

Climate change mitigation potential of carbon capture and utilization in the chemical industry

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Chemical production is set to become the single largest driver of global oil consumption by 2030 and currently causes about 1.5 Gt of CO₂-equivalent greenhouse gas emissions per year. To reduce the oil consumption and the resulting greenhouse gas emissions of the chemical industry, carbon dioxide can be captured from stacks or air, and utilized as alternative carbon source for chemicals.

In this presentation, we determine the technical climate change mitigation potential of Carbon Capture and Utilization (CCU) in the chemical industry. We build a bottom-up model of the chemical industry covering the production of 20 bulk chemicals, which account for more than 75% of the industry's greenhouse gas emissions. The model is based on engineering-level data enabling the determination of flows of materials, energy, and emissions throughout entire chemical value chains at a high level of detail. Using our model, we determine pathways for CCU implementation leading to minimal greenhouse gas emissions and analyze the resource requirements.

The results show that CCU has the technical potential to decouple chemical production from fossil resources, reducing annual GHG emissions by up to 3.5 Gt CO₂-eq in 2030. Exploiting this potential, however, requires large amounts of low-carbon electricity substantially exceeding current production estimates for 2030. Therefore, a large-scale CCU implementation is likely to result in competition for limited renewable electricity resources. Most CCU technologies considered in this work are found to be less efficient in reducing GHG emissions per unit low-carbon electricity when benchmarked to power-to-X efficiencies reported for other large-scale applications including electro-mobility and heat pumps. Once and where competition for limited renewable energy resources with more efficient power-to-X technologies can be avoided, CCU in the chemical industry can provide a substantial contribution to climate change mitigation.