TO UTILIZE OR NOT TO UTILIZE?
A LIFE-CYLE-ASSESSMENT PERSPECTIVE ON CARBON DIOXIDE UTLIZATION

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Global warming is mainly driven by anthropogenic emissions of carbon dioxide. Utilizing this carbon dioxide instead of emitting it to the atmosphere therefore seems intuitively as the best means to mitigate climate change. However, utilizing the inert carbon dioxide molecule for chemical conversion usually requires energy. Since the production of this energy leads to greenhouse gas emissions, the intuitive benefits of carbon dioxide utilization cannot be taken for granted.

In this work, we present pathways for chemical conversion of carbon dioxide and assess their potential environmental benefits based on life-cycle assessment (LCA). LCA quantifies the environmental impacts along the full life-cycle from cradle-to-grave and for all categories of environmental impacts. Thereby, LCA avoids problem shifting along the life-cycle and between impact categories. The application of LCA to carbon dioxide utilization leads to methodological issues which will be reviewed and critically discussed.
For CO2 capture, we discuss the methodological issues in assigning a carbon footprint to captured CO2 serving as chemical feedstock and provide recommendations to ensure that the environmentally most beneficial decisions are fostered by LCA. Available CO2 sources for utilization are analyzed and ranked according to their environmental impacts.

For the subsequent chemical conversion of the feedstock CO2, we illustrate the different conversion classes by highlighting novel developments from catalysis and chemistry. In particular, we discuss the production of novel fuels combining CO2 with hydrogen from renewable energy and the production of novel CO2-based polymers. The different character of these routes will be discussed from a LCA perspective.
The product scope is then expanded. To overcome the high requirements on data of classical life-cycle assessment, we move to the in silico screening of the environmental potential of novel carbon dioxide utilization pathways. For this purpose, we introduce a short-cut LCA method which provides us with a quick indication to answer the question whether and when to utilize or not to utilize CO2 as chemical feedstock from an environmental perspective.