ICCDU XVI
27-30 August, 2018
Rio de Janeiro, Brazil

16th INTERNATIONAL CONFERENCE ON CARBON DIOXIDE UTILIZATION

A guideline for standardized life cycle assessment on carbon capture and utilization

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Keywords: Life Cycle Assessment, Guideline

Carbon capture and utilization (CCU) technologies have shown the potential to reduce environmental impacts. However, many CO_2-based products lie thermodynamically uphill, i.e., CO_2-based products have a higher Gibbs enthalpy of formation than CO_2. In these cases, activation of CO_2 for utilization requires energy. Since the supply of this energy is associated with environmental impacts, intuitively expected impact reductions for CCU technologies cannot be taken for granted. Environmental impacts can be systematically analysed by Life Cycle Assessment (LCA). LCA is a holistic method to account for environmental impacts of products over the entire life cycle. However, LCA for CCU products has led to substantially deviating results even for identical technologies. E.g., for CO_2-based methanol, greenhouse gas emissions vary from – 1.5 to 9.7 $kg_{CO2\text{-}eq.}$.[1]. These results show that the application of LCA for CCU technologies is challenging, and substantial methodological choices and pitfalls exist.

Because deviating results for identical technologies could potentially mislead decision makers, we develop a guideline for standardized life cycle assessment of CCU technologies. Building upon existing LCA standards[2] and guidelines (e.g. ILCD[3]), our work targets CCU-specific challenges for the LCA methodology, and provides recommendations on how to address these challenges to ensure comparability and transparency of the results.

For this purpose, we first identify archetypical research questions (i.e., goal definition) from current LCA studies on CCU. By comparing these archetypical research questions to goal definitions described in the ILCD handbook, we develop guidance on how to answer research questions on CCU systematically. The key is here a sound scope definition. Our guidance on the scope definition covers the definition of the functional unit as basis for comparison, the system boundaries, the life cycle inventory modelling approach and co-product management. The guidance is refined for specific classes of CCU technologies covering fuels, chemical feedstock, materials and minerals. Ambiguity caused by deviating inventory data sets for feedstocks is reduced by introducing standard inventory data sets of main process inputs (e.g., electricity, hydrogen and heat) for the status quo and potential future scenarios. Moreover, guidance on how to account for temporary storage of CO_2 and how to interpret negative emissions is provided. Finally, a checklist is given for reporting to guarantee transparent LCA studies.

To demonstrate how the guideline supports LCA for CCU, we present the life cycle assessment of CO_2-based methanol in comparison to conventional production.

Acknowledgments

We acknowledge the financial support from CO_2 Science.

References

[1] Jens Artz et al. *Chem. Rev 2017* 118 (2), P. 434
[2] European Committee for Standardisation ISO 14040-Environmental management – Life cycle assessment – Principles and framework
[3] Joint Research Center, ILCD handbook General guide for LCA – Detailed guidance 2010