CO₂ VALUE EUROPE

Carbon Capture and Utilisation

Towards a CO_2 recycling industry in Europe

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CARBON CAPTURE AND UTILISATION

Definitions, Impact and Opportunities

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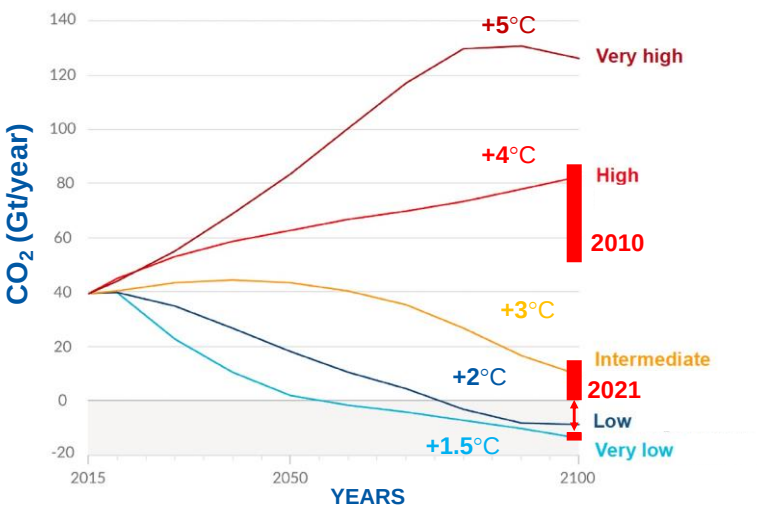
Climate Change Mitigation: It is time for action



EU CLIMATE TARGETS

- At least **55% GHG emission reductions by 2030** in comparison to 1990 levels.
- **Net-zero emissions** (emissions = sink capacities) by 2050.
- **Negative emissions are needed** regardless of the emission scenario. Not possible to mitigate climate change well below 2 ºC without carbon removal.

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Definitions

- **Carbon Dioxide Removal (CDR):** Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and **direct air capture** and storage. But it excludes natural CO_2 uptake not directly caused by human activities.
- **Carbon Capture and Storage (CCS):** A process in which a relatively pure stream of CO_2 from industrial and energy related sources is captured, conditioned, compressed and transported to a storage location for long-term isolation from the atmosphere.
- **Carbon Capture and Utilisation (CCU):** large range of processes capturing CO_2 from flue gas or directly from the air and converting it into essential products such as renewable fuels and chemicals or building materials.

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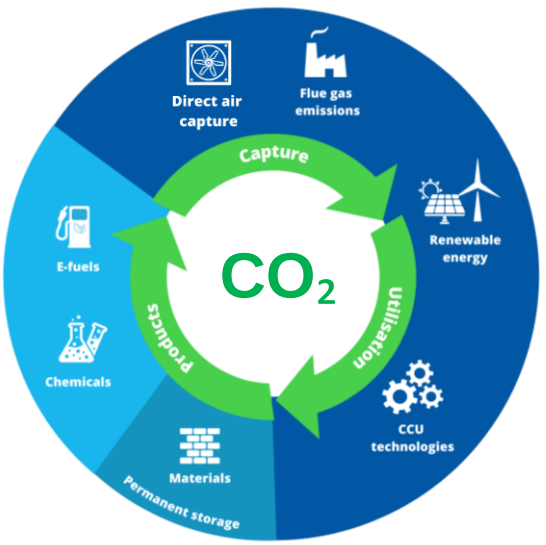
What is Carbon Capture & Utilisation (CCU)?

Carbon Capture and Utilisation (CCU) aims at capturing CO_2 from flue gas or directly from the air and converting it into essential products such as renewable fuels and chemicals or building materials.



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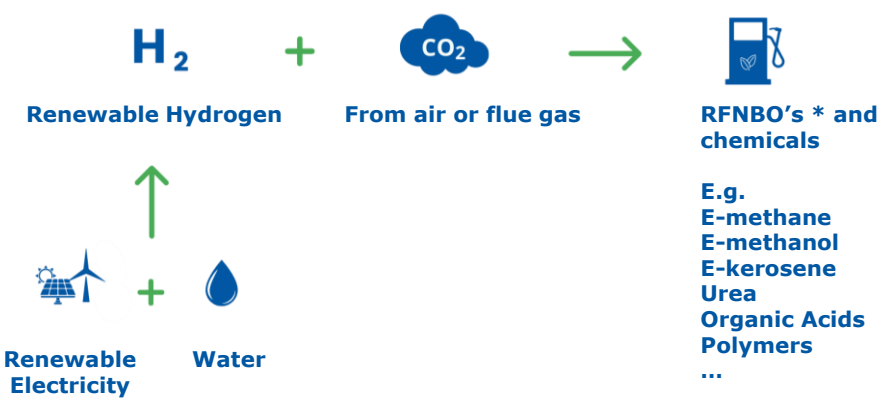
CO_2 to renewable fuels and chemicals (Power to X)



*RFNBOs= Renewable Fuels of Non Biological Origin

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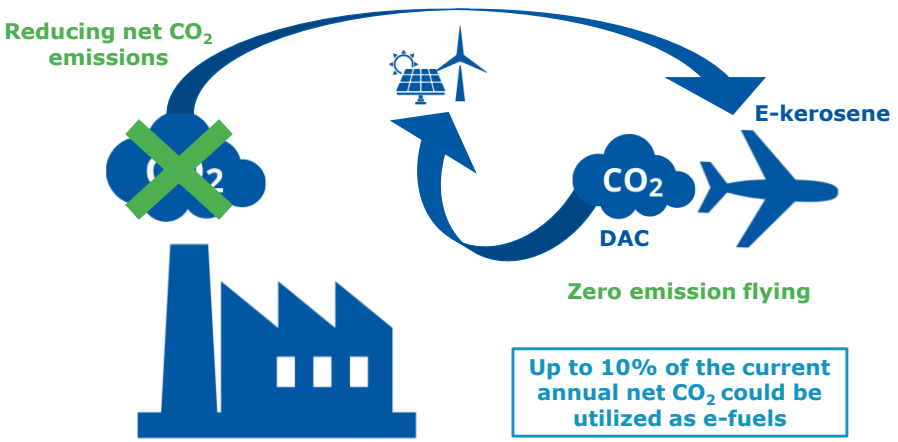
The example of Sustainable Aviation Fuel



Up to 10% of the current annual net CO_2 could be utilized as e-fuels

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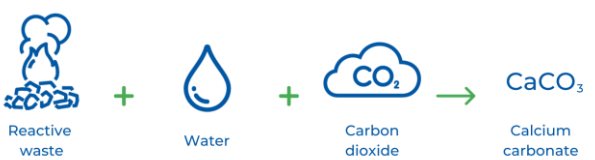
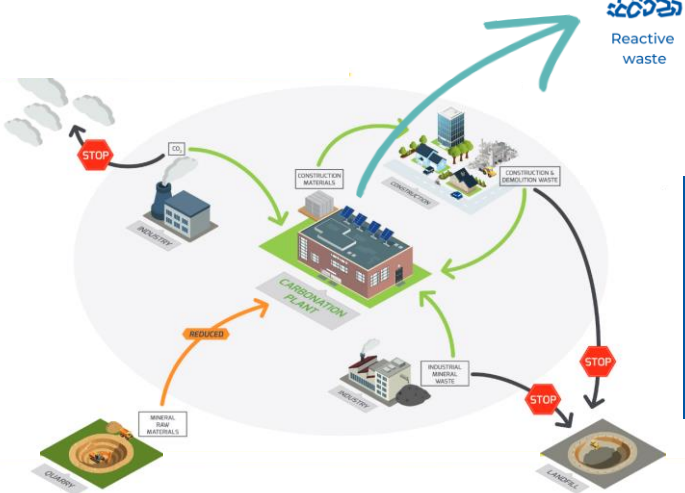
CO_2 mineralisation





- CO_2 is stored permanently in building materials
- Stronger and more sustainable material
- Reduction of landfill
- Reduction of mineral raw material use

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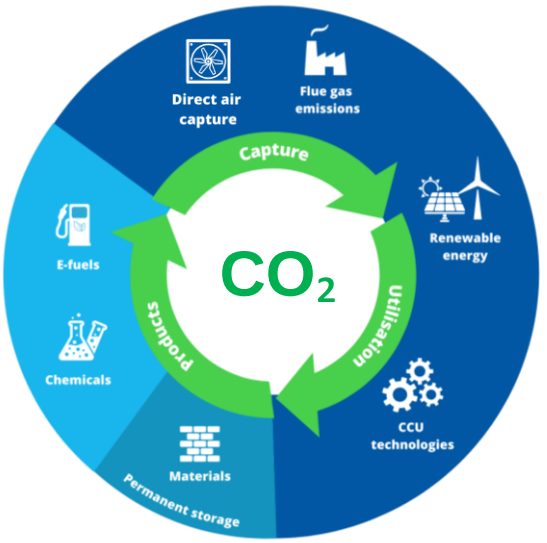
What is the impact of CCU?

- Net-zero to negative emissions
- Alternative carbon feedstock
- Circularity and waste management
- Sustainable & resilient industry
- Storage & transport of renewable electricity



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CCU opportunities towards a more sustainable industry?

CHEMICALS

Alternative carbon feedstock

CCU represents a key opportunity to "defossilise" the chemical industry and decrease its carbon footprint.

Production of high value chemicals and polymers based on CO_2 as a feedstock.

Most of the existing chemical building blocks could be produced using CO_2.

BUILDING MATERIALS

Storing CO_2 in materials

The storage of CO_2 via mineralisation to produce building material is a crucial opportunities to decrease the carbon footprint of this sector.

CO_2 emissions from hard to abate sectors can be stored permanently in materials.

These materials can substitute carbon-intensive products such as cement materials.

ENERGY

"Defosilise" heavy duty transport

Renewable CO_2-based fuels have an energy density adapted for heavy transports and do not require changes in infrastructures and vehicles.

Storage of Renewable Electricity (RE)

Via Power-to-X, ***CCU can support the storage and transport of RE*** *and thus be a non-fossil and renewable alternative for processes or locations that cannot directly use RE.*

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Numbers and Facts

- CCU technologies have the potential to **utilize up to 8 Gt of CO_2 per year by 2050**
  (Sources: GCI, 2016, Hepburn et al., 2019)
- The estimated potential for the scale-up of CO_2 **utilization in e-fuels varies from 1 to 4.2 Gt CO_2 yr^{-1}**
  (Sources: Hepburn et al., 2019, Farfan et al., 2019, RAM et al.,2020)
- Life-cycle analysis demonstrate that **both point source and DAC to fuel pathways can provide climate benefit** over conventional diesel fuel if a low carbon source of electricity is used
  (Sources: Daggash et al., 2018, CONCAWE, 2019, Liu et al., 2020)
- CCU has the technical potential to decouple chemical production from fossil resources, **reducing annual GHG emissions by up to 3.5 Gt CO_2-eq in 2030**
  (Source: Katelön et al., 2019)
- **All considered CCU technologies for mineralization could reduce climate impacts over the entire life cycle based on the current state-of-the-art and today's energy mi**x. Up to 1 Gt per year of the cement market could be substituted by mineralization products
  (Sources: Ostavari et al., 2020, Di Maria et al., 2020, Hills et al., 2020)

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CARBON CAPTURE AND UTILISATION

State of the Art and Perspectives in Europe

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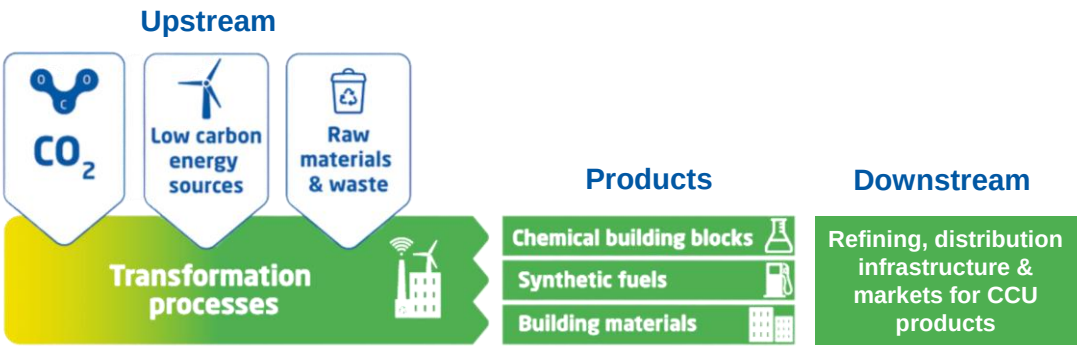
CO_2 Value Europe

CO_2 Value Europe is the only European association dedicated to CO_2 Utilisation, bringing together stakeholders from the complete CCU value chain and across industries



Multinational Companies, SMEs, Regional Clusters, Research Institutions, Universities

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CO_2 Value Europe: EU projects

IMPACTS9

The EU SET-PLAN recognises CCUS as one of the ten priority actions to help reach the EU's climate goals. IMPACTS9 project supports and **accelerates the delivery of R&I activities** to achieve such goals.

INITIATE
A STEPWISE PROJECT

INITIATE demonstrates how **residual carbon-rich gas from the steel sector can be used as a valuable feedstock for the chemical sector**. Such emissions are used to produce ammonia, a precursor for urea, a widely used fertilizer.

TAKE-OFF
Sustainable aviation fuel from CO_2

Take-Off develops **cost-effective sustainable aviation fuel using CO_2 emissions and renewable energy**, helping the aviation sector reach the EU 2050 climate-neutrality targets.

CO_2SMOS

CO2SMOS will develop, in a circular approach, of a set of **technologies to transform the CO_2 emissions produced in bio-based industries (BBIs) into high-value chemicals** for the manufacturing of bio-based products.

vivaldi

VIVALDI proposes a circular and sustainable solution **to convert off-gas emissions from Bio-industries to produce 4 industrially relevant organic acids**, which can re-enter to the production process of biorefineries.

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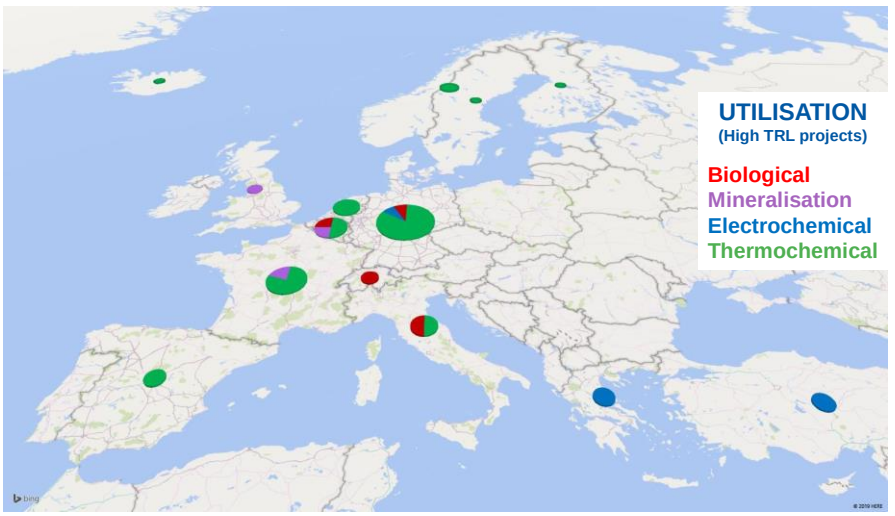
> 125 CCU projects in Europe



- **50%** high TRL projects (from demo. to comerc.)
- **63%** CO_2 to chemicals and fuels projects
- **27%** CO_2 Capture projects
- **10%** CO_2 to mineralization projects

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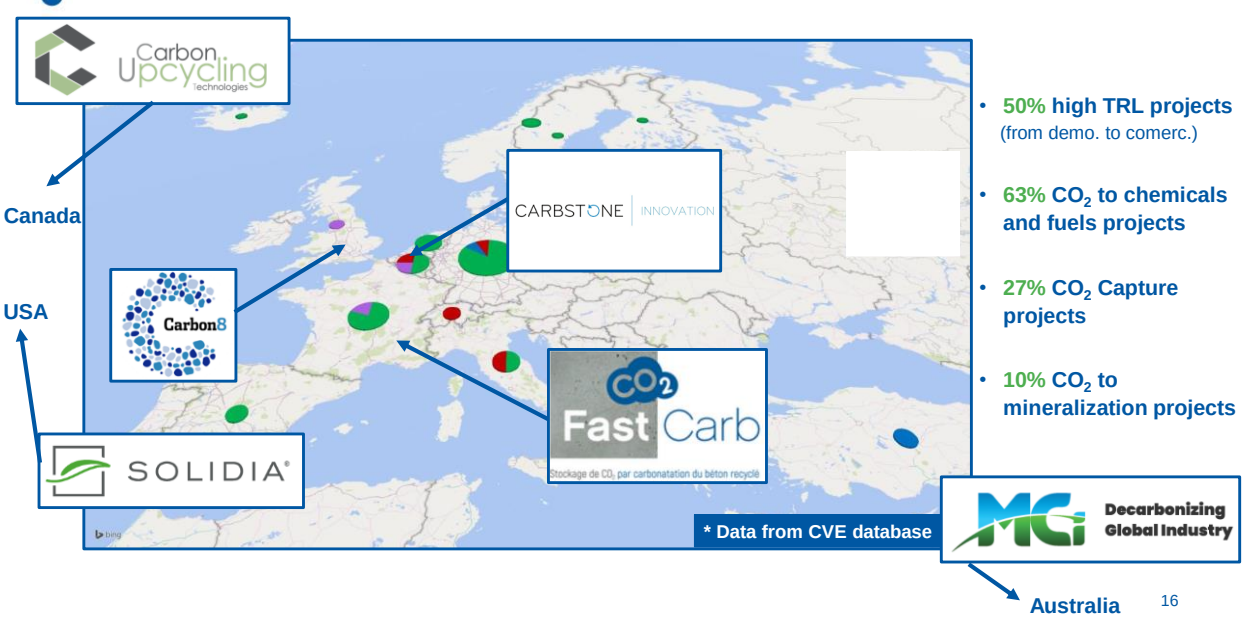
Some examples of CO_2 mineralisation projects



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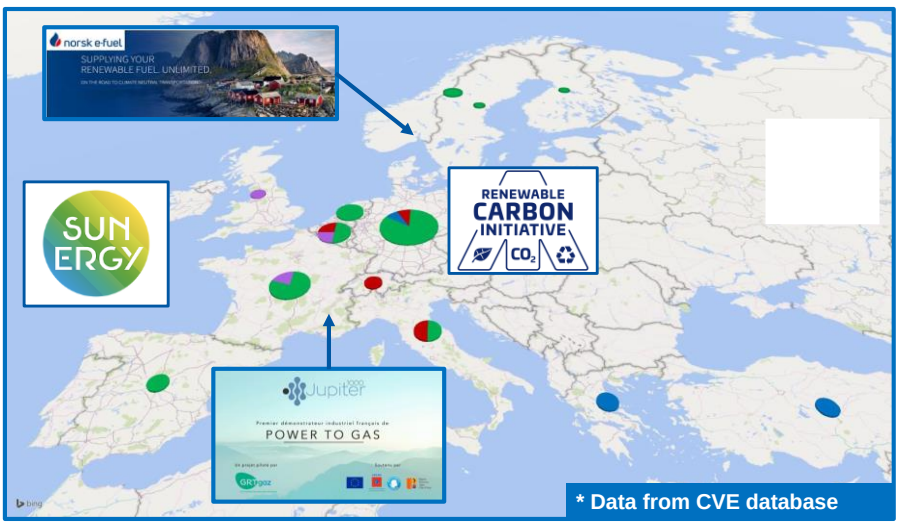
Some examples of Power-to-X projects and initiatives



- **50% are high TRL projects** (demo. -> comerc.)
- **63% CO_2 to chemicals and fuels projects**
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17 ongoing/soon starting CCU projects in Belgium

Steelanol
Fueling a sustainable future

CARBON 2 VALUE
Interreg
2 Seas Mers Zeeën

Leilac

Columbus
Carmeuse/ENGIE/John Cockerill

NORTH CCU HUB

CARBSTONE | INNOVATION

Examples of high TRL CCU projects

Forecasted production of CO_2-based fuels and chemicals in near-term:

Project	Country	Route	Production of CO_2 based products
Norsk-efuel	Norway	DAC to jet-fuel	82 000 tons of jet-fuel/year
Carbon Recycling International	Iceland	CO_2 to methanol	4 000 tons of methanol/year
Jupiter 1000	France	CO_2 flue gas to CH_4	25 Nm^3/h of methane = 160 000 tons of methane/year
North CCUhub	Belgium	CO_2 to methanol	44 000 tons of methanol/year
Mo-Industrial e-fuel	Norway	CO_2 to methanol	80 000 tons of methanol/year
C2Fuel	EU	CO_2 to formic acid	2.4 Million tons of formic acid/year
Audi e-gas plant	Germany	CO_2 to methane	1 000 tons of methane/year

Support Research, Innovation & Deployment

Several topics of interest for CCU topics in 2021-2027

First topics expected in April 2021

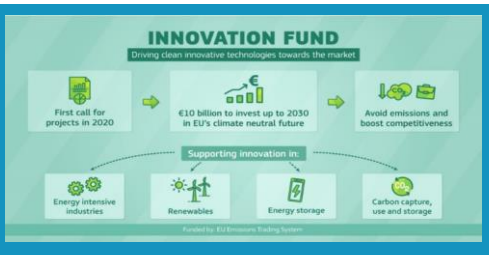
IMPORTANT PROJECTS OF COMMON INTEREST (IPCEI)

Based on Strategic Value Chains, two of which are linked to CCU:

- Hydrogen Technologies
- Low CO_2 emissions industries

CCUS SET-PLAN

CCU/CCS is a priority in the Strategic Energy Technology Plan



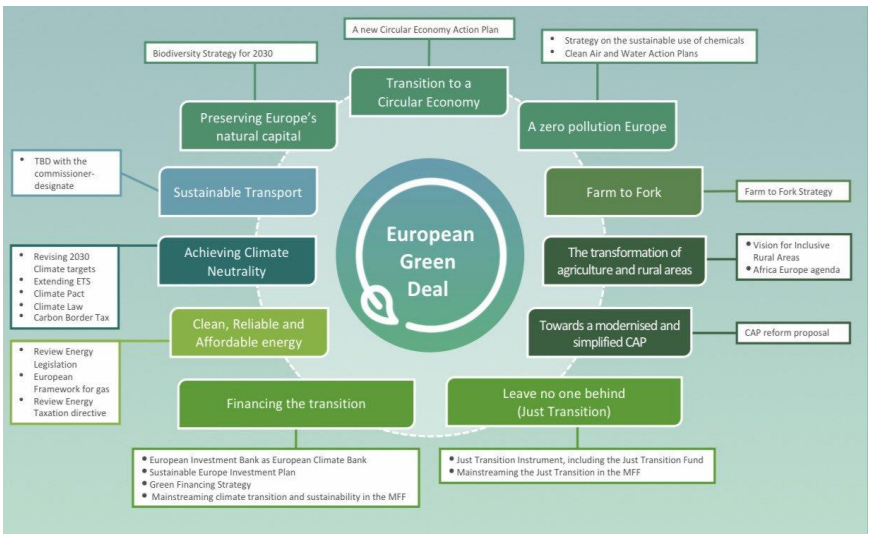
CCU is part of the Innovation Fund

Two calls already published (for large- and small-scale projects)

€10-20 billions for 10 years; yearly calls

High TRL, mature, innovative, pre-commercial projects with significant climate mitigation benefit

EU Green Deal: driving Europe's action on climate change



Objective: making Europe the 1st climate neutral continent

Three pillars

1. **Planet:** no net GHG emissions by 2050 in Europe
2. **Prosperity:** economic growth decoupled from resource use
3. **People:** no one and no place left behind

Key flagship initiatives for CCU industry:

- Climate neutrality by 2050 (Fit-for-55 = -55% GHG emissions by 2030)
- Sustainable transport
- Clean, Reliable & Affordable energy
- Transition to a Circular Economy

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Complex regulatory framework

non exhaustive list

- **Sustainable Taxonomy**
- **RED II revision**
- **ETS revision**
- **Carbon Removal Certification Mechanism**
- **ReFuel Aviation / FuelEU Maritime**
- **Energy System Integration → CCUS Forum**
- **SET-Plan CCUS Action 9**
- **Sustainable Products Initiative**
- **Alternative Fuels Infrastructure**
- **Hydrogen Strategy**
- **Next Generation EU → *Recovery & Resilience Fund***
- **New Industrial Strategy**
- **Climate Law**
- **Energy Taxation Directive**
- **Carbon Border Adjustment Mechanism**
- **CO_2 emissions for cars and vans**
- **….**

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CCU in Fit-for-55 Package

The Fit for 55 Package was launched on 14 July 2021 by the European Commission. Among the different policies proposed, a number of them* will directly impact how CCU can be further deployed and incentivised across the EU:

Policy instrument	Impact on CCU
EU Emissions Trading System (EU ETS) revision	Recognises that CO_2 which is chemically and permanently bound in a product – as in CO_2 mineralisation – is excluded from the obligation to surrender emission allowances; Announces specific provisions to avoid double-counting of emissions released by the use of RFNBOs that were produced from CO_2 emitted under activities covered by ETS.
Renewable Energy Directive (REDII) revision	The impact of RFNBOs is considered only if they reach 70% of emission reduction. Requires that at least 2.6% of the energy supplied to transport by 2030 is covered by RFNBOs; Requires that 50% of the use of hydrogen in the industry is covered by RFNBOs.
ReFuelEU Aviation	Sets binding targets per volume shares for RFNBOs: minimum 0.7% of RFNBOs by 2030; minimum 8% by 2040 and minimum 28% by 2050.
Fuel EU Maritime	Sets binding GHG reduction targets for ships: 2% in 2025; 6% in 2030; 26% in 2040 and 75% in 2050 by including RFNBOs to reach these targets.
Energy Taxation Directive revision	Sets minimum taxation rates of zero for a transitional period of 10 years (2023-2033) for RFNBOs and other sustainable & low carbon fuels for specific types of air and waterborne navigation.

* Non-exhaustive list

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Take-home messages

- CCU technologies are **technically ready now** for large scale deployment
- CCU technologies can be **used immediately** to **reduce net CO_2 emissions and help reaching net-zero to negative emissions (LCA are essential to assess impact)**
- CCU technologies require **renewable electricity** and will support the clean energy transition by facilitating **electricity take-up, storage and transportation**
- CCU technologies and products can use **existing infrastructure**
- A **supportive regulatory/market framework** is required **urgently -> things are moving in the right direction in the EU**
- CCU technologies have the potential to provide **solutions to hard-to-abate sectors, but also to generate revenues** through producing marketable products out of waste

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