Written on 28 May 2025

5 minutes of reading

Economic outlook

IFPEN

Biofuels and e-fuels

E-FUELS: CHALLENGES AND OPPORTUNITIES

Focus n°6

CCU and CCS: two complementary industries

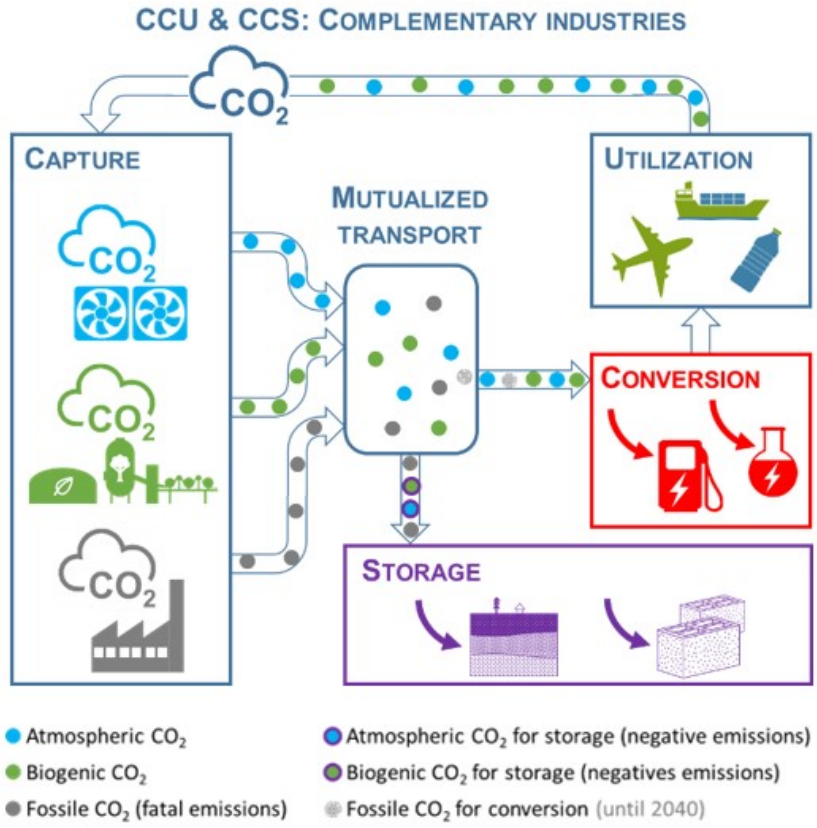
The industrial carbon management strategy published by the European Commission in February 2024 [1] is based on three pathways: carbon capture and storage (CCS), carbon capture and utilization (CCU), and carbon dioxide removal (CDR) (not addressed in this fact sheet). **CCS** aims to capture and

permanently store CO_2 in a technological carbon sink approach. **CCU** aims to valorize the captured CO_2 in a circular carbon economy approach. And **CDR** aims to remove CO2 from the atmosphere and store it permanently.

Both CCS and CCU industries are necessary and complementary with a common goal of carbon neutrality.

- They rely on a common technological building block: CO_2 capture. Transport infrastructure and the development of distribution hubs can also be shared, with a common CO_2 purity level to be defined. The downstream components (storage or conversion) are specific to each industry.
- The services provided by the two industries are different and include:
    - **A decarbonization goal** for fossil CO_2 emitters through CCS and the possibility of negative emissions by treating biogenic or atmospheric CO_2**,**
    - **A defossilization goal** for CCU through the production of synthetic fuels or molecules as substitutes for products derived from fossil resources.

The two industries are expected to develop in parallel, with a pace imposed by regulations and national and European roadmaps. These deployments can only be achieved through an integrated vision that relies on both efforts of sobriety and the intensification of net zero technologies (electrification, use of low-carbon hydrogen, energy efficiency, etc.). By 2050, the European Commission anticipates a need to capture 450 Mt of CO_2 in Europe, with 55% to be stored and 45% to be utilized. In France, as mentioned in focus #1, with a need to convert about 15 Mt of CO_2 into e-SAF by 2050, the volumes of CO_2 required by the CCU industry are of the same order of magnitude as those targeted by the CCS industry (15-20 Mt of CO_2).



Trade-offs will certainly be necessary, particularly in terms of territorial and societal challenges:

- What will be the balance between CCS and CCU to meet the decarbonization trajectories within different industrial basins, for example, based on emission levels and the territorial infrastructure?
- What will be the social and societal appropriations of the CCU and CCS value chains?
- How the allocation and supply of critical resources will be structured (for example, electricity, CO_2, biomass)?
- What will be the geographical and temporal accessibility of storage areas?

The regulatory framework is thus expected to be precised in the coming years

[1] COM (2024) 62, Towards an ambitious Industrial Carbon Management for the EU, 6.2.2024

From the perspective of achieving carbon neutrality, the development and deployment of both industries must be based on **multi-criteria analysis** (including techno-economic and LCA) across the entire value chain to

ensure that solutions will be sized to the needs. R&D activities of CEA and IFPEN contribute to the development of all the technological building blocks of these two industries at different maturity levels and their integration into complete value chains.

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LES BRÈVES

ADEME: French energy transition agency (www.ademe.fr)
ANCRE: French National Alliance of Coordination of Research for Energy
CBAM: Carbon Border Adjustment Mechanism
CCS: Carbon Capture and Storage
CCU: Carbon Capture and Utilization
COP: Conference of the Parties
DAC: Direct Air Capture
DME: DiMethyl Ether
EU: European Union
EU-ETS: EU Emissions Trading System
FuelEU: European law for shipping decarbonization (Fit for 55)
HTE: High Temperature Electrolysis
ICAO: International Civil Aviation Organization (www.icao.int)
ICM: Industrial Carbon Management
ICR: Industrial Carbon Removal
IEA: International Energy Agency (www.iea.org)
IPCC: Intergovernmental Panel on Climate Change (www.ipcc.ch)
LCA: Life Cycle Analysis
Mtoe: Millions tons of oil equivalent
NZE: Net Zero Emission by 2050 (IEA scenario)
PEM: Proton Exchange Membrane
PEPR: French Priority Research Programs and Equipments
Power-to-X: Approach consisting of transforming electricity into a chemical carrier such as an e-fuel or an e-molecule
RED: Renewable Energy Directive
ReFuelEU: European law for aviation decarbonization (Fit for 55)
R&D: Research & Development
R&I: Research & Innovation
RWGS: Reverse Water Gas Shift reaction
SAF: Sustainable Aviation Fuels
SGPE: French General Secretariat for Ecological Planning
SMF: Sustainable Maritime Fuels
TIRUERT: French incentive tax relating to the use of renewable energy in transport
TRL: Technology Readiness Level

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