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Comparative cross-sectoral systems analysis of production, use and recycling of CO_2 based products

Sebastian Turnau,[1,*] Stefan Bringezu,[1]
[1]*Center for Environmental Systems Research, University of Kassel, Kassel, Germany*
**Corresponding author: sebastian.turnau@uni-kassel.de)*

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In general, when CO_2 is transformed into hydrocarbons this requires high energy inputs. An environmental benefit depends on the provision of renewable electricity, which is still a scarce resource. We compare different routes of CO_2 use with regard to their environmental performance, including chemical products and transport fuels. The analysis also allows to evaluate which purpose of using renewable power is associated with higher benefits, including e-mobility.

CO_2-based chemicals such as methanol and methane, and derived polymers such as polyoxymethylene (POM) are compared with their fossil-based substitutes. Various CO_2 sources, including cement kilns, biogas plants and DAC are considered. Electrolysis is assumed to be supplied by wind power, which is increasingly available in Germany.

Comparative life cycle analysis determines the benefit of CO_2-based routes with regard to GWI (Global Warming Impact) and input indicators such as RMI (Raw material input), TMR (Total material input), CED (Cumulative energy demand) and water input.

Each route is considered on a cradle-to-cradle basis. Earlier studies [1] on a cradle-to-gate basis showed a trade-off between GWI benefits and higher requirements of raw materials. We extend the system in order to consider also subsequent recycling routes. CO_2 based production enables different recycling options, such as mechanical or material recycling, to keep materials in the recycle loop and reduce new material input and increase resource efficiency.

CO_2-based chemicals such as methanol can be used in the chemical and polymer industry or as fuels in the transport sector. The life-cycle impacts resulting from the use of 1 MWh of renewable energy for CO_2-based chemicals and polymers are compared to a use of that energy in e-mobility.

Scenario analysis is used to vary relevant parameters, such as electricity mix, electrolysis technology and recycling options and quantities.

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References

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