Restoring sustainable carbon cycles

Sustainable Carbon Cycles Driven by Low-Carbon Energy

The paper "Sustainable Carbon Cycles Driven by Low-Carbon Energy" is part of the Position Paper on

"Restoring sustainable carbon cycles" stating that:

As the European chemical industry, we have the ambition to become climate-neutral by 2050. We are currently looking into the "HOW" and the elements needed for achieving this objective. Cefic welcomes the European Commission's initiative on restoring sustainable carbon cycles, which we see as an important step towards an effective carbon management policy and which will guide our thinking towards 2050. We aim to go as far as possible in reducing our own carbon footprint by maintaining high levels of resource efficiency and circularity, by introducing alternative processes enabling the use of circular and alternative feedstock and low-carbon energy including low-carbon heat and steam supply as well as by capturing and storing CO_2*. However, when it comes to the role that carbon plays within industry, the chemical sector has its own specificity: carbon is and will remain at the very heart of many of our processes and it is an essential element of many chemicals, like it is for most products society is using. Having access to alternative sources of carbon, notably from waste,* CO_2*/CO captured from industrial processes and bio-based resources is therefore an absolute necessity. In the longer-term, as residual emissions become hard or even impossible to abate, balancing options will also be needed to reach our climate-neutrality objective.*

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Sustainable Carbon Cycles Driven by Low-Carbon Energy

Sketching a pathway for the European chemical industry to neutralize the impact on the climate.

This opinion paper presents a vision for the chemical industry how to contribute to meeting the UN climate goals and remain within the planet's boundaries. This vision is proposed to provide a narrative about available carbon stocks and the carbon flows within the creation of a carbon stock across the economy. As the chemical industry is placed at that point of the economy in which carbon is introduced into the structure of our day-to-day products, it plays with its carbon processing capacities a pivotal role for the overall change from fossil to non-fossil based materials. The paper is intended to be a basis to build upon when discussing decarbonisation strategies at EU, Member States or company level. It is not to be confused with a carbon accounting system but it intends to focus on the strategic cross-industry's role to use alternatives to fossil and hereby contributing to the goal of a climate-neutral society.

A feedstock vision for the chemical industry

Considering our planet's boundaries, neutralising our impact on the climate is imperative. Implementing sustainable carbon cycles driven by low-carbon energy is the path the European chemical industry is taking, and for which it has many solutions to offer.

The concept of Sustainable carbon cycles entails the reduction of fossil carbon utilization as structural carbon in our products. It describes the available means to utilize alternative feedstock from non-fossil sources and ways to keep as much carbon as possible inside the economic system, minimise losses and minimise the impact from losses. In this respect, this vision discusses both replacing fossil carbon with non-fossil feedstock sources as well as circular economy measures to keep existing carbon as long as possible in use with acceptable efforts and sustainability advantages. It also includes carbon capture measures as e.g. storage (end-of-pipe) or utilization. With this, it covers the entire lifecycle of the carbon, from the extraction or production of raw materials to end of life carbon management.

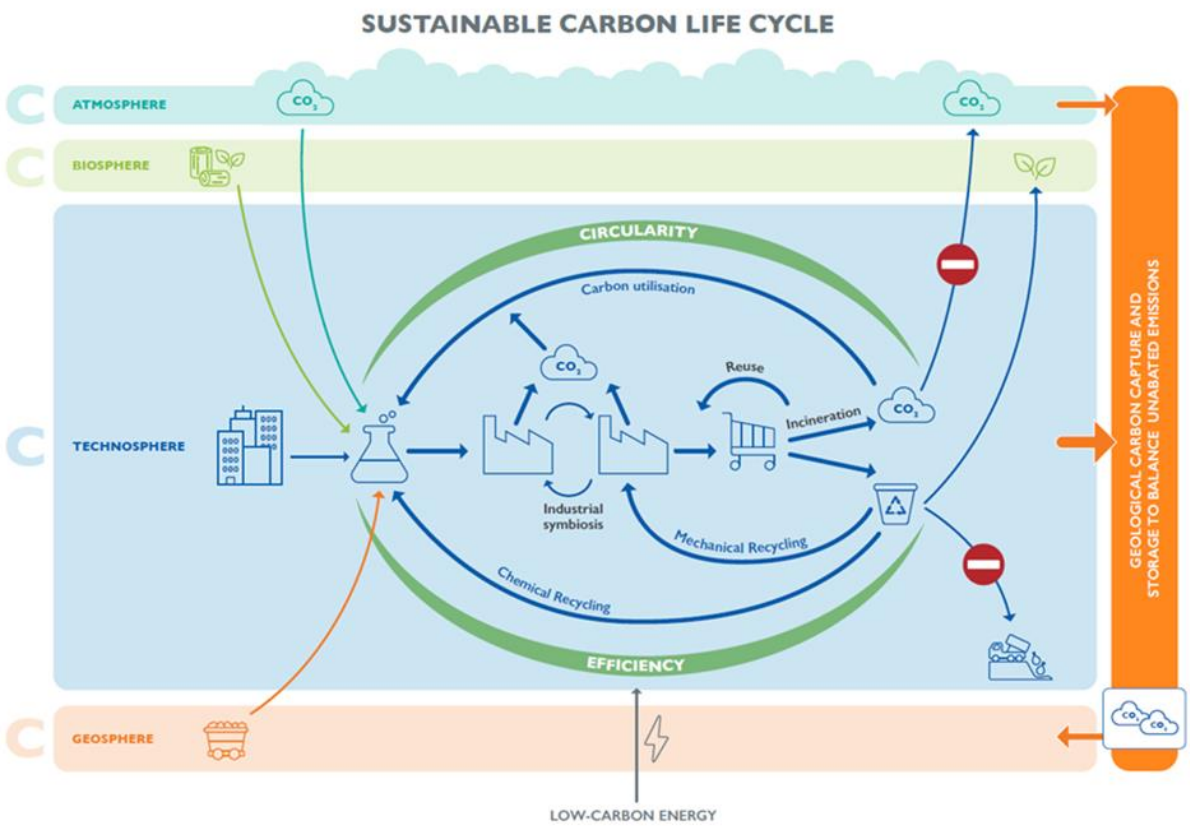
Maximising carbon circularity and minimising losses of carbon is key to create sustainable cycles. This can be achieved by reusing products, considering incremental approaches e.g., by increasing resource efficiency in production, recycling waste or reusing carbon which is already in the ecosystem (which we call technosphere carbon) through carbon capture technologies. The latter includes reusing carbon from industrial releases. The carbon losses and leakages should be restorative in nature. Idealised, maximizing carbon circularity and minimal losses can, in principle, contribute to keeping CO_2 out of the atmosphere by storing it in the "carbon chemical pool" (i.e., the stock of carbon-bearing manufactured products). The higher the degree of circularity reached within society, the more meaningful the contribution;

Because a 100% circularity is however not feasible, due to a.o. thermodynamics of the system, losses will be inevitable. A residual input of additional carbon containing feedstock remains needed to provide for increased need of carbon because of growth and to compensate for losses. In our vision, possibilities of "additional carbon" to replenish the carbon stock are in preference biosphere carbon and atmosphere carbon, although fossil carbon cannot be excluded.

Maintaining carbon in our economic system, and avoiding the losses of carbon, will however not be enough to achieve the imperative climate-neutral objective in 2050[9]. It will be necessary to take measures to actively remove carbon as CO_2 from the atmosphere, to address the hard-to-abate emissions of our own ecosystem, as well as others. That's where Carbon Capture and Storage (CCS) comes in.

CCS is yet another mitigation technology and part of the solution, next to choosing alternative carbon sources such as biomass and waste applying Carbon Capture and Use (CCU), increase circularity, electrification, CCS is to be considered as a mitigation measure to be deployed to address the remaining and hard-to-abate emissions. Avoidance of these additional emissions to the atmosphere, should be strived for first. A balance needs to be struck between utilization (CCU) and storage (CCS) of sources of CO_2. In any case, a safe and sustainable CCS needs to be preceded by a sound Environmental Impact Assessment and siting process, and a long-term monitoring and management scheme needs to be put in place.

Finally, the contribution of the above vision in meeting the Paris Goals is largely defined by **the efficiency** of processes and their **energy consumption**. Shifting to **low-carbon energy is imperative**. Some of the technologies discussed e.g. CCUS, or Direct Air Capture (DAC) consume a lot of (low-carbon) energy today; this will be an important element to consider when moving towards climate-neutrality.



[9] The Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA) and National Energy Technology Laboratory (NETL) argue that without carbon removals it is difficult to keep the temperature levels indicated in the Paris agreement.

Scope of the opinion paper

It is well known that the chemical industry is providing building blocks for materials and product applications that are resulting in GHG emission savings. These contributions are not specifically addressed within the vision of the carbon feedstock. They do have an important contribution in the overall demand of fresh carbon to be brought into the system. By reducing this demand, a lot of additional GHG emissions will be avoided. Some examples: styrofoam for household insulation is instrumental to achieve the various national targets on housing CO_2 emission reduction; battery materials are a key enabler for a net-zero transportation sector; high performance plastic materials are enablers of highly efficient blades for wind power generation.

In discussing the impact of feedstock choices on the planetary carbon budget one should not forget to take other planetary boundaries into account and to also consider the impact on biodiversity, soils, etc. Likewise, the carbon cycles in an industrial system will impact and compete with carbon cycles in other sectors, such as the agriculture sector. These equally important considerations are not subject of this opinion paper but should not be forgotten.

Carbon stocks and their contribution to the climate neutrality objective

To secure a livable future, the EU has committed to achieving climate neutrality by 2050, and has written this target of climate neutrality into law with the European Climate Law (Regulation (EU) 2021/1119). In a first step we need to drastically reduce our greenhouse gas emissions - emission avoidance - and next compensate for residual emissions (e.g. from industry or agriculture) through carbon (CO_2).

In this section we will discuss how feedstock choices in our industrial system, influence the atmospheric carbon budget. The impact can be evaluated by following the CO_2 emissions during processing or end-of-life; (-) means removing CO_2 from the atmosphere, (0) means avoiding additional CO_2 added during processing or end-of-life, (+) means emitting additional CO_2.

Carbon can be sourced from following carbon stocks:

Sustainable Biomass

Atmospheric CO_2 will be stored in biomass through photosynthesis. When biomass is used as a carbon feedstock in our current economic system, part of it will eventually be released back to the atmosphere as CO_2 emissions through incineration or through other degradation routes. This will result in a "neutral[10]" CO_2 balance (0). In a circular economy, less biogenic carbon would go back to the atmosphere as CO_2[11]. This would result in storing the carbon in the economic stock, and in a well-functioning-circular system, one could qualify this situation as approaching removal (-). Carbon capturing and sequestration of biosphere carbon classifies as carbon removal (-). As mentioned above, the efficiency of such removal processes depends highly on the energy source.

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[10] "neutral" is an approximation, as the system is never 100 % efficient

[11] In a vision for circular carbon cycles, landfilling is not considered.

Atmospheric carbon

Using atmosphere carbon as a feedstock for carbon-bearing materials is another option to avoid additional CO_2 (0) from fossil origin, being emitted to the atmosphere. However, technologies like Direct Air Capture (DAC) are today still in full development and not being scaled up. The use of atmosphere carbon can be a low-impact option if further development reduces its energy needs in combination with the use of low-carbon energy. DAC in combination with CCS could be considered as carbon removal (-).

Technosphere carbon

Technosphere carbon is a source of concentrated carbon in industrial emissions in the form of CO_2, and can be brought back in use through Carbon Capture and Utilisation technologies, via e.g. using hydrogen to convert CO_2 into methanol by using industrial emissions from different sectors as a carbon feedstock, again, the release of additional fossil carbon to the atmosphere would be avoided and the impact will be higher in a well-functioning circular system (0). Thus, applying CCS to technosphere carbon from fossil origin will result in a "net-zero emission[12]" if low-carbon energy is used, applying CCS to technosphere carbon of biogenic carbon will result in carbon removal (-).

Geosphere carbon

Current models still rely on carbon feedstock of fossil origin. In today's waste management set-up, this unfortunately often means an additional input of CO_2 to the atmosphere because today, a large portion of waste is still incineration without recovering the CO_2. By increasingly installing circular loops, the C can be seen as stored in the stock of carbon-bearing manufactured products or "carbon chemical pool"[13], hereby avoiding additional CO_2 to be emitted (0), and in a well-functioning circular economy CO_2 in products may approach CO_2 removal, in line with the principles outlined in Annex III. Utilising CCS as a sink for concentrated fossil CO_2 streams, would "permanently" avoid the release (0).

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About Cefic:

Cefic, the European Chemical Industry Council, founded in 1972, is the voice of large, medium and small chemical companies across Europe, which provide 1.2 million jobs and account for approximately about 15% of world chemicals production.

[12] "net-zero" is an approximation, as the system is never 100% efficient.

[13] As defined in the IPCC Carbon Dioxide Capture and Storage report, available here.