

Reuse Project Overview

CCUS in Action” – A Deep Dive into
the Future of Carbon Capture and
Utilization

Online Webinar-22/05/2025

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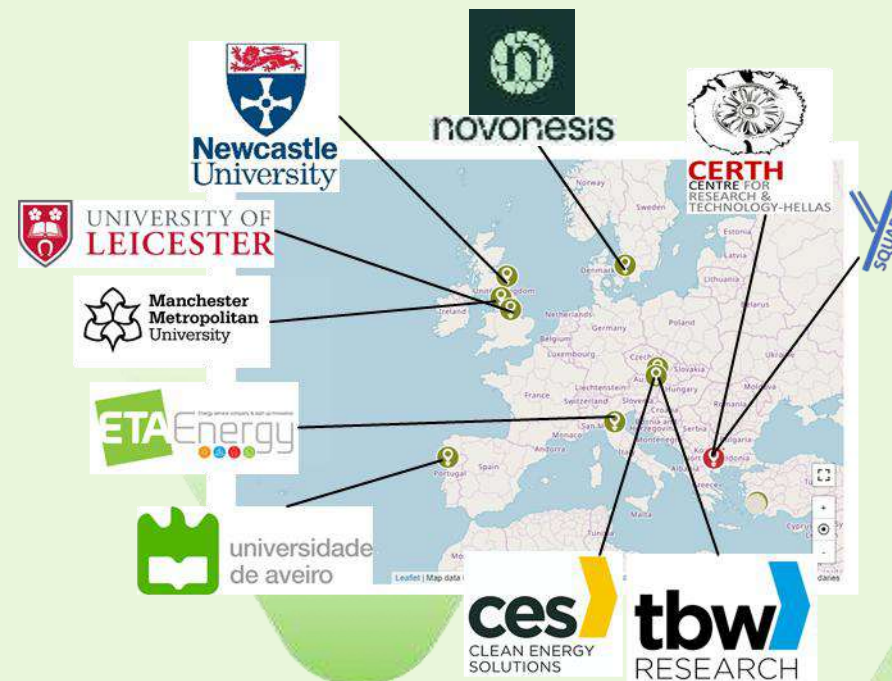
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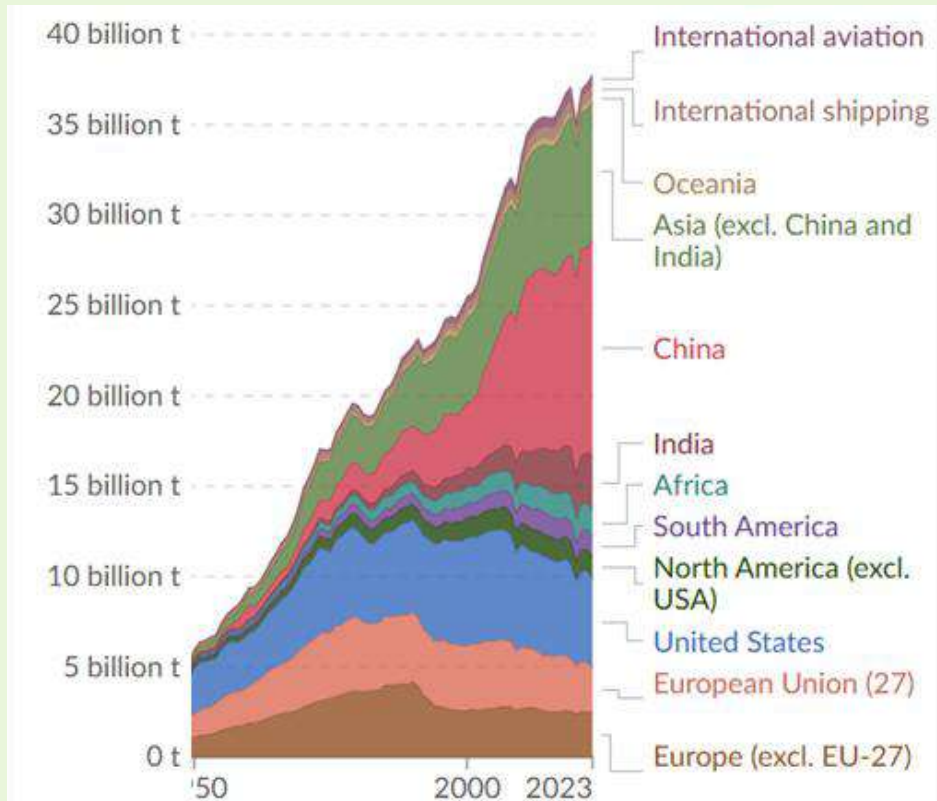
A HORIZON EUROPE project- ID: 101172954, DOI: 10.3030/101172954, (01/10/2024-31/09/2027)

HORIZON-CL5-2024-D3-01-05 - Development of carbon fixation technologies for biogenic flue gases

Enzymatic CO₂ Capture in a Rotating Packed Bed and Electrocatalytic CO₂ Reduction to Useful Products



CO₂ emissions - Facts



- 1950 the world emitted $6 \cdot 10^9$ t CO₂/y.
- By 1990 this had almost quadrupled, reaching more than $20 \cdot 10^9$ t CO₂/y.
- Emissions have continued to grow rapidly; we now emit over $35 \cdot 10^9$ t CO₂/y.
- Europe's contribution is $5 \cdot 10^9$ t CO₂/y in 2023
- Europe, USA, America, Africa, India- slow decrease
- China, Asia- steep increase
- In 2023 China emitted about $10 \cdot 10^9$ t CO₂ = SUM(EU and USA)!
- All Asia emitted $20 \cdot 10^9$ t CO₂ = **2** x SUM(EU and USA)!

EU targets



The first climate-neutral continent

by 2050

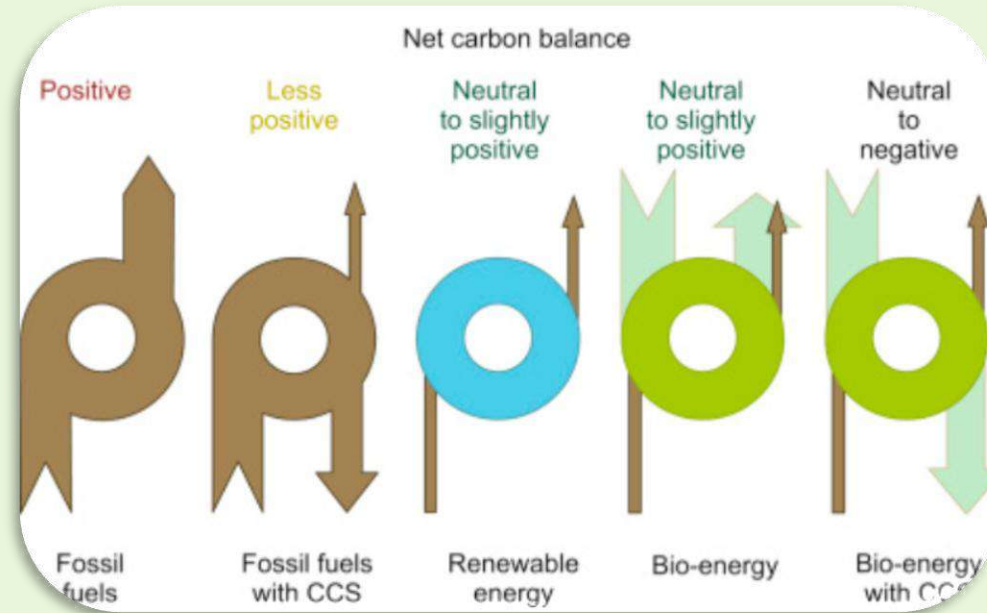
At least 55% less

net greenhouse gas emissions by 2030, compared to 1990 levels

- The European Green Deal (EGD) establishes the objective of becoming climate neutral in 2050.
- This objective requires a greenhouse gas emissions reduction of 55% by 2030.
- This in turn requires significantly higher shares of renewable energy sources (RES).
- The current EU target of at least 32% RES by 2030, set in the Renewable Energy Directive (REDII), is not sufficient and needs to be increased to 38-40%, according to the Climate Target Plan (CTP).



Biomass-derived emissions



- Biomass will be a key energy carrier to accomplish energy and climate targets
- Biomass combustion systems may enable the decarbonization of various sectors as they allow for highly efficient use of sustainable biomass residues
- The combination of biomass with carbon capture and utilization or storage can result to net zero or negative systems

CO₂ capture- How?

Pre-combustion

Oxy-fuel

Post combustion

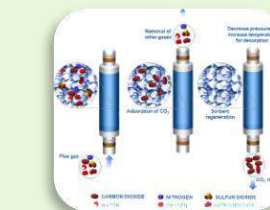
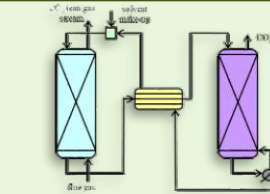
Solvent-based absorption

Calcium-looping

Membranes

Adsorption

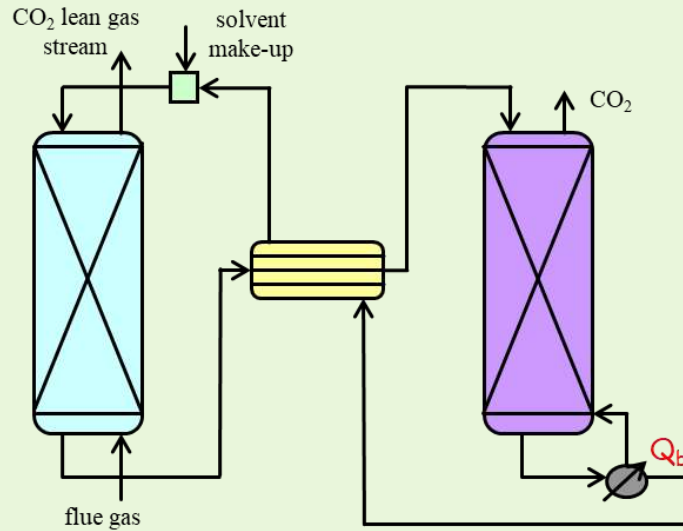
Algae



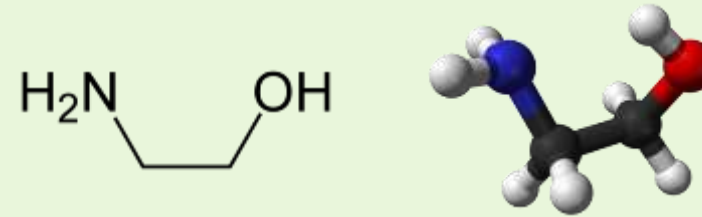
Reuse

- Various technologies available
- All have pros and cons depending on
 - The flue gas composition
 - The emitting plant requirements

Solvent-based absorption-desorption



Monoethanolamine (MEA)



➤ Pros:

- Well-established technology
- Easy to meet conditions
- Easily retrofitted onto existing plants

➤ Cons:

- High capital costs
- 40% cost penalties to plant operation
- 70% due to solvent regeneration

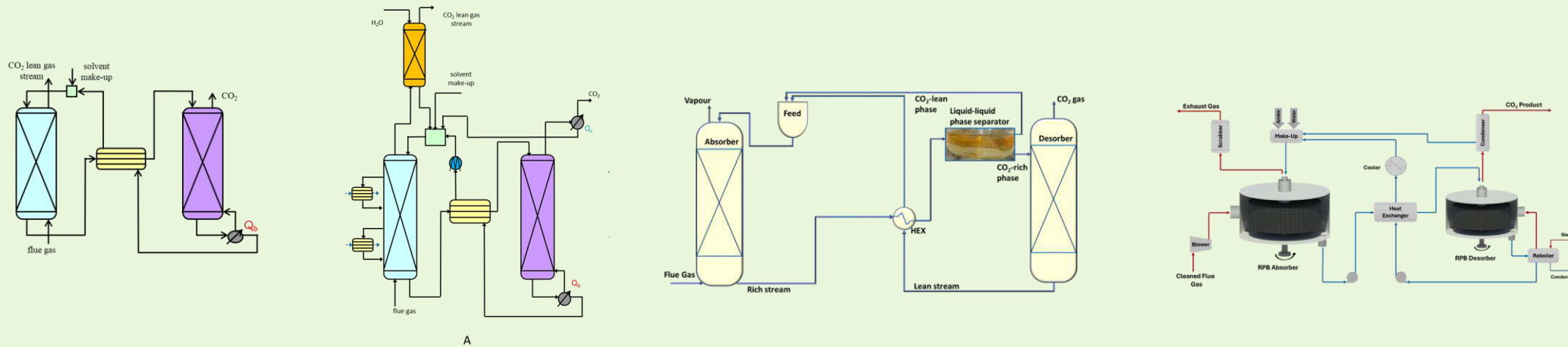
➤ MEA:

- High stripping energy
- High heat of absorption
- Solvent vapor losses due to high vapor pressure

New and considerably improved solvents and processes required

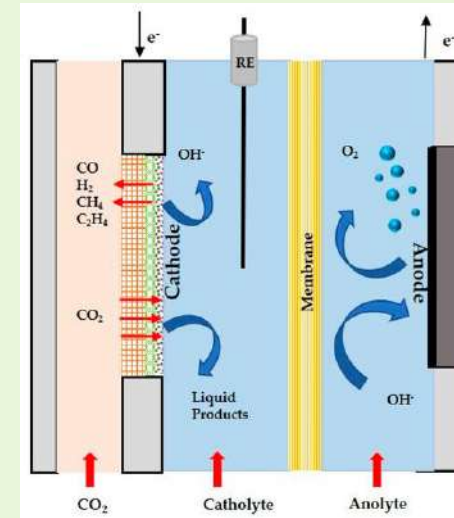
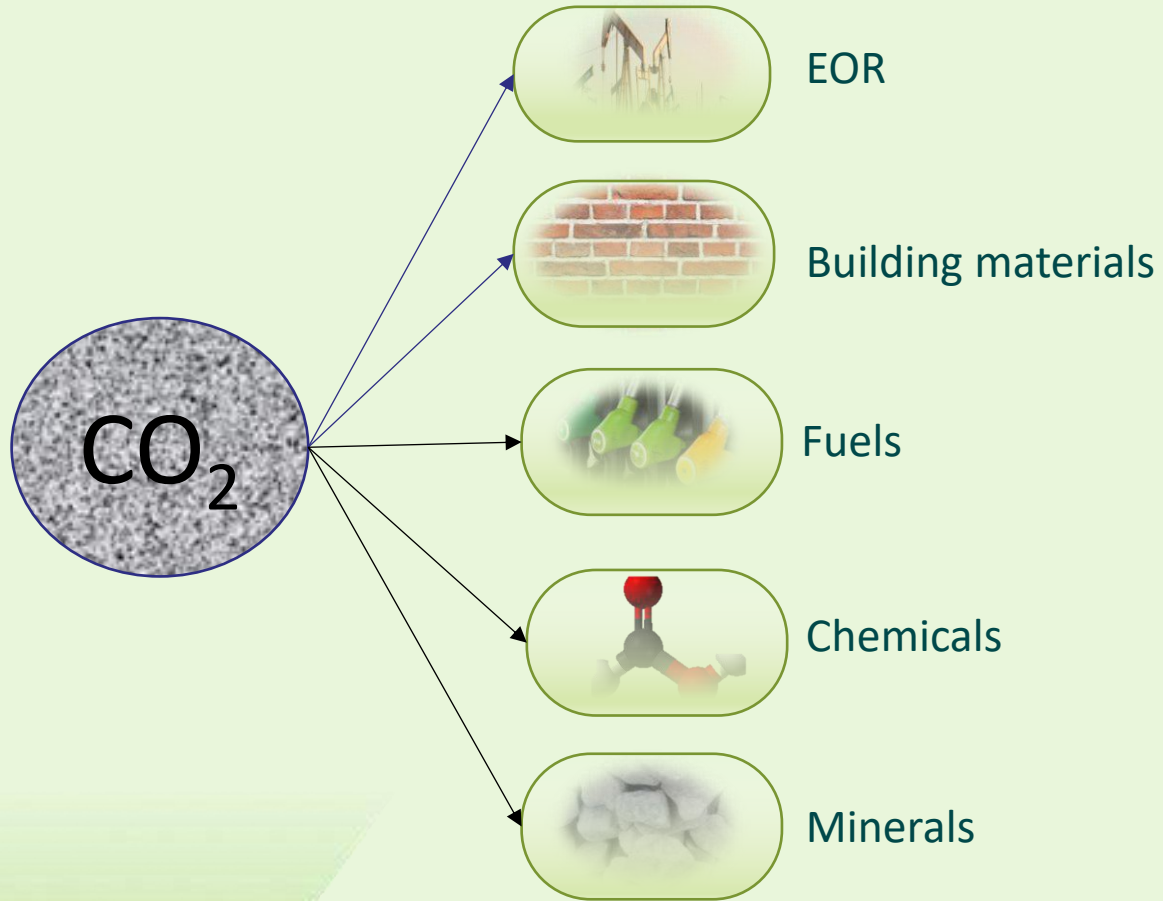


Options to mitigate costs



- **Packed-bed columns (PB):** Standard flowsheet (Absorber-Cross heat exchanger-Desorber)
- **PB: Modified flowsheets**, where the standard scheme is intensified through additional equipment, mainly for energy recovery.
- **Phase-change systems:** Liquid-liquid phase-separation
- **Rotating-packed bed systems (RPB):** Highly intensified equipment

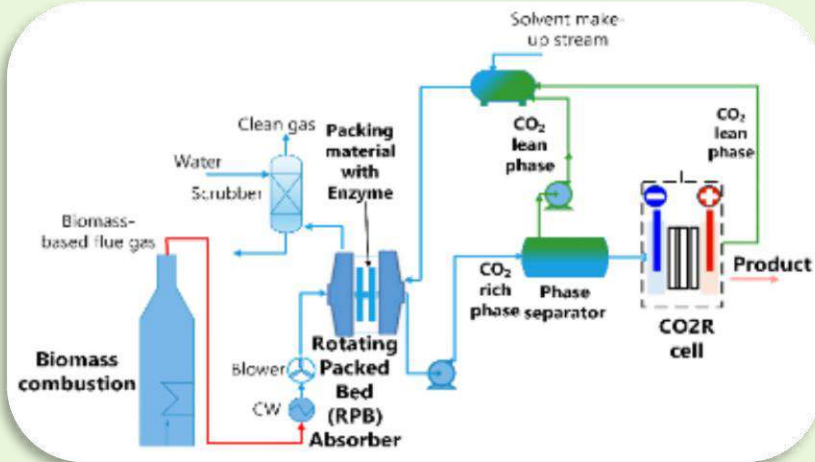
Captured CO₂- What do we do with it?



 Reuse

- There are various different technologies for CO₂-to-fuels or - chemicals
- Electrocatalytic ones are gaining ground because:
 - They may use renewable energy
 - They require considerably milder conditions than thermo-catalytic ones

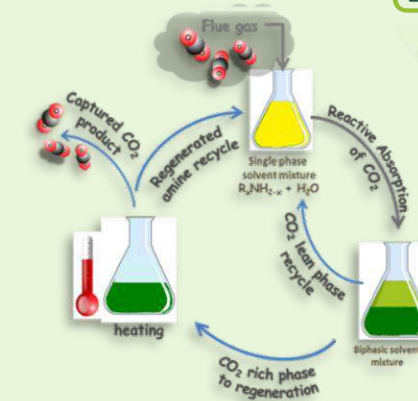
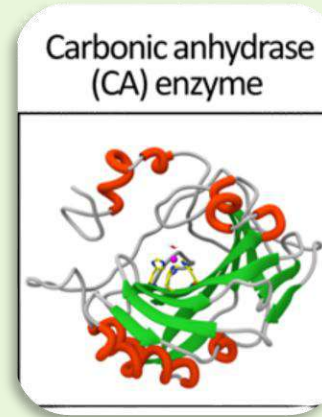
REUSE idea



- **Direct CO₂ Capture-CO₂R**
- Use of RPB for CO₂ absorption
- Use of zero-gap electrocatalytic cell for reduction to formic acid
- Combine biomass gasification and demonstrate integrated system



Key innovations- CO₂ absorption



- RPB
- Short residence time
- 15-20 times lower volume
- Fast mass transfer $\times 10$ -100 and micro-mixing
- Low space footprint

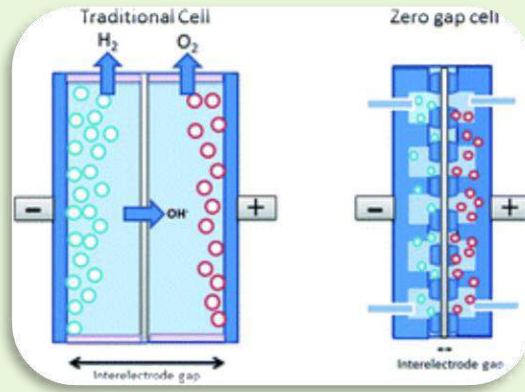
- Biomimetic absorption with CA
- Up to 4000 times faster CO₂ hydrolysis than solvent MEA
- Replaces solvent that exhibits fast kinetics
- Need only for solvent that enable high absorption rate
- CA immobilized on fiber (fabric) knitted onto the packing material

- Phase-change solvent
- Exhibits 2 liquid phases
- One rich in CO₂-> led to CO₂R
- One lean in CO₂-> recycled to absorber
- Delivers more concentrated CO₂ into CO₂R cell



Key innovations- CO₂ reduction and gasification

 Reuse



- CO₂R cell
- Design of zero-gap, membrane type flow cells to reduce ohmic losses by decreasing the inter-electrode distance.

- Catalysts
- Design functionalised carbon surfaces utilising carbon materials with different morphological nature (1D-carbon nanotube, 2D-graphene) via plasma
- Design of template free shape-controlled tin based catalysts (with or without dopants) via plasma and electrochemical routes on functionalised carbon surfaces that favour selectivity towards FA

- Gasification
- Design and test advanced catalysts for tar abatement
- Address variability in biomass gasification
- Combine biomass with wastes

Thank you!

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 REUSE - Horizon Europe Project
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