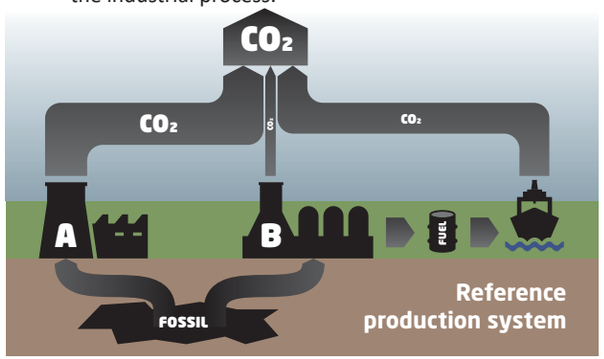
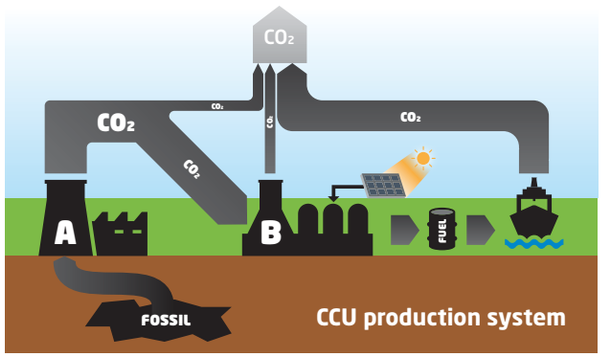
3. What are the key benefits of CCU?

CCU can largely contribute to mitigating global climate change by reducing net CO_2 emissions in several ways:

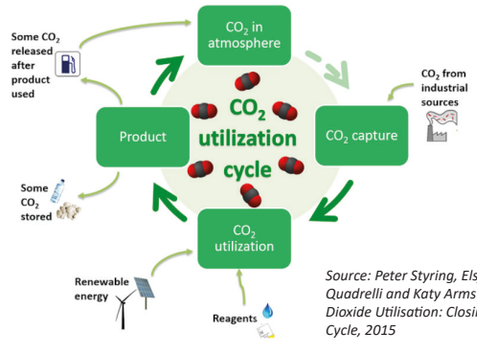
- The conversion of CO_2 into building materials binds CO_2 in the form of calcium carbonate, a compound which is known to be stable, hence permanently reducing the amount of CO_2 which is present in our atmosphere.
- If CCU technologies are used to recycle CO_2 molecules emitted by an industrial process into useful fuels or chemicals, CO_2 gets only emitted once (at the end of the lifetime of the product) instead of twice (at the chimney of the industrial process and at the product end) as illustrated in the following figure. In addition, less fossil feedstock needs to be extracted from the ground to feed the industrial process.





- In the transportation sector, CCU-derived fuels can immediately contribute to reduce net CO_2 emissions because they can be used in existing combustion engines and do not require any change to the existing fuel distribution infrastructure, unlike other solutions like electrification or hydrogen.
- CCU can facilitate the transition of the EU energy systems by offering options for the storage and transportation of renewable electricity, in the form of liquid or gaseous fuels.

CCU is the tie to close the human-made carbon cycle, where CO_2 is captured from industrial sources but also, in the long run, from the atmosphere via direct air capture. A circular economy can emerge where CO_2 is no longer considered as a waste emission but as a carbon source in replacement of fossil feedstock.



Source: Peter Styring, Elsje Alessandra Quadrelli and Katy Armstrong | Carbon Dioxide Utilisation: Closing the Carbon Cycle, 2015

In summary

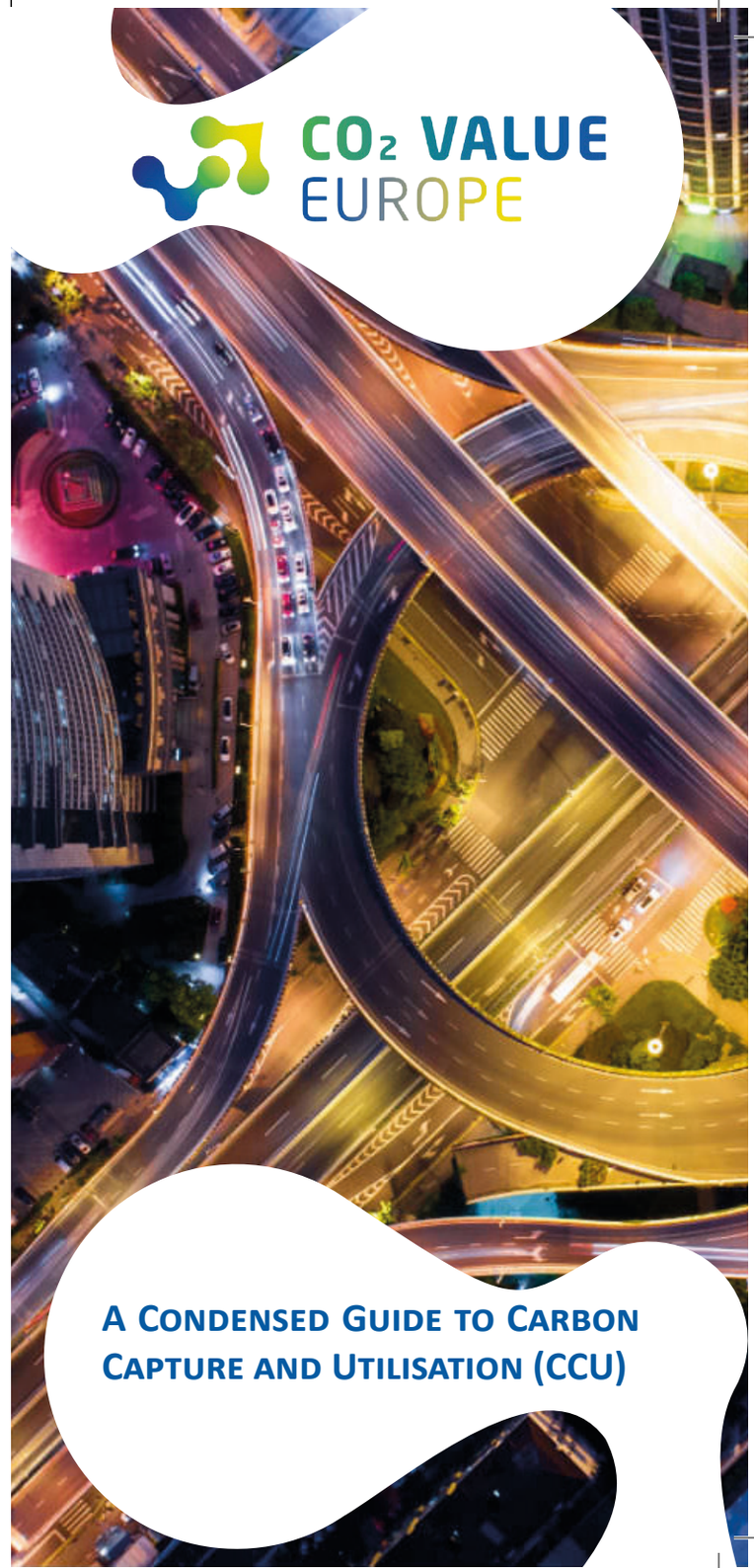
CCU has three main positive effects:

1. it contributes to reaching global climate goals
2. it broadens the carbon feedstock base needed for growing societies.
3. it enables the development of a circular carbon economy where Europe could take a leadership position.

In conclusion, Carbon Capture and Utilization provides a major opportunity for climate mitigation, energy transition and industry redeployment, for the benefit of all.

Together, we can make it happen!

CO2 VALUE EUROPE



A Condensed Guide to Carbon Capture and Utilisation (CCU)

1. What is CCU?

Imagine a tomorrow where CO_2 is no longer emitted but rather used as a key input factor for making everyday materials and products...

Not many of us are aware that carbon is an essential chemical element contained in almost all products used by mankind. Innovative technologies now enable to close the carbon cycle by using CO_2 as a viable source of carbon to manufacture such products.

Carbon Capture and Utilisation (CCU) is a diverse set of technologies that allow for the capture and use of carbon dioxide (CO_2) as a carbon feedstock for making everyday products such as fuels, chemicals and building materials that are currently predominantly derived from fossil resources. Such technologies are at various stages of development and some are already commercially available today.

a) Fuels

Fossil-based fuels, from gasoline in the road sector to jet fuel in the aviation sector, consist of mixtures of different hydrocarbons (molecules consisting of carbon and hydrogen). Today, hydrocarbons are mainly refined from crude oil but also from natural gas or coal. Besides biofuels, electrification and hydrogen, synthetic hydrocarbons ("synthetic fuels") produced from CO_2 represent a fourth option for sustainable transportation.

b) Chemicals

Most of the chemical products used in our modern daily life, such as plastics, packaging, furniture, clothing, pharmaceuticals or food supplements, are based on carbon as a key feedstock. Today, over 90% of such chemicals are derived from fossil carbon and responsible for 11% of the global primary demand for oil and 8% of natural gas (source: IEA July 2018). BBesides the use of biomass as a feedstock or the recycling of products at the end of their useful life wherever possible, CCU processes using CO_2 as a feedstock provide another alternative to reduce the reliance on fossil oil and gas for the production of chemicals.

c) Materials

CO_2 can also be permanently bound in materials in the form of minerals through a process called carbonation or mineralisation. This process happens in nature over geological times as seen with the formation of limestone over millions of years. CCU processes use the same basic principle in an accelerated manner, when CO_2 is combined with calcium-rich materials to produce calcium-carbonate ($CaCO_3$) which can be used as building material either directly (e.g. as aggregate) or after being further processed into cement. Mineral waste such as slags and ashes from the power and steel sectors or concrete from the demolition of old buildings are abundant sources of calcium that can be carbonated by captured CO_2 to produce building materials, thereby reducing the need to extract fresh mineral resources from quarries.

2. What is physically required for sustainable CCU?

CCU or CO_2 conversion technologies require two essential inputs: CO_2 and Energy:

a) CO_2

Carbon dioxide is currently emitted from various industries, such as the power, chemicals, cement and steel sectors but also from biological fermentation processes such as biogas facilities. All existing sources can be used to capture and provide the CO_2 as long as it is ecologically reasonable. Longer term innovations include the capture of CO_2 directly from the atmosphere (direct air capture).

b) Energy

Technologies that convert CO_2 into fuels or chemicals typically require energy input in the form of either:

- heat
- electricity to power the process or produce hydrogen via electrolysis from water, or
- solar radiation (e.g. to grow algae)

Such energy should be produced from renewable sources or at least have the lowest environmental footprint (e.g. waste heat that is currently being dumped).

For technologies that convert CO_2 into mineral materials, only very small amounts of energy input are required, because the chemical reaction that transforms CO_2 into carbonates is naturally exothermic (i.e. it generates heat).

c) Water

For the production of fuels and chemicals, water is also required.