Guidelines for life cycle assessment of carbon capture and utilization as negative emissions technologies

Sibylle Duval--Dachary[1,2,3], Amandine Pastor[2,3], Sandra Beauchet[1], Daphné Lorne[1], Thibault Salou[2,3] and Arnaud Helias[2,3]

[1] IFP Energies nouvelles, 1 et 4 avenue de Bois-Préau, 92852 Rueil-Malmaison, France
[2] ITAP, Univ Montpellier, INRAE, Institut Agro, Montpellier, France
[3]Elsa, Research Group for Environmental Lifecycle and Sustainability Assessment, Montpellier, France
E-mail contact: sibylle.duval-dachary@ifpen.fr

Moving towards a circular carbon economy would prevent the extraction of additional fossil raw materials. Carbon capture and utilization (CCU) technologies could reduce greenhouse gases emissions by the replacement of fossil-based products by CO_2-based products (avoided emissions). In this study, we focus on CCUNET: CCU systems combining these avoided emissions with negative emissions technologies (NET). Quantifying the whole environmental impacts (both avoided and negative emissions) is complex. Guidelines to harmonize LCAs of CCU systems and improve results comparability between several studies exist. However, the coupling with NET generates issues on, for instance, system boundaries or biogenic carbon accounting. To address these concerns, existing recommendations to perform LCA on CCU or NET systems are identified and discussed. This allows proposing tailored recommendations for LCA of CCUNET systems. The framework addresses, among others, the choice of i) the functional unit, ii) the system boundaries, iii) the method to deal with multifunctionality, and iv) the integration of biogenic carbon flows, including soil carbon sequestration. For instance, the functional unit should consider carbon sequestration to allow comparison with other NET. A case study is modelled to exemplify this framework. To be able to evaluate negative emissions, the system boundaries must be cradle-to-grave, i.e. from CO_2 removals from the atmosphere to the end-of-life of the CO_2-based product. Thus, the case study includes i) biomass production (CO_2 removal from the atmosphere by photosynthesis during biomass growth), ii) conversion of the biomass into energy and capture of the produced CO_2, iii) transformation of the captured CO_2 into a value-added product, iv) use of the CO_2-based product, v) end of life of the CO_2-based product. For instance, it could be CO_2 captured in a fuel ethanol plant supplied by corn, miscanthus or even wood residues. This CO_2 will then be transformed into a reusable plastic bag. At its end-of-life, the plastic bag can be recycled, landfilled, or incinerated with carbon capture and storage. This LCA study innovates by proposing to model a complete CCUNET system and provide some first insights on the potential of CCUNET system to reach negative emissions. This framework is interesting in view of the growing interest in both CCU and NET systems, that will hopefully result in more and more LCA on CCUNET systems.