PEPs Group: Products, Environment, and Processes

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LIÈGE université

PEPs CHEMICAL ENGINEERING

Our plan

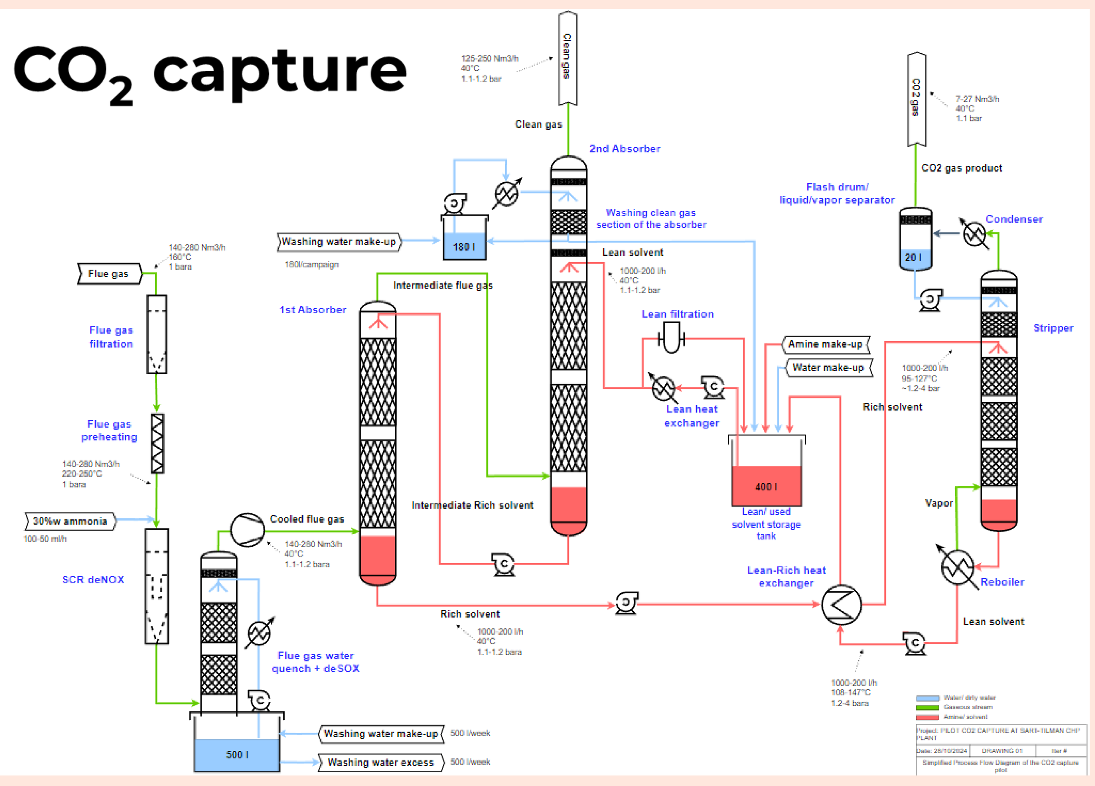
TRANSFORM THE CAMPUS INTO A LABORATORY FOR THE ENERGY TRANSITION

The energy sector is undergoing a major transformation to reduce CO_2 emissions and shift towards more sustainable practices. This involves developing cleaner processes, improving energy efficiency, and integrating new technologies.

At the University of Liège, the PEPs group contributes to this transition through research in chemical and energy process engineering. Our work focuses on CO_2 capture and utilization, Power-to-Fuel systems, and the design of low-carbon industrial solutions. This poster highlights ongoing projects combining lab-scale experiments, process modeling, and pilot development to support decarbonization in industry.

1 CCUS pilot

CO_2 capture



- 1 tCO_2/day
- Mobile
- Fully automated
- Fully electrified
- Flexible design
- Pretreatment

A mobile post-combustion CO_2 capture unit is under development. A heat pump is integrated into the system, enabling a reduction in energy consumption of 23% to 73%, depending on the operating pressure. This pilot unit will treat flue gases from a biomass boiler at the university to further study CO_2 capture.

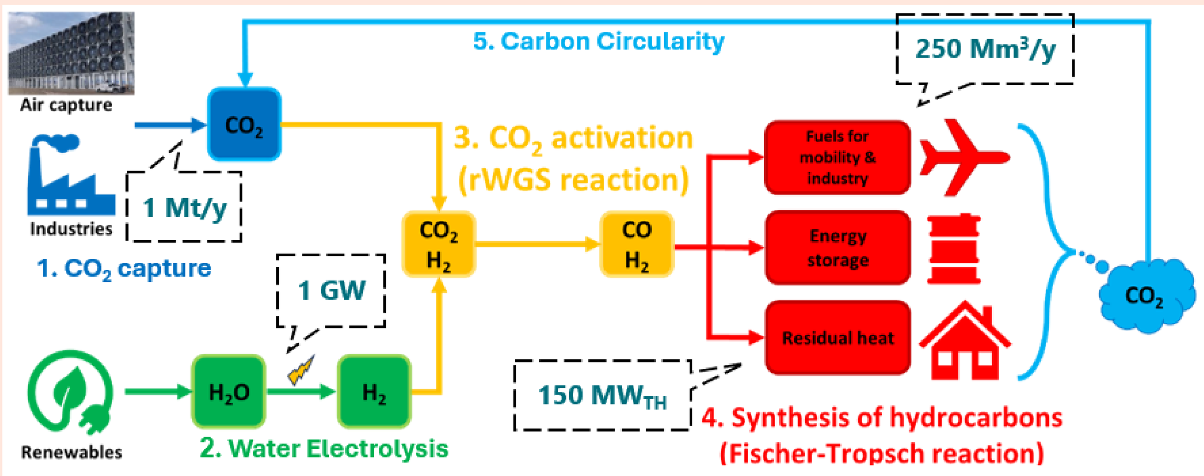
CO_2 → Kerosene

A second pilot is being developed to convert captured CO_2 into jetfuel. H_2 from electrolysis first reacts with CO_2 to form syngas :

$$CO_2 + H_2 \rightarrow CO + H_2O$$

The resulting syngas is then converted into kerosene via the Fischer–Tropsch process.

$$(2n+1)H_2 + nCO \rightarrow C_nH_{2n+2} + H_2O$$



Our team is responsible for the engineering and design of the pilots, but also for administrative processes such as obtaining construction and environmental permits, conducting HAZOP studies, and ensuring overall project coordination.

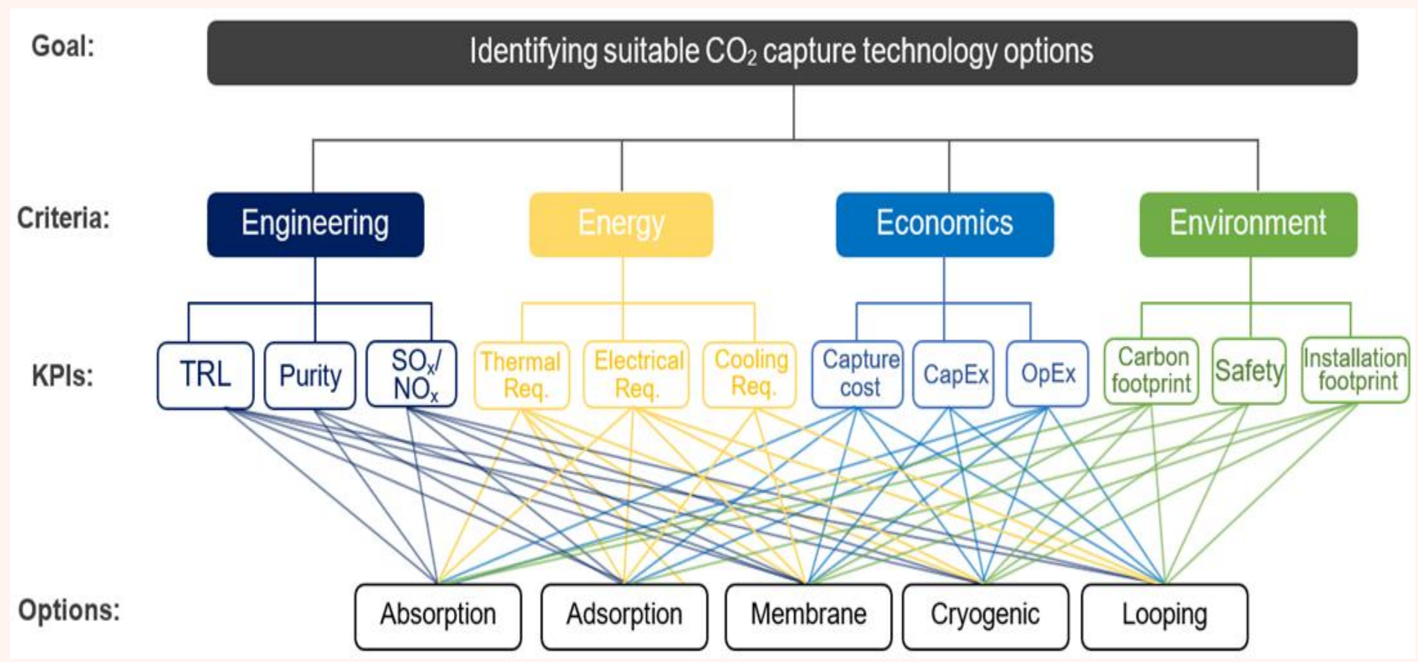
2 Support Decision Tool (DST)

This tool helps identify the most suitable CO_2 capture technology for a given case study. It relies on two types of input:

- **Process data**, used to evaluate technologies based on key performance indicators (KPIs) such as TRL, carbon footprint, energy demand, and costs.
- **User preferences**, grouped into technical, energy-related, economic, and environmental criteria.

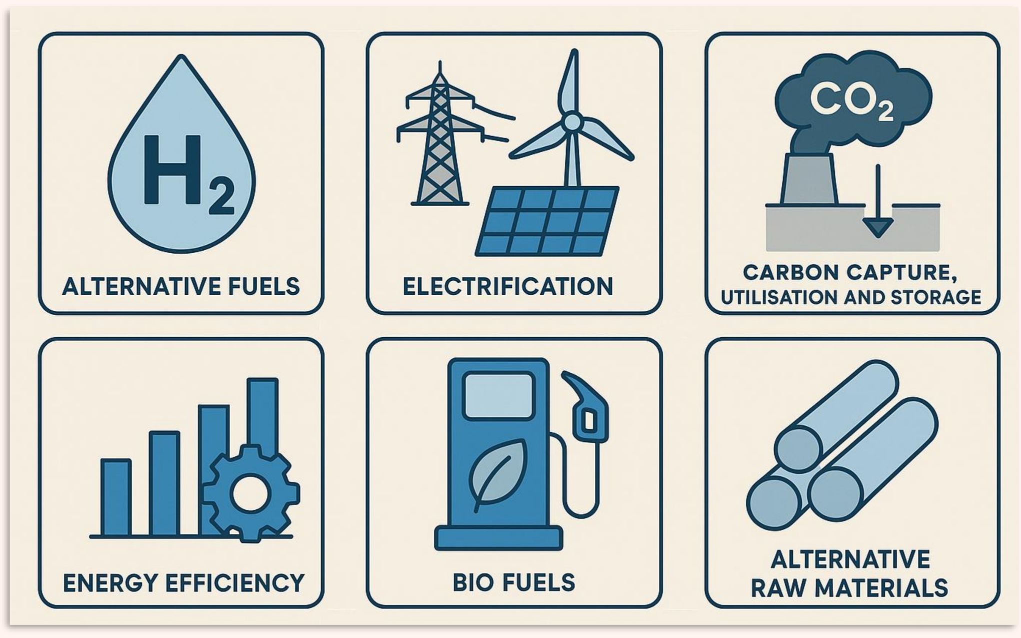
An Analytical Hierarchy Process (AHP) is used to assign weights to the user-defined criteria. These weights are then applied to the performance scores of each technology.

The results are based on a bibliographic database and models derived from process simulations. A final score is assigned to each technology, allowing them to be ranked by relevance.



3 Industry decarbonization pathways

Modeling of various industries is carried out to evaluate their optimal decarbonization pathways.



For an industrial process (such as cement, paper, or sugar production), a **superstructure model** can be developed that integrates multiple decarbonization options, ranging from innovative solutions to more established alternatives. These include different energy sources like fossil fuels, biofuels, hydrogen, or electricity; alternative feedstocks; and various output strategies such as paying carbon quotas, capturing CO_2, producing biogas from waste, or recovering waste heat. Each combination defines a potential decarbonization pathway.

These pathways are evaluated in terms of cost, energy consumption, and CO_2 emissions. A comparative analysis is then conducted using energy scenarios that consider variations in fuel prices, electricity costs, and CO_2 pricing. This approach helps identify the most relevant decarbonization route for a given industrial process under specific conditions.

4 Amine solvent degradation

Solvent degradation is a major issue in CO_2 capture. For example, amines degrade when exposed to oxygen, high temperatures, or flue gas impurities, leading to emissions and reduced performance. **Understanding degradation kinetics and developing mitigation strategies** is essential. ULiège specializes in this field, conducting **lab experiments** and advanced kinetic modelling to minimize the impact of degradation on CO_2 capture.

5 Direct Air Capture (DAC)

We are building **a lab-scale direct air capture** (DAC) unit to study material degradation over cycles. This setup allows assessing the effects of ambient conditions (dry vs. humid) and regeneration parameters on adsorbent performance. The aim is also to integrate this technology on existing infrastructure.

6 Spin-off

Drive the energy transition in your industry.

Entrain Engineering explores innovative energy strategies and implements technological solutions towards sustainability. This spin-off combines chemical engineering expertise, research, industrial know-how, and strategic support to develop concrete solutions for reducing CO_2 emissions. Key areas of expertise include:

- Chemical & Energy sectors
- Unit Operations & Energy Systems
- Integration of Decarbonization Solutions
- CO_2 Capture, Transport & Reuse

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Energy Transition in the Industry