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Membrane-assisted Ethylene Synthesis over Nanostructured Tandem Catalysts

Project Overview

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Meeting Name
Place, Date

Contact: *Name*
Email

Company Logo

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Outline:

- **Motivation**
    - **Carbon capture and utilization**
    - **Sustainable pathway for ethylene production**
- **Goal of MemCat project**
    - **Highlights**

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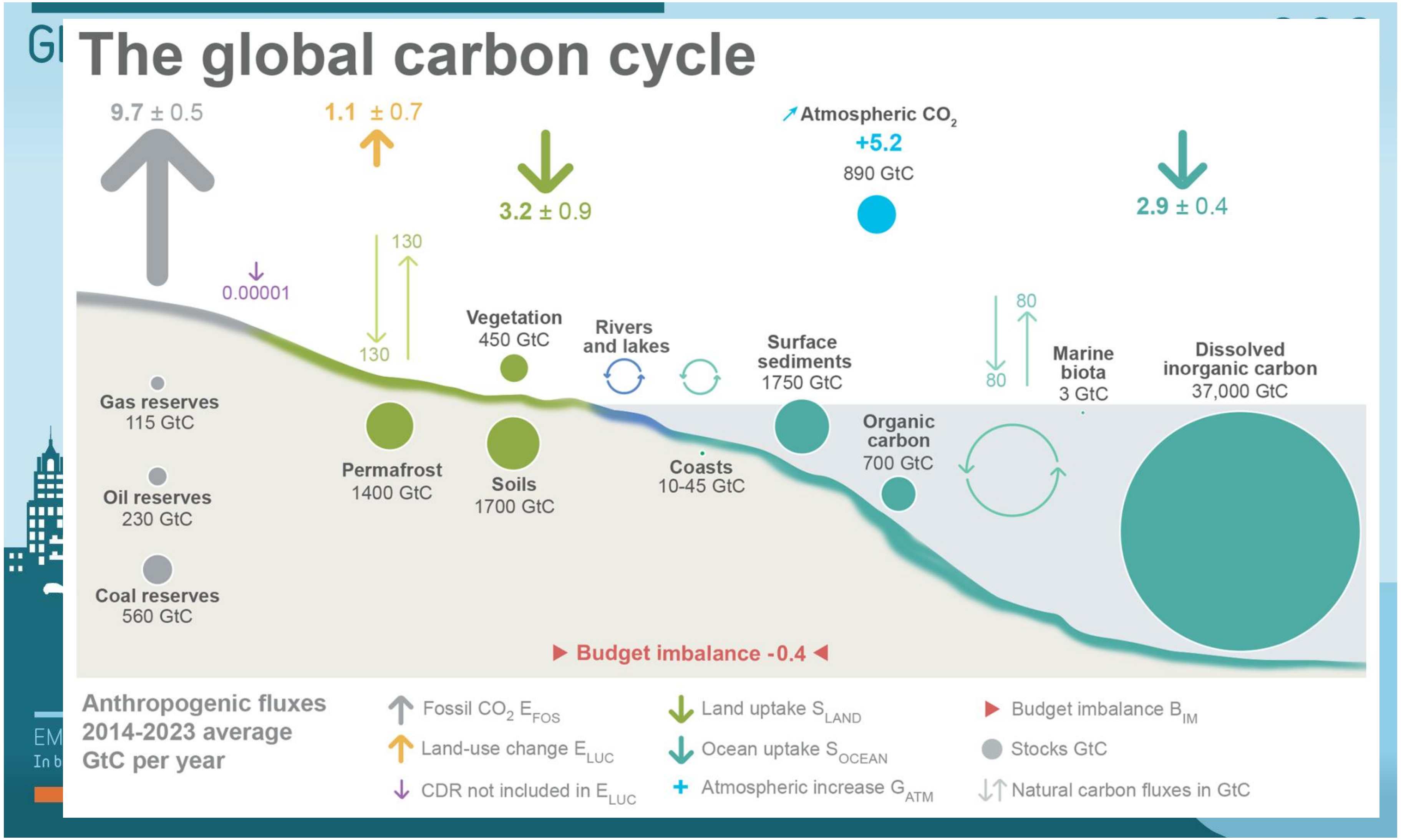
Motivation: Carbon capture



https://doi.org/10.5194/essd-17-965-2025

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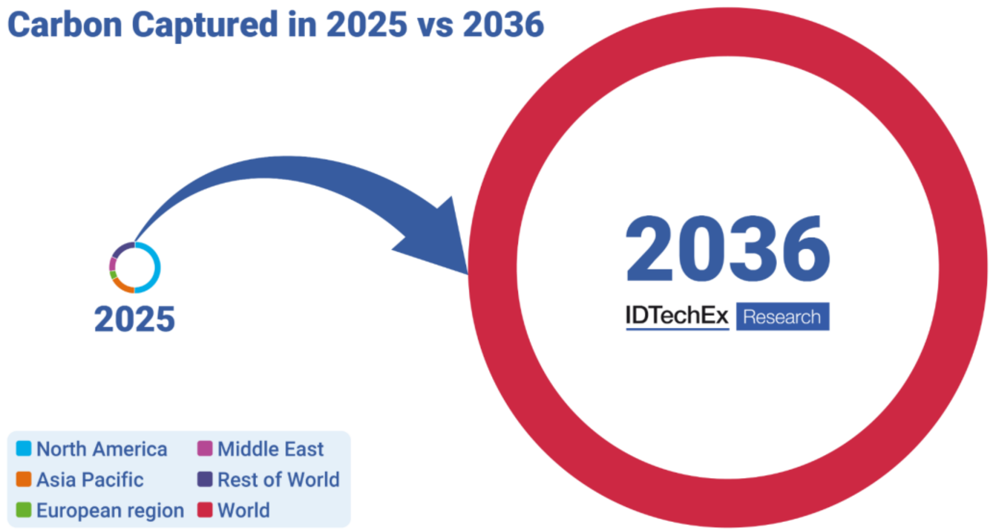
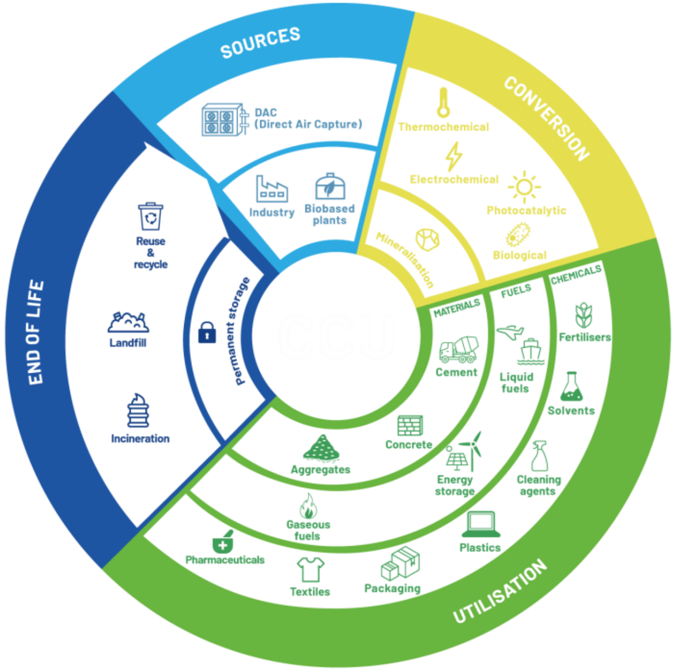
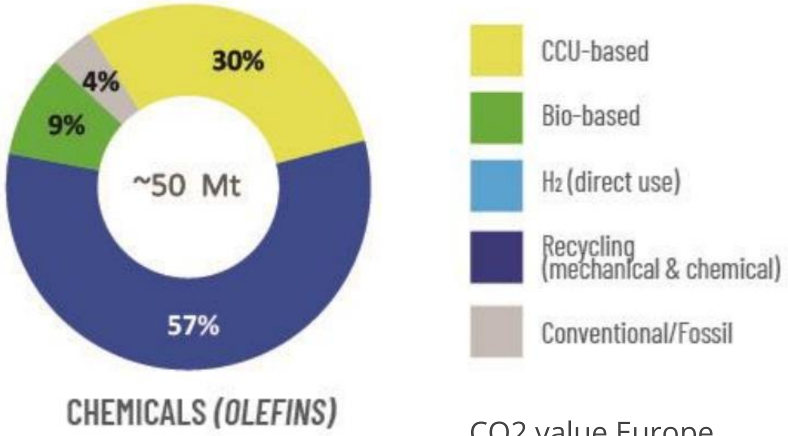
Motivation: Carbon capture & utilization



It has been forecasted nearly **700 million tonnes** of CO_2 will be captured globally each year by 2036.



Share of CCU products in 2050: CCU products will have a major contribution to replace fossil-based products in the industry.



CO2 value Europe

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Motivation: current production & utilization of ethylene

Diverse Applications of Ethylene

Healthcare Applications: Ethylene derivatives are essential in manufacturing medical devices, sterilization agents, and pharmaceuticals.

Renewable Energy Materials: Ethylene-based materials contribute to solar panel production and wind turbine components.

Advanced Industrial Materials: Ethylene is vital in developing advanced materials for construction, automotive, and electronics industries.

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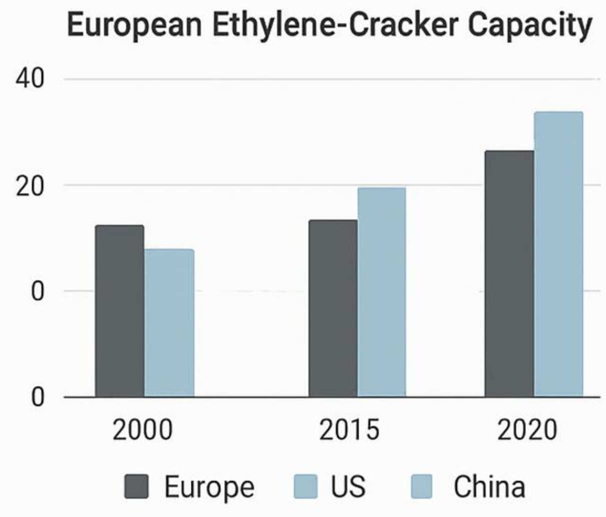
Motivation: current production of ethylene & sustainability challenges

- In Europe, the petrochemicals industry is confronted with competitive and sustainability pressures.
- European ethylene-cracker capacity is falling: Europe's installations have declined, while regions such as China and the US are expanding.
- Heavy reliance on fossil feedstocks ⇒ high CO_2 emissions and climate burden.
- Europe faces high production costs (energy, feedstock, regulation) compared to other regions.
- Infrastructure ageing, risk of plant closures (e.g., up to ~40% of EU capacity may be at risk) due to environmental and economic pressures.



Consequently, to keep the chemical industry viable and sustainable, a shift in feedstocks and production pathways is needed.

1. https://www.eepc.cu/about-petrochemistry/petrochemicals factıs:and /igıures/
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3. https.//www.petrochemistry.ou/altee/defauTollisa/feld_athschmp-to/2-leatunes.es@popal/

a shift in feedstocks and production pathways is needed.

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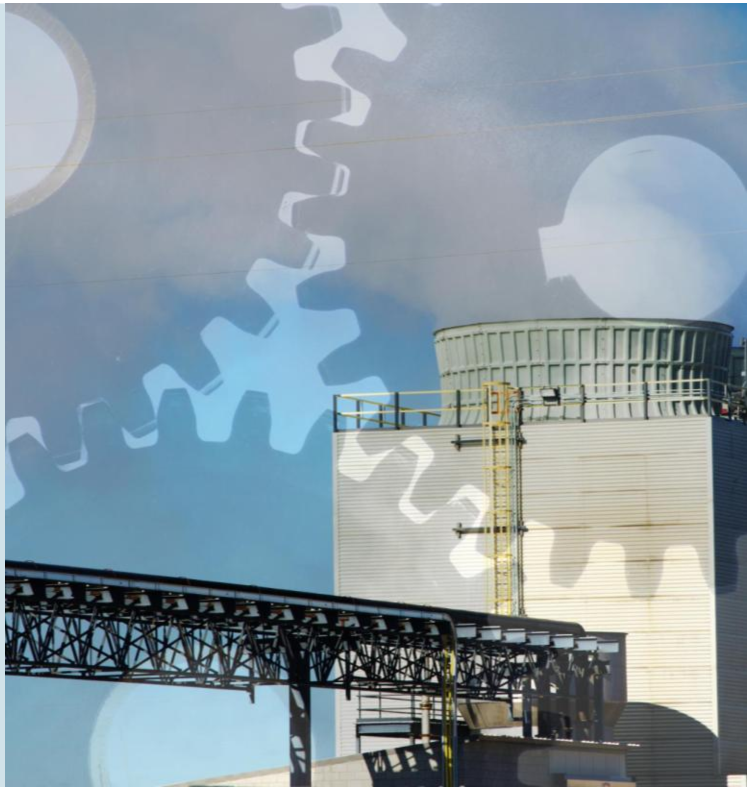
Motivation: Emerging Sustainable Ethylene Pathways
Our [CO_2 → Ethylene] Approach

- Bioethanol dehydration is the most commercially mature
- Our method: captured CO_2 + green hydrogen → **ethylene**
- Use of captured CO_2 as the carbon feedstock — **closing the carbon loop.**
- Reducing reliance on fossil fuels
- Compared to other emerging paths, CO_2-to-ethylene offers a dual benefit of carbon reuse + renewable hydrogen, aligning with **circular economy goals.**



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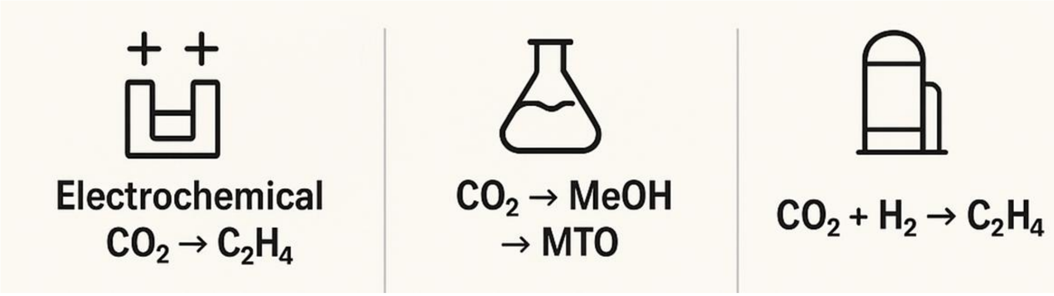
Motivation: high yield, high efficiency & high selectivity: Our [CO_2 → Ethylene] targets



- Electrochemical $CO_2 \rightarrow C_2H_4$:

  low energy efficiency (often ~20–35%) & questions on long-term stability
- Two-step methanol route (CO_2 → MeOH → MTO)

  high yield and high selectivity, but adds extra steps (and energy losses)
- Direct hydrogenation $CO_2 + H_2 \rightarrow C_2H_4$: low selectivity & high H_2 demand

Our targets: high yield, high efficiency & high selectivity

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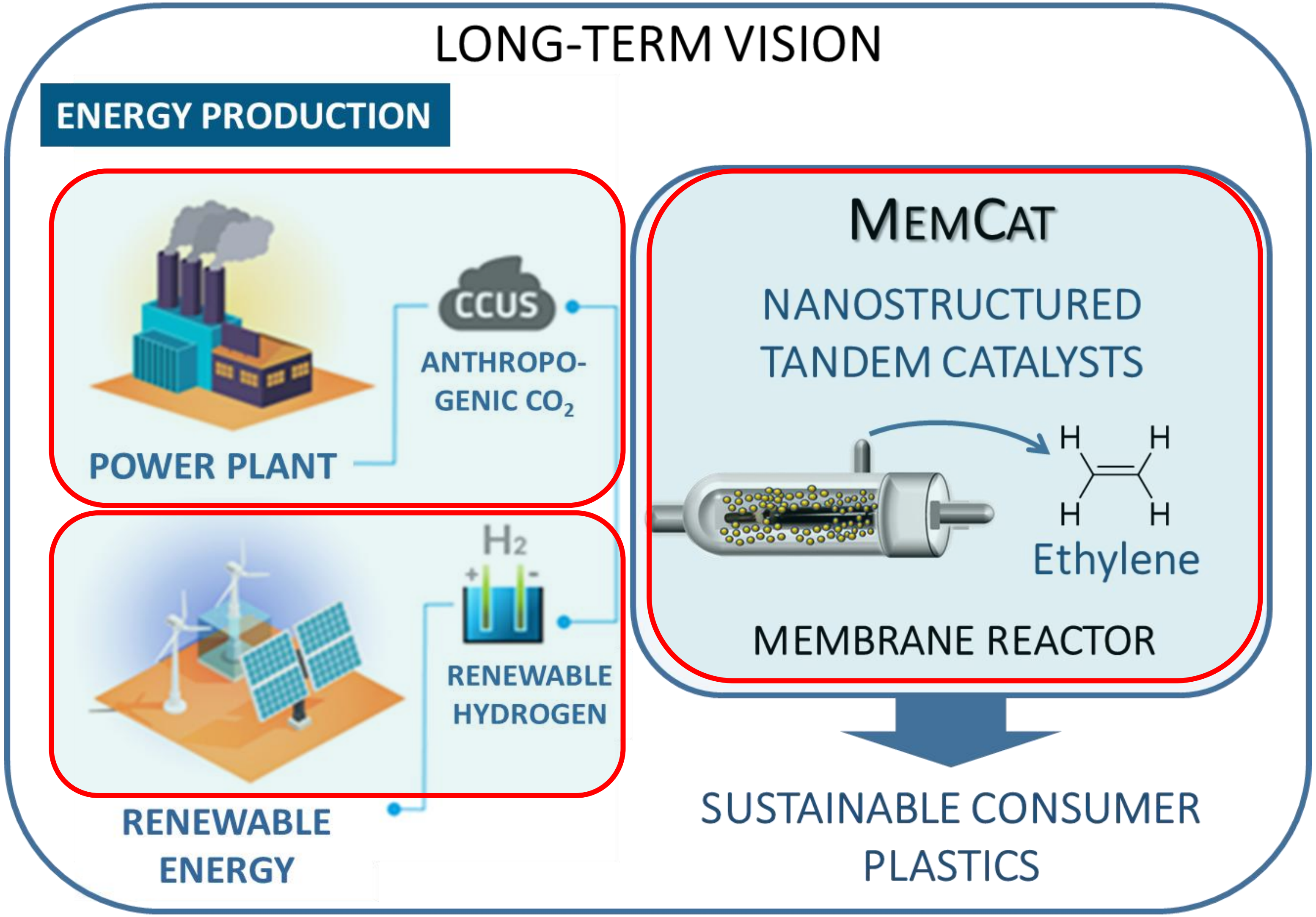
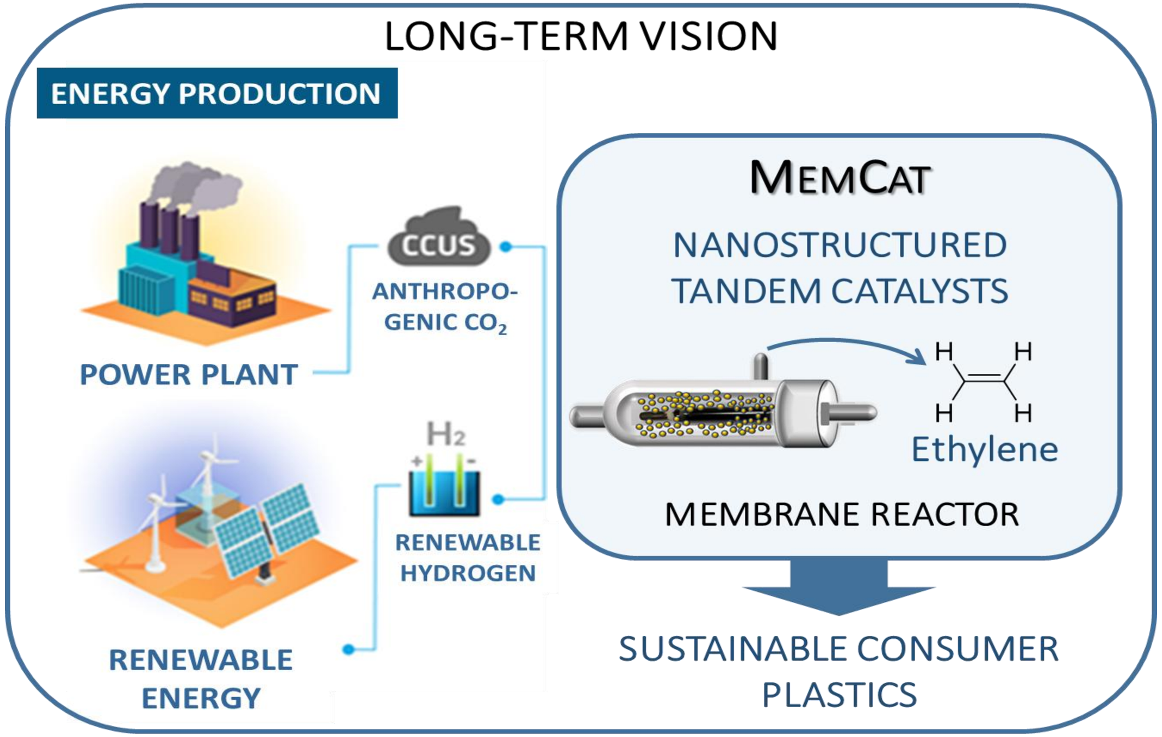
Objectives & concepts



Objectives & concepts



Contract number: 101130047

Funding scheme: HORIZON EIC Grants

Granting Authority: European Innovation Council (EIC)

Starting date : 1st May 2024

Duration: 48 months

Project funding: € 3,948,500.00

Coordinator: International Iberian Nanotechnology Laboratory (INL)

- High yield CO_2 to ethylene conversion
- High Efficiency & Selectivity:
  The process aims for ≥80% CO_2 conversion with ≥95% selectivity to ET

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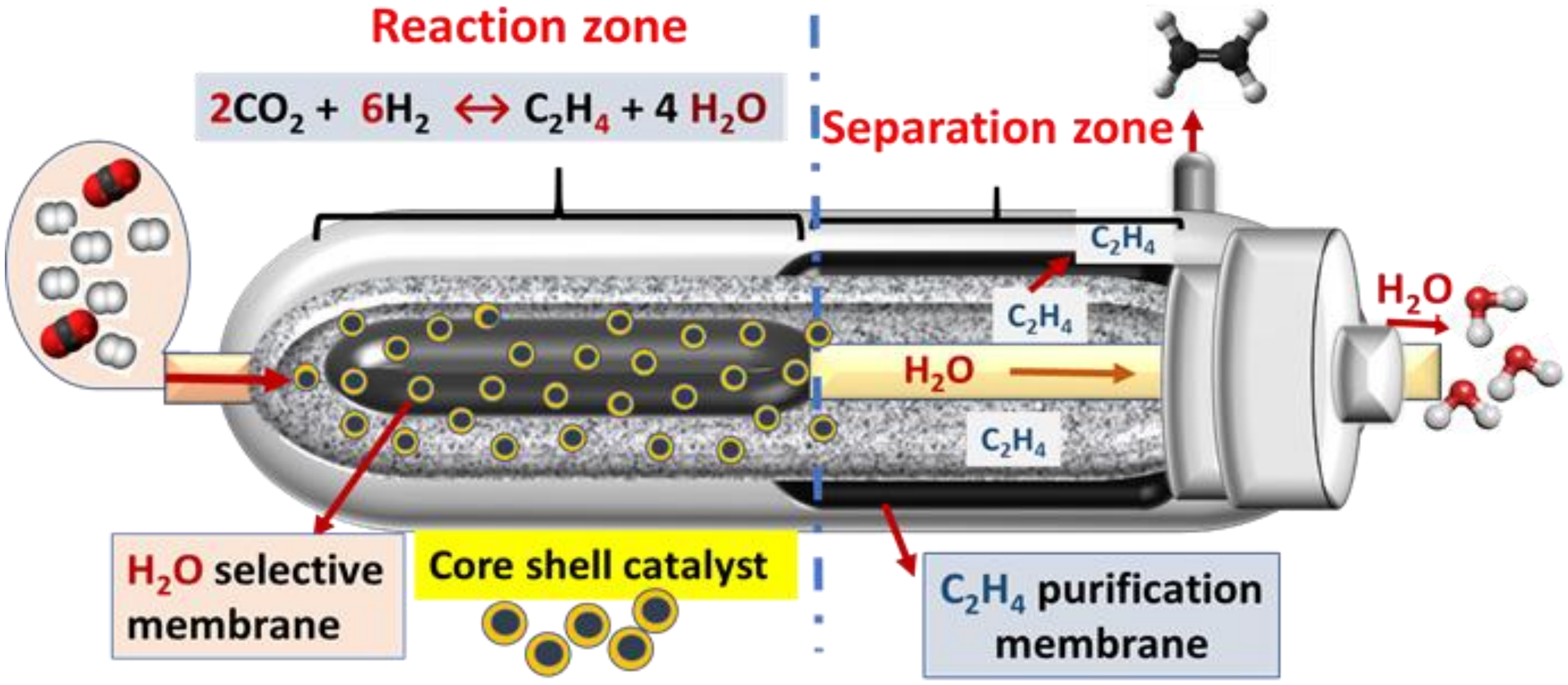
Methodology and Execution



- **Nanostructured tandem catalysts** give access to **low-temperature ethylene synthesis from CO_2**
- Operando spectroscopy coupled to DFT calculations elucidate **catalyst structure–activity relationships**
- **Catalytic membrane reactor** enables selective **CO_2 conversion to ethylene**
- **Nanocomposite membranes** containing nanofillers afford high selectivity

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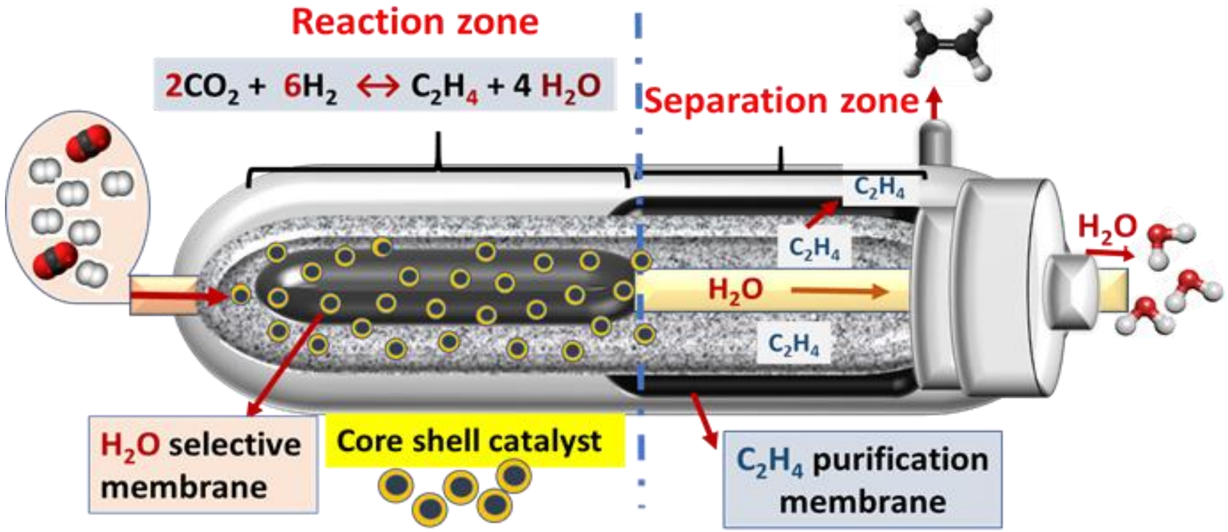
Breakthroughs

Breakthroughs

- Developing nanostructured tandem catalysts for efficient CO_2-to-ET conversion;
- Understanding the catalytic processes through computational and experimental methods;
- Creating temperature-resistant membranes to improve ET production and purification;
- Building a prototype MR with optimized catalysts and nanocomposite membranes;
- Maximize the impact of the project by promoting open science practices, protecting intellectual property, and fostering inclusive outreach efforts



- CMS water-gas selective membrane
- Development of nanofillers for ET separation
- Nanocomposite CMSM

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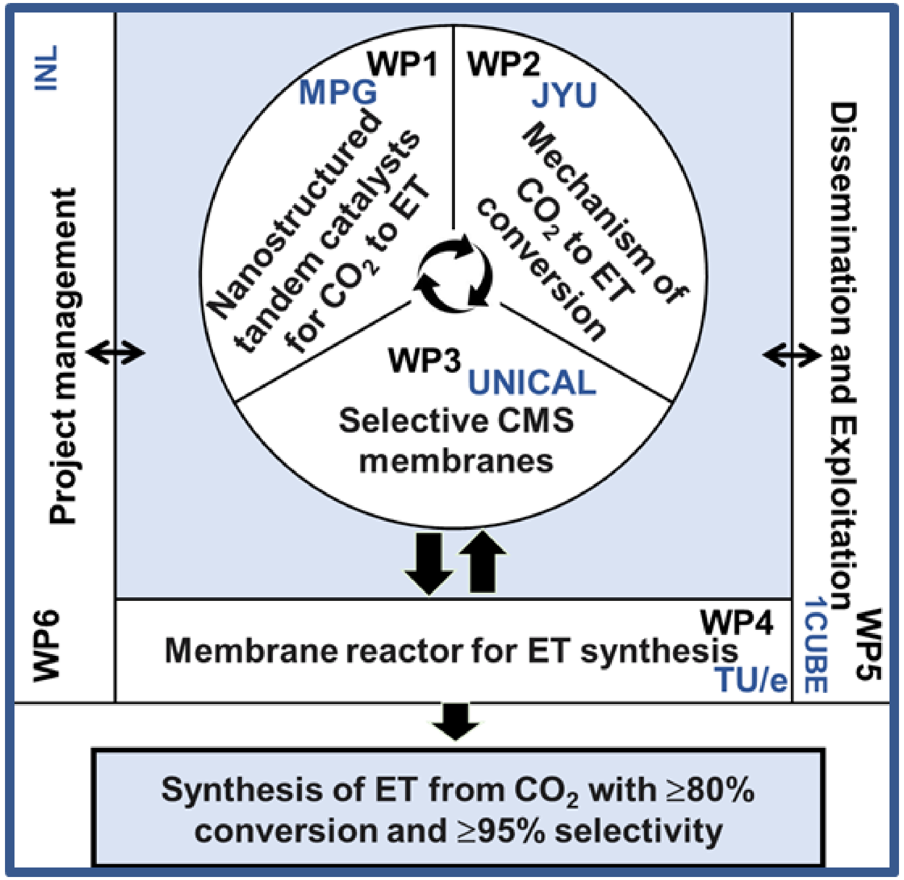
Participants and Consortium Synergies

A consortium through an interdisciplinary approach, with complementary capabilities ranging from fundamental spectroscopic and theoretical insight to synthesis coupled to membrane and reactor engineering.

Partner	Role
INL, PT	Nanomaterials/Catalysts synthesis
MPG, GE	Catalytic investigations
JYU, FI	Theoretical studies & computational modeling
UNICAL, IT	Nanocomposite membrane development
UVIGO, ES	Framework nanomaterials/nanofillers
TU/e, NL	Membrane reactor prototype and testing
I Cube, NL	Dissemination activities

Work Plan and Expected Results



Possible IPs
New catalysts and synthesis protocols, catalytic testing results
Theoretical description of the catalytic activity of the nanomaterials
Temperature-resistant selective membranes
Catalytic membrane reactor designs
Process using the catalytic MR for the production of ET from CO_2 and H_2

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Long term Impact

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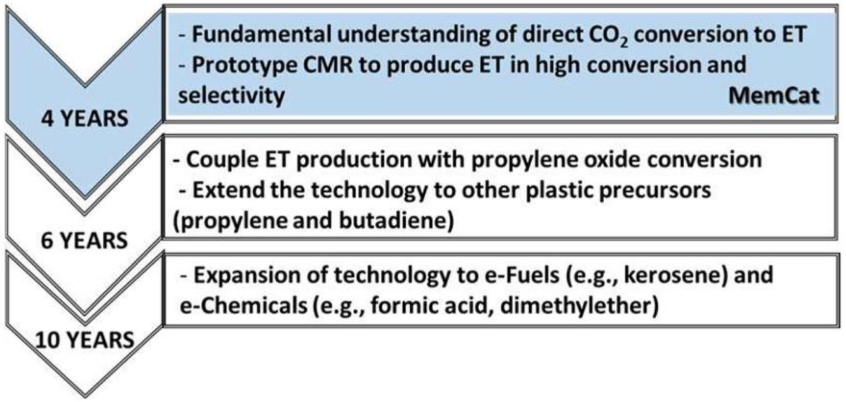
MemCat enables sustainable, carbon-negative production of light olefins (e.g., ethylene) using captured CO_2 as feedstocak, replacing fossil-based sources.

Addresses the growing global demand for ethylene, which is expected to reach a market value of €110 billion by 2027, with MemCat offering a greener alternative to high CO_2-emission processes.

Support the EU in leading green chemical production, creating employment and contributing to a sustainable solution for plastics production.



The technology could reduce ethylene production costs by 35%, improving yields and reducing downstream separation costs.

The price of green H_2 and CO_2 capture technologies is expected to decrease.

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MemCat will harness the basic science to catalyze energy transition towards global Net Zero targets

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Thank you for your attention

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