΜΕΙΟ

- Establishment and Development of a H2 Innovation HUB in the Region of Western Macedonia **to conduct research in H2 Applications and circular economy**
- **Vision:** *"Become the number on hub connecting science, industry, politics and other partners in the Greek hydrogen economy by 2025 and onwards , establishing a green hydrogen technology park , offering top-quality services, promoting innovation and know-how transfer"*

Future plans

- Engagement in research projects
- Optimization of laboratory CO_2 capture unit optimization
- Collaboration with industries to identify and address the challenges in upscaling of CO_2 capture process
- Development of enzymatic CO_2 capture processes for industrial applications
- Accomplishment of Green H_2-Hub and production of synthetic fuels

Ptolemais branch, Greece

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Website

https://www.cperi.certh.gr/el/research-areas-2/solid-fuel-techonology-application-sector-2