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How much CO_2 emissions can be avoided by Carbon Capture and Utilization in the chemical industry?

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The chemical industry largely relies on fossil feedstock and causes about 1.5 Gt of direct CO_2-equivalent greenhouse gas emissions per year (in 2010).[1] A promising way to reduce the climate impact of the chemical industry is using captured CO_2 from industrial point sources or ambient air as alternative carbon feedstock. So far, however, climate benefits have been demonstrated only for individual CO_2 conversion technologies. The total climate change mitigation potential of the field of Carbon Capture and Utilization (CCU) in the chemical industry is still under debate.[2]

In this work, we therefore conduct a detailed assessment of the climate change mitigation potential of CCU in the chemical industry, focusing on bulk chemicals. We built a bottom-up model of the chemical industry covering the production of 20 bulk chemicals, which account for more than 80% of the industry's energy demand and 75% of the greenhouse gas emissions. The model is based on engineering-level data of the production technologies to determine flows of materials, energy, and emissions throughout the entire chemical value chains. For each chemical, both conventional and CO_2-based production technologies are included, while the choice between the technologies is determined to minimize the climate impact. By this means, the model allows to determine the maximum climate change mitigation potential of CCU in comparison to conventional production.

Our results show that CCU in the chemical industry can lead to CO_2 emissions savings on a gigatonne-scale. To exploit this potential, however, large amounts of low-carbon electricity are needed to produce hydrogen, which is used as co-reactant by many CCU technologies. The required amounts of low-carbon electricity largely exceed current production estimates for the next decades. Thus, the supply of low-carbon electricity is likely to remain a limiting factor for the large-scale implementation of CCU. We therefore further investigate the potential climate impact reductions in relation to the amount of electricity available and the carbon footprint of the technologies used to deliver the electricity. In addition, we discuss the results in comparison to alternative utilization options for low-carbon electricity. Our study suggests that CCU has the potential to play a meaningful role in the transformation of the industry in support of global climate targets.

Reference

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