THE POTENTIAL OF CARBON UTILISATION IN A NET ZERO EMISSION ECONOMY

To achieve net zero emissions (NZE) by 2050-70 requires a range of approaches and technologies including electrification, the use of low-carbon hydrogen, sustainable biofuels and carbon capture, utilisation and storage (CCUS). Studies from organisations such as the IPCC and IEA conclude that CCUS, with its versatility of application, demonstrated effectiveness and ability to deal with enormous volumes of emissions, is a necessary element of the technology suite that must be deployed. An Increasing number of countries include CCUS in their long-term climate change mitigation policies.

CCUS has grown rapidly in the past few years, with new projects announced and in planning and construction. However, CCUS is still in the early stages of technology and market development.

DEVELOPMENTS IN CARBON CONVERSION TECHNOLOGIES

CO_2 is a valuable commodity and can be converted into a variety of value-added products including fuels, chemicals, polymers and building materials via multiple chemical and/or biological processes. Many technology pathways exist for carbon conversion, which are at varying levels of technical and commercial maturity.

CO_2 can be combined with hydrogen to synthesise hydrocarbon fuels that can replace many of the fossil-based fuels currently available. CO_2 can also be used to make chemical intermediates such as syngas and methanol as the basis of other chemicals. A host of technologies based on mature processes but with specifically designed catalysts for converting CO_2 to established commercial products have been developed. Several technologies have been implemented successfully and are now in commercial use; some innovative processes have been developed and reached the commercialisation stage; and many more being developed are at the pilot and laboratory stages.

Figure 1 Atmosfair FairFuel Power-to-Liquid kerosene plant (Image credit: dpa picture alliance/Alamy Stock Photo

Commercial plants are operational today in Asia, America, Europe and the Middle East producing synthetic fuels, chemicals and/or polymers from CO_2 emitted from various sources. CO_2-to-Fuel projects have been announced, or are in development worldwide, using various technologies.

The market for building materials from the carbonation of industrial wastes with captured CO_2 and CO_2-cured concrete has developed rapidly in the past few years. A group of companies are supplying various carbonation and CO_2-curing products and technologies on the market and more companies are commercialising their novel processes. CO_2-curing processes have been adopted in concrete production facilities worldwide, and several plants for CO_2 mineralisation of wastes for commercial production of aggregates and other valuable products are in operation.

With continued technological development, it can be expected that carbon capture and use (CCU) will be increasingly found in commercial applications.

POTENTIAL CONTRIBUTION OF CCU TO ACHIEVING NZE GOAL

The climate change mitigation benefits of a CCU product depend on several factors including the scale of its application, the life-cycle emissions of the product that it displaces, and the source of energy used. Almost all the CCU pathways investigated exhibit potential for lower life cycle emissions per tonne of product compared to conventionally produced counterparts. Thus, CCU can contribute to emissions reduction where the application is scalable, uses low-emission energy, and displaces a product with higher life-cycle emissions. In addition, CCU offers a versatile and practical solution for emissions reduction in hard-to-abate sectors where alternatives are technically limited.

The potential demand for CO_2 by different CCU products, estimated by the IEA, shows that CO_2-derived fuels have the greatest market potential with an annual demand for CO_2 of >5 Gt. Building materials and chemical intermediates can generate a CO_2 demand of between 1–5 Gt/y, and CO_2 demand from polymers is >1 Gt/y. There is interest in CO_2-derived synthetic fuels for aviation and shipping. For example, the EU has introduced new standards for the use of sustainable fuels, which could increase the uptake of CCU for the production of CO_2-derived fuels in the region.

The growth in demand for CO_2 is limited to the anticipated market size of the CCU products. Due to many uncertainties, the estimated global CO_2 demand from CCU is wide ranging, from 1 $GtCO_2$/y to 7 $GtCO_2$/y in 2030. The higher figure of 7 $GtCO_2$/y equates to nearly 20% of current global CO_2 emissions, which is significant but not adequate for climate change mitigation. Thus, CCU can have a role in complementing other mitigation measures and contribute as part of an 'all technologies' approach to meeting global energy and climate goals.

In addition, CCU can generate useful income to offset carbon removal costs, providing a low-cost decarbonisation solution in some sectors and regions. It also provides a new source of essential carbon feedstock in the transition from fossil fuel resources, and so helps to close the carbon loop and create a circular economy. Therefore, CCU can be used as a supplement to other technologies and measures and can play an important role in efforts to achieve NZE and a circular economy.

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Each executive summary is based on a detailed study which is available separately from: www.sustainable-carbon.org. This is a summary of the report: The potential of carbon utilisation in a net zero emission economy by Dr Qian Zhu, ICSC/330, ISBN 978–92–9029–653-9, 92 pp, January 2024