IASS WORKSHOP REPORT

Institute for Advanced Sustainability Studies (IASS)

Towards a common understanding of LCA and TEA for CO_2 Utilization technologies

An exchange among policymakers, industry and practitioners. Brussels, 1. October 2019

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Summary

On October 1st, 2019, the CO_2nsistent Project (co-financed by the Global CO_2 Initiative and EIT Climate-KIC) and the PHOENIX Initiative jointly organized a workshop in Brussels on the topic of CO_2 utilization technology and assessment methodologies such as Techno-Economic and Life Cycle assessment (TEA and LCA). The event brought together LCA and TEA practitioners, national and European policy agencies, and the corporate field. To stimulate and enhance participation, diverse session formats were offered: thematic presentations by experts, a panel discussion, as well as a break-out session modeled on the "world café" method. The foci of the day were two-fold: Learning how to support European policymakers when assessing the environmental and economic aspects of CO_2 utilization, and initiating an exchange with parallel European initiatives conducting research on CCU assessment methodologies and their environmental and economic perspectives.

The event shed light on some unresolved issues raised by industrial actors with regard to the upcoming European policy and funding mechanisms (such as ETS Phase IV and Innovation Fund), while national and European decision-makers described the difficulties they face when evaluating CO_2 utilization. The current ETS rules are inadequate to properly quantify the climate benefits of industrial CCU application, while the Renewable Energy Directive (REDII) lacks requirements for broader environmental and social assessments. Workshop participants broadly agreed that the harmonization of LCA approaches could help to quantify the extent to which CCU can contribute to achieving the GHG emission targets described in the REDII, should address all environmental aspects, and can provide sound guidelines for implementing CCU in the ETS. At the same time, solution-oriented collaborations with LCA and TEA experts (e.g. the CO_2nsistent group and others) were considered and examined, also with regard to new instruments and strategies to reduce complexity for policymakers.

The event also aimed at expanding the networks between the organizers and relevant actors in the field, with a particular focus on national and European policymakers. Members of CO_2nsistent, LCA4CCU and the Joint Research Centre – all of whom are engaged in CCU assessment methodologies – scrutinized alignments of proposed solutions and elaborated on specific divergences such as low-TRL technology. The likelihood that this effort could ultimately lead to standards for LCA and TEA for CCU was extensively debated with the direct support of the French (AFNOR) and German (DIN) associations for standardization.

Contents

1. Introduction

High volumes of greenhouse gases (GHGs) emitted into the atmosphere are responsible for the climate crisis the planet is facing. Combatting this crisis requires prompt, novel and effective action from policymakers and funding organizations. Substantial changes in the way we produce, utilize and recycle resources are needed. At the same time, economic profitability and the well-being of citizens and their environment need to be ensured. In addition to curbing worldwide emissions and achieving a renewables-based energy system, mitigation measures are mandatory when it comes to tackling global warming in transitioning economies that are still reliant on fossil fuels. Novel strategies to re-use CO_2 emissions in a variety of production processes (often referred to as Carbon Capture and Utilization, CCU or CO_2 Utilization) have been a research focus in recent years. These techniques cover innovative ways of producing materials, chemicals and fuels, and involve capturing the greenhouse gas CO_2 from point sources or the air and converting it into products (for a more detailed description, see Zimmerman and Schomäker, 2017). In recent years, researchers, policymakers and entrepreneurs have all turned their attention to CCU in the search for sustainable alternatives to existing market products or services. This growing interest from diverse stakeholders also promotes industrial symbiosis by bringing together CO_2 utilizers and producers, with the promise of both economic growth and a reduction of existing environmental burdens. In the context of energy transition processes, some CCU applications might provide new possibilities for storing energy. Furthermore, the implementation of CCU technologies could foster the transition to a circular economy by adding to an industrial carbon cycle.[1]

When assessing the potential environmental and economic benefits of CCU technologies, it’s important to remember that an adequate supply of competitively priced renewable energy is a prerequisite for both environmental performance and economic feasibility. Since the specific properties of CCU applications differ widely, they need to be assessed on a case-by-case basis. Life Cycle Assessment (LCA) and Techno-Economic Assessment (TEA) are effective tools for evaluating the economic, technical and environmental performance of an industrial process, service or product.[2] They are performed to achieve different outcomes: LCA studies investigate the environmental impact of one or multiple technologies, whereas TEA studies assess the costs of deploying a given technology, or delivering a product to market.[3]

[1] CO_2 Utilisation Today. Report 2017. EIT Climate-KIC, ENCO2RE and TU Berlin. Available at: file:///C:/Users/lcr/Downloads/CO2_utilisation_today.pdf; The circularity gap report 2019. Circle economy. Available at: https://www.circularity-gap.world/.

[2] Novel carbon capture and utilisation Technologies, 2018. Available at: https://ec.europa.eu/research/sam/pdf/sam_ccu_report.pdf.

[3] Techno-Economic Assessment & Life Cycle Assessment Guidelines for CO_2 Utilization, 2018. GCI and EIT Climate-KIC. Available at: https://www.globalco2initiative.org/2018/09/06/the-global-co2-initiative-at-the-university-of-michigan-publishes-valuable-toolkit-to-assess-co2-utilization-technology/.

2. Motivation and goals

A sound and comprehensive evaluation of the impact of CO_2 utilization technologies is essential to support decision-making by both private and public stakeholders. The CO_2nsitent project seeks to provide tools for such evaluation. Consistent evaluation tools will enable such technologies to contribute effectively to achieving a circular economy and climate targets. They are therefore a prerequisite for creating a customized and supportive policy environment. LCA and TEA studies are very helpful for decision-makers, as they allow them to assess the viability of CCU technologies and their possible contribution to emission reductions. In this way, stakeholders can evaluate and compare the impacts of different technologies (against each other and against established benchmark/market-dominant technologies) in order to make informed decisions about what projects to fund or support. To be assured of regulatory support, R&D funding and marketplace competitiveness, it is essential that the CCU technologies proposed to decision-makers can be shown to contribute meaningfully to the aforementioned objectives. While some guidance on CCU assessment is available (such as the ISO standards for LCA and the CO_2 utilization guidelines published by the Global CO_2 Initiative[4] – GCI), common methodologies are still lacking. This creates confusion among policymakers and decision-makers, who find it difficult to compare the results of studies based on different methodologies.

Such a quickly evolving area of study may be challenging for policymakers to navigate due to their different knowledge and skillsets in comparison to LCA/TEA practitioners. The CO_2nsistent project and the PHOENIX Initiative jointly hosted a workshop on October 1st 2019 in Brussels, bringing together policymakers, industry representatives, and practitioners to exchange ideas on the state-of-the-art of LCA and TEA for CO_2 utilization technologies and their future implementation in policy frameworks and the economic system. Eighty people, mainly from research bodies, industry, and regulatory agencies in Europe, attended the workshop. The event focussed particularly on what is currently lacking from the perspective of policymakers and industry, and how LCA and TEA practitioners can act to fill this gap. The activities organized during the event aimed at collecting suggestions and sharing viewpoints on how to provide clear guidance and support to policymakers. This included reflection on how best to support decision-makers from governmental bodies, academia, and industry in reading, understanding and commissioning TEA and LCA studies. During the morning session, selected speakers from the policymaking community, academia, and regulatory agencies presented their work. The afternoon was dedicated to interactive activities, such as a break-out session and a panel discussion aimed at formulating potential solutions by sharing expertise in different areas. The panel discussion was held at the end of the day to clarify some points of controversy and hear the standpoints of all participants.

[4] See: Footnote 3.

3. LCA and TEA for CCU in the European policy land-scape

The following section builds on the workshop contributions of Pieter-Willem Lemmens, Climate Policy Officer at the Department of Environment and Spatial Development, Flemish Government.

With the launch of the Innovation Fund, the Renewable Energy Directive II (REDII) and phase IV of the Emission Trading System (ETS), it is now more important than ever that decision-makers are capable of commissioning and interpreting LCA and TEA studies for CCU technologies. The capacity to assess the quality and information value of assessment results is essential for making the best use of scientific evidence in policymaking and avoiding inappropriate technological solutions and "lock-in effects" that may be detrimental to environmental causes or other societal objectives. A set of potential solutions has been explored by the German Federal Environmental Agency (UBA, 2019).[5]

From the left: Pierre Barthélemy (CEFIC), Sira Saccani (EIT Climate-KIC), Guillaume Coron (EC DG CLIMA), Horacio Hormazabal (AFNOR), Hans J. Garvens (UBA), and Pau Bonnetblanc (French Ministry for the Ecological and Inclusive Transition). ©Copyright: Iris Haidau

[5] UBA 26/2019: Support for the revision of the monitoring and reporting regulation for the 4th trading period - focus: Carbon Capture and Utilisation. Available at: https://www.umweltbundesamt.de/publikationen/support-for-the-revision-of-the-monitoring.

Recycled carbon fuels[6] (RCFS) may contribute to the 14% renewable target defined for road and rail transport under REDII, provided they meet the minimum GHG saving threshold of 70%. To this end, LCA is the most suitable and easy-to-use instrument to validate this threshold. The same is true for the Innovation Fund, where LCA-based approaches may and should be used to determine the environmental eligibility of future applications. Aside from environmental aspects, TEA is an essential tool to provide detailed information about the potential scalability and monetary aspects of a given technology, which are of keen interest to industrial partners, general investors and funding bodies. That said, during the workshop it was pointed out that TEA studies often show that current policy frameworks are inadequate to enable long-term revenues for the industry, even in the case of high-potential CO_2 utilization. The current ETS monitoring, reporting and verification rules (MRV) for assessing the CO_2 stored or emitted at plant level are insufficient to address all industrial processes developed by CO_2 utilization technologies. Here, too, harmonised LCA approaches for CO_2 utilization are required.

Photo from the 'World Café' breakout session. @Copyright Iris Hildau

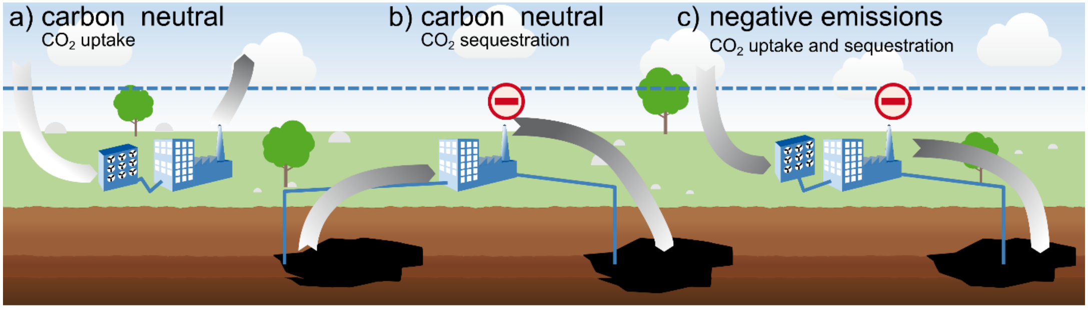
As currently regulated by the ETS MRV, CO_2 captured and utilized at industrial installations can be exempted from reporting in just three cases: i) if CO_2 is captured and reused within the installation where the CO_2 is generated; ii) if CCU is applied in an ETS installation that receives inherent CO_2 (i.e. not pure CO_2 but mixed in the flue gas) from another ETS installation; and iii) if the CO_2 generated is transferred and used for the production of precipitated calcium carbonate. In all cases, CO_2 emitted at the installation is calculated on a mass balance:

$$CC\ emitted = C_{in} - C_{out}$$

[6] "'Recycled carbon fuels' means liquid and gaseous fuels that are produced from liquid or solid waste streams of non- renewable origin […] or from waste processing gas and exhaust gas of non-renewable origin which are produced as an unavoidable and unintentional consequence of the production process in industrial installations." From: Renewable Energy Directive II, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC.

In all other cases, European carbon allowances (EUA) have to be surrendered. These reporting systems – which are applicable only to the aforementioned cases – lack a comprehensive framework to regulate all possible present and future ways of re-utilizing CO_2. The revision of the ETS MRV for Phase IV of the ETS (2021–2030) is currently ongoing and a new version will be released in May/June 2020. Different approaches to integrating CCU into the ETS MRV were discussed during the workshop. It became clear that simply reporting CO_2 released into the atmosphere on site might result in unaccounted for GHG emissions delayed in time (e.g. from the combustion of CCU fuels) or transferred and released in non-ETS installations. So, environmental integrity also needs to be considered in the future ETS. More specifically, we need instruments to quantify the extent to which CCU can contribute to the GHG emission savings described in the REDII or the Innovation Fund. LCA is useful when comparing the GHG emissions reduction potential of a given technology with available benchmark technologies, and helps to categorize that technology as carbon negative, carbon neutral, or carbon positive (Figure 1).

Figure 1. Case a) Carbon neutral CO_2-uptake: CO_2 is taken from the atmosphere and re-emitted after the product life cycle. Case b) Carbon-neutral CO_2 sequestration: Fossil carbon is taken from underground reservoirs and CO_2 is sequestered after product life cycle. Cases a) and b) are only carbon neutral if no emissions occur during the product life cycle. c) Negative emissions: CO_2 is taken from the atmosphere and sequestered after the product life cycle. Case c) will only have negative emissions if emissions over the entire life cycle are less than 1 kg CO_2-eq. per kg CO_2 uptaken. Source: Techno-Economic Assessment & Life Cycle Assessment Guidelines for CO_2 Utilization, 2018. GCI and EIT Climate-KIC (Source: Footnote 3).



4. The need for a harmonized approach

The following section builds on the workshop contribution of the CO_2nsistent Group.

Sira Saccani, EIT Climate-KIC
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One major drawback of current LCA and TEA studies is the lack of harmonized assessment practices. Studies differ in terms of how they handle uncertainties and assess system boundaries, the CO_2 sources, reference scenarios, and the multi-functionality of product systems. These methodological discrepancies often result in contradictory results,[7] and lead to confusion among practitioners as to how to conduct assessments. Although the problem is due in part to a lack of precise guidelines or regulation in the field of LCA and TEA for CO_2 utilization, the different interests of the studies' authors can also explain divergences. For example, an LCA study of a given technology carried out by a stakeholder primarily interested in investment opportunities may neglect some environmental aspects, while a broader analysis (with variable system boundaries, efficiency of industrial processes, etc.) might evidence larger environmental impacts for the same technology. Similarly, in TEA studies, the practitioner's assumptions and specified conditions (e.g. the goal and scope of the study) can have a significant impact on the outcome. Therefore, it is crucial to assess whether the conditions assumed by a given study fit the remit of the decision-makers and answer their questions. The workshop participants discussed efforts towards establishing European assessment standards (see section "LCA and TEA guidelines: European research efforts towards harmonization").

Another important factor in decision-making is how economic and environmental evaluations are synthesized. The integration of LCA and TEA will ultimately make it easier to identify existing trade-offs in order to gain a comprehensive overview of a given CCU technology. However, as long as these methods are not systematically aligned, synthesizing the results of economic and environmental evaluations will remain a challenge and lead to unreliable conclusions. The CO_2nsistent Project is actively working to address this issue.

[7] Artz et al., 2018. Sustainable Conversion of Carbon Dioxide: An Integrated Review of Catalysis and Life Cycle Assessment. Chem. Rev. 118, 2, 434–504.

5. Defossilization and CO_2 utilization technologies

The following section builds on the workshop contributions of Hans J. Garvens, German Environmental Agency (UBA), Thomas Fröhlich, Heidelberg Institute for Energy and Environmental Research (IFEU), and the CO_2nsistent Group.

As yet there are no national and international policies with clear guidance on how to assess GHG emission reductions due to CCU – a circumstance that could slow down the transition to a defossilized society. This section summarizes some of the issues that were raised during the workshop regarding the foreseeable use of these technologies and the application of methodologies for their assessment.

From the left: Horacio Hormazabal (AFNOR), Hans J. Garvens (UBA), and Pau Bonnetblanc (French Ministry for the Ecological and Inclusive Transition). ©Copyright: Iris Haidau

The following examples provide a quick overview of the complex challenge of meeting economic, political, environmental and social needs when deploying CO_2 utilization technologies in the real world. One crucial aspect to be aware of when applying LCA to a CO_2 utilization technology or product is the extent to which a comparison of global warming impacts (GWI) – a term that refers to net emissions – is feasible. A relative GWI reduction of a given technology means that its deployment would reduce emissions if it substituted the benchmark product, but would not eliminate them completely. Nevertheless, when comparing two CCU products or services, the one with lower anticipated emissions may be mistakenly presented as GWI negative. Furthermore, in addition to calculating the GWI, LCA studies should provide information on all other environmental impacts such as air, ground and water contamination as well as risks for human toxicity (see for example ISO14044). Currently, these aspects are largely unreported in evaluations and comparisons of technologies. This is a gap in research that needs to be promptly addressed. The deployment and dissemination of CO_2 utilization processes can also be either facilitated or hindered by the impact that such technologies have on societies (e.g. job creation), a factor that deserves further investigation through approaches described as “social LCA”.

From a broader climate perspective, the preferred option for reducing atmospheric carbon concentrations is avoiding additional anthropic GHG production (avoidance). This is justifiable because once CO_2 is produced, a lot of energy will be needed to reuse it, making this process rather inefficient. When avoidance is not feasible, attempts should be made to reduce CO_2 production. Some alternatives to conventional industrial processes have the potential to do this. In the construction industry, for example, using alternative clinkers could significantly reduce the carbon footprint of building materials. The efficient reuse of CO_2 should only be considered as a way of tackling emissions after all other options for avoidance and reduction have been exhausted. Here, more research is needed to understand how much of this material could be used, and how accessible other materials needed in the production process are. In the energy transition, the deployment of CCU must evolve in tandem with a rising share of renewables in the energy mix – i.e. additional capacity dedicated only to CCU has to be factored in. The risk that such technologies could, in fact, boost the utilization of fossil fuels is real and should be avoided at all costs.

6. LCA and TEA guidelines: European research efforts toward harmonization

The following section builds on the workshop contribution of Horacio Hormazabal, French Association of Normalization (AFNOR).

To guarantee accuracy, precision and easy comparison of results, precise guidance on how to perform LCA and TEA for CO_2 utilization technologies is urgently needed by the industry and political actors. In the case of existing and "under development" standardization groups on CCS (e.g. ISO/TC265: Carbon dioxide capture, transportation and geological storage), a certified standardization of CO_2 utilization assessment methodologies could help to achieve these requirements. Policymakers and members of European DGs present at the workshop also agreed on the benefits of applying clear and uniform rules for LCA and TEA and the need to align current guidelines rather than creating new ones. Importantly, the high financial cost of harmonization or even standardization by agencies such as AFNOR or DIN will probably require the robust financial support of industry or even the European Commission.

A standard is an established norm or requirement based on agreed performance criteria that is used as a reference to validate a certain product or service, applied at global or regional level. ISO (International Organization for Standardization) or CEN (European Committee for Standardization) could support CCU by prescribing technical standards that would support existing regulations and allow labels for CO_2-based products or services. There is no obligation to comply with standards, implement them or participate in their development. They are tools for market players to guarantee and enhance loyal competition, economic competition, quality recognition, comparability of performance, sound environmental assessment and minimize liability risk. Should a standard support the achievement of policy objectives, it could be adopted by public authorities at national or European level (i.e. voluntary agreement) as a valid alternative to taking legislative action. A standard could respond to self-regulation (e.g. by a group of business stakeholders) or co-regulation, depending on the specific policy objectives and context.

A few research projects are currently addressing the need to harmonize assessment methodologies such as LCA and TEA for CO_2 utilization in Europe and North America side by side with policymakers and industry representatives. This interdisciplinary approach represents the first effective steps toward the potential standardization of LCA and TEA methodologies for CO_2 utilization technologies. In the following paragraph we present a short overview of the structure and goals of three of the research projects that participated in and presented at the workshop.

6.1 The CO_2nsistent Project

The following section builds on the workshop contribution of Lorenzo Cremonese, Institute for Advanced Sustainability Studies (IASS).

The CO_2nsistent Project is a joint initiative with experts from the United States and Europe. The project team, which consists of groups from the University of Michigan, the University of Aachen, the IASS Potsdam, the University of Sheffield and TU Berlin, is engaged in further developing LCA and TEA for CO_2 utilization technologies. With funding from the Global CO_2 Initiative (GCI), the same partners published the first version of the "Techno-Economic Assessment & Life Cycle Assessment Guidelines for CO_2 Utilization" in 2018.[8] The second phase of the project started in April 2019 and is co-financed for three years by GCI and EIT Climate-KIC. In this new phase, the CO_2nsistent group aims to provide science-based guidance on the most relevant remaining challenges and develop technical solutions in close cooperation with an international panel of experts. The current focus is on expanding the first version of the guidelines in order to broaden and deepen their scope in the following areas:

- Harmonize key elements (e.g. vocabulary) of current international activities for CCU assessments;
- Enable practitioners to account for multiple criteria, for example by using combined indicators (e.g. CO_2 abatement costs);
- Provide guidance for meaningful low-TRL-stage and integrated LCA/TEA assessments required for investment decisions;
- Disseminate best practices for TEA, LCA and combined assessments among relevant stakeholders;
- Provide guidance for policymakers on how best to commission and use TEA and LCA studies in accordance with their needs.

The CO_2nsistent Group. ©Copyright: Iris Haidau

[8] See: Footnote 3.

As mentioned above, one important goal of the CO_2nsistent group is to provide clear guidance to policymakers on how to navigate the complex landscape of LCA and TEA tools as applied to CO_2 utilization technologies. One specific aim is to support decision-makers from government agencies, academia, and industry in reading, understanding and commissioning TEA and LCA studies. To this end, the CO_2nsistent group is currently involved in the preparation of the guidance document, **Making Sense of Techno-Economic and Life Cycle Assessment studies for CO_2 Utilization**. With a first version due in March 2020, this document is intended to support decision-makers by describing tools for the execution of LCA and TEA exercises and reporting, and underlining notions related to decision-making processes and needs: understanding, interpreting and commissioning CCU studies. A more comprehensive guidance report is planned in the second version of the full LCA and TEA Guidelines for CO_2 utilization, which are due to be published in March 2022.

6.2 The Joint Research Centre (JRC)

The following section builds on the workshop contribution of Robert Edwards, European Commission Joint Research Centre (JRC).

The Joint Research Centre (JRC) is the European Commission's science and knowledge service that provides scientific advice and support to EU policy. The JRC in Ispra (IT) is involved in the evaluation of CO_2 utilization technologies, in particular through LCA. The research team is advising DG CLIMA on how to assess GHG emission reductions under the REDII and for the Innovation Fund, with a focus on Renewable Fuels of Non-Biological Origin (ReFuNoBiOs) and Carbon Capture Fuels. For the latter, the method used in the Fuel Quality Directive was applied on two types of CCU fuels: i) Power-to-Fuels (electrofuels) that borrow CO_2, and ii) industrial exhaust-streams to fuels (e.g. blast furnace gas).

This research strand is needed since existing LCA standards for CCU (e.g. ISO) cannot be applied to European policy frameworks. This is because these standards still leave important methodological choices to the user and often yield ambiguous results, making them a questionable basis for decisions on legislation or funding. Despite differences in the sectors of application and foci, it is a common interest to align the Innovation Fund methodology to the one proposed in REDII and/or ETS.

6.3 The LCA4CCU Project

The following section builds on the workshop contribution of Aïcha El Khamlichi, French Environment & Energy Management Agency (ADEME).

The Project LCA4CCU is funded by the European Commission's DG Energy and is intended to provide general guidance on LCA for CCU with a special focus on observed limitations and typical pitfalls. Topics include: i) attribution of impacts; ii) co-products and multi-functionality; and iii) double counting of emissions. The recommendations that the group develops will build on existing and undisputable state of the art in LCA. This project also wants to focus on questions that are still debated among practitioners and require consensus, such as systemic effects or the prerequisites for a thorough evaluation of CCU systems. Among others, it will address the following questions: which phase of development has the technology under investigation reached? What is its main purpose (e.g., GHG emission reductions, cost reductions, etc.)? And who is the main actor that we need to address (politicians, investors, etc.)? The project is planned to run for about one year, with the first draft of the report expected October 2019 and a final version due by December of the same year.

7. Perspectives from the workshop participants

To enhance interaction among the workshop participants and gather a wide range of inputs based on their broad spectrum of expertise and experience, a breakout session along the lines of the “world café” method was organized. The participants were divided into three different groups, each of which was equipped with a table and blank posters to document and report on the principal topics of discussion and findings. After a set period of time, participants were asked to switch tables in order to share their viewpoints and experiences with a different group. In the following paragraph we present an overview of the material that resulted from this exercise.

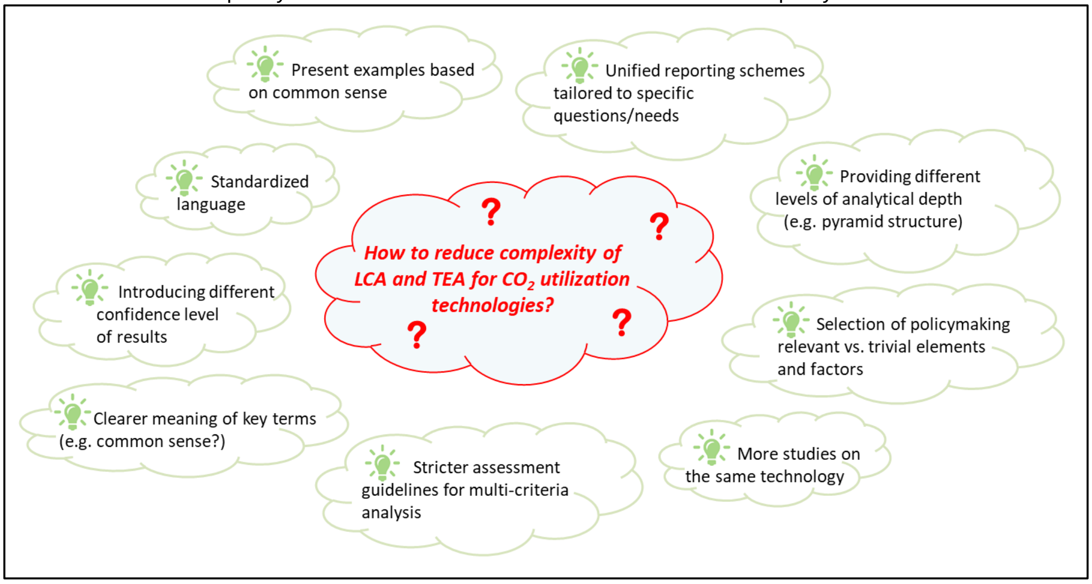
Photo from the 'World Café' breakout session. ©Copyright: Iris Haidau

7.1 Table 1 – CO_2nsistent Guidance Report – How can we translate assessments into policy language?

At this table the participants focussed on how to improve the effectiveness and quality of information transferred from practitioners to policy- and decision-makers. The inputs gathered at this table on narratives, language barriers and policymaker mindsets were particularly useful for the guidance document for policymakers (Making Sense of Techno-Economic and Life Cycle Assessment studies for CO_2 utilization) that the CO_2nsistent group plans to publish in March 2020.

Participants highlighted the importance of providing evidence for why and how CCU can help in the climate crisis, and what implications we can already envision for the future industry and economy at national level. There was broad agreement among the participants that, from a content perspective, policymakers do not generally have a lot of confidence in LCA studies. This is a crucial problem that the scientific community should be aware of and need to address in order to maximize interaction with policymakers and transfer know-how into the political sphere. For assessments to be translated into policies, it may be very useful to elaborate key aspects of LCA and TEA studies, such as goal and scope, and develop several examples. With regard to the language used in LCAs and TEAs, participants generally agreed that standardized terminology is a simple but effective way to ease the comprehension and comparison of different studies. A single study will very likely not be enough to lead to a political decision, but several (and comparable) studies of the same technology or a technology portfolio are needed to obtain accurate and unbiased results. A uniform methodology that ensures comparability not only in the assessment itself but also in the reporting for policymakers was therefore another critical point that emerged in the discussion. This does not mean that practitioners have to simplify their assessment, but for the purposes of communicating the results, the level of complexity could be reduced, for example by identifying those aspects that are most relevant for decision-making (i.e. exclusion cut-off criteria for LCA and TEA). Different amounts of information and details might be filtered from the assessment studies according to the level of accuracy the reader wants to achieve, for example through unified reporting schemes tailored to the questions and needs of the final users. Defining a "sufficient" confidence level of results (e.g. 90% of certainty) could be another way to determine the quality of results as a basis for further decisions. As an additional communication/translation tool, the concept of a pyramid showing different levels of analytical depth has been proposed; this could include an indicative LCA or TEA assessment (a "rule-of-thumb" approach) based on the combination of relevant elements of a technological process. These elements could be the technology assessed, the final product, and the source of CO_2 considered. With regard to how to properly set up a methodology to ensure best practice, a step-by-step guide with the support of decision trees has been proposed. A simplified summary of all these solutions is shown in Figure 2. Overall, the discussion showed that gaps between the language of practitioners and policymakers/decision-makers exist and tools are needed to help practitioners translate the results and guide policymakers in the decision-making process based on LCA & TEA studies.

Figure 2. Schematic visualization of some options discussed at table 1 (world café method) on how to reduce the complexity of LCA and TEA submitted to decision-makers and policymakers.



7.2 Table 2: What support is needed by policymakers/decision-makers and how can we address it?

People at this table discussed what regulatory frameworks or funding initiatives require technical support for CO_2 utilization technologies in order to ensure accurate evaluation and effective deployment of these technologies.

The participants considered it necessary to foster a general understanding of the specific attributes of CCU technologies among politicians and other decision-makers. First of all, it has to be clear that CCU is only one piece in the climate mitigation jigsaw. Policymakers need additional support and advice with regard to CCU. They would find it helpful to be presented with several deployment options with clearly reported upsides, downsides, and comprehensible conclusions. It was generally agreed that having LCA and TEA experts report the results of such assessments in relatively jargon-free language would be the best strategy to follow. This approach should be part of a concerted effort to communicate more intensely with policymakers and decision-makers, for example, by involving them more often in the process of carrying out LCA and TEA. Such close cooperation could contribute to the development of a comprehensive, interdisciplinary approach to CCU, and would help practitioners to understand other relevant drivers beyond environmental and economic aspects (e.g. political, social, etc.) that policymakers have to take into account. Some participants pointed out that, while this might be helpful, a distance from the political and decision-making spheres has to be maintained to ensure the independence, transparency and trustworthiness of the research process.

Photo from the 'World Café' breakout session. ©Copyright: Iris Haidau

It was also agreed that more clarity on what LCA for CCU can and cannot achieve is probably needed (e.g. decision trees). This led to a discussion of methodology harmonization and the preconditions necessary for that. The following points were seen as particularly important:

- Develop a common terminology. Standardization of vocabulary around LCA and TEA for CCU was recommended;
- More exchange of ideas to 'sharpen' the community's thinking. Events and meetings for this purpose should be run systematically;
- Agreement on system boundaries. There is still no complete agreement among practitioners on how to define and apply system boundaries. Moreover, there is still a lack of understanding among non-technical audiences of the climate implications of applying different system boundaries;
- Use the most widely-accepted background data for marginal energy and future energy scenarios. The participants were also divided on the question of how to define the scenarios that underlie a specific technology. Different background scenarios would in fact lead to different conclusions for the same case study, and would therefore make direct comparisons difficult between studies of the same technology. Several solutions to this problem were proposed: for example, one standardized scenario could be included in all studies in addition to more context-specific scenarios. Furthermore, providing short- and long-term scenarios for a certain technology would make it possible to evaluate initial impacts as well as their evolution over time. However, the participants highlighted the risk of deploying unrealistic scenarios (e.g. too ambitious in terms of the green power available) that would distort impacts.

The participants were generally in favour of developing standards, but were concerned about the implications that this may have for the competitiveness of European products. Nevertheless, before standards can be designed and implemented, pilot cases still need to be consulted. The participants also proposed solutions for making CCU assessment tools better and more user-friendly. One relates to the development of databases as a repository of calculations (e.g. for carbon capture) and successful examples from industry to facilitate the application of proposed future standards.

With regard to the implementation of RED II, industry and other actors are particularly interested in the evaluation methodology soon to be proposed by the European Commission, where questions are still open. Concerning the future Innovation Fund, the participants emphasized that not only the research and development phases should be supported, but also funding mechanisms for operational expenditure (OPEX) and scaling up the technology. These would significantly ease the market entry of a specific innovative technology.

7.3 Table 3: How can standardization of TEA and LCA help?

The discussion at this table focused on the standardization of LCA and TEA methodologies for CO_2 utilization technologies. Particular attention was paid to the question of how to harmonize different assessment approaches, and which national and international standardization pathways are desirable.

The term standardization itself was confusing for some participants, as it was not clear to them how standardization relates to governmental regulations, or whether it is rather a collection of best practices recommended by the industry. They suggested that it would be better to use the term "harmonization" in the context of LCA and TEA for CCU. Nevertheless, the participants still discussed the advantages and limitations of setting an LCA-TEA methodological standard. It was thought that a certified procedure may build confidence in the results, and also provide reliable legal frameworks for standardization. The limitations related to the uncertainty regarding the inclusion of future technologies and reference systems that are rather difficult to predict. This may make continuous updates of a harmonized methodology necessary.

Most of the participants agreed that product-specific standards increase confidence within the product category, while generic standards can only influence its overall confidence. Nevertheless, an "umbrella structure" with generic standards but multiple specifications for product categories may be a feasible solution. In addition, the participants suggested that although the creation of standards will very likely be led by a standardization organization in collaboration with industry, future users should also be involved in this process to ensure that their interests and wishes are addressed from the beginning. These actors should also be involved in successive updates of the standard to comply with the systematic innovation of technologies. Nevertheless, concerns were raised about the updating procedures: even if an update is required, this should not compromise the reliability and relevance of previous studies. The persistence and reliability of past and parallel references has to be guaranteed. Once a methodological standard is put in place, labelling organizations, certification bodies and external critical reviewers should check compliance with that standard and then certify. The participants also raised the point that developing standards for LCA and TEA that satisfy the interests of both industry and policy may be significantly challenging.

Photo from the 'World Café' breakout session. ©Copyright: Iris Haidau

8. Outlook

The workshop “Towards a common understanding of LCA and TEA for CO_2 utilization technologies” organized by the CO_2nsistent Project and PHOENIX aimed to bring together industry experts, practitioners and policymakers. This meeting enhanced the participants’ understanding of the pitfalls and potentials of LCA and TEA for CO_2 utilization technologies. As a result, a shared baseline on the next steps and possible solutions was defined. An event modeled on the “world-café method” and an informal, extensive Q&A session facilitated mutual learning. The active participation and feedback provided by decision-makers and policymakers testified to their strong interest in the research questions that were the focus of this workshop.

The workshop underlined that much still needs to be done in the complex field of CO_2 utilization, environmental and economic assessment methodologies, and at the interface of decision-makers and practitioners. The workshop gave the organizers a unique opportunity to assess the “common denominator” in the understanding of many aspects of LCA and TEA for CCU and to identify areas where a shared understanding is still to be attained. The discussion underlined the urgent need for European regulators to provide a policy framework, for example in the context of the ETS, REDII and the Innovation Fund, with aligned prescriptions and clear procedures for LCA and TEA for CCU. The preconditions for the harmonization of methodologies thus need to be investigated. The proper adoption of system boundaries, clear definitions of technical terms, and a lower complexity of assessment to facilitate understanding by non-practitioners are important issues here. Furthermore, all stakeholders need to be aware of the intrinsic limits when comparing LCA and TEA studies. Transparency in technology comparison must be guaranteed by precise procedural guidelines. To develop and tailor solutions to the challenges and drawbacks identified at the workshop, close, regular and structured communications between policymakers and practitioners are vital. All of these considerations, gaps and suggestions will be taken into account by the CO_2nsistent group when planning and implementing its upcoming plan of action.

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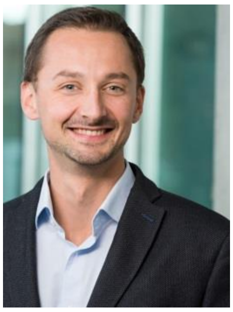
9. About the authors



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Institute for Advanced Sustainability Studies e.V. (IASS)

Funded by the ministries of research of the Federal Republic of Germany and the State of Brandenburg, the Institute for Advanced Sustainability Studies (IASS) aims to identify and promote development pathways for a global transformation towards a sustainable society. The IASS employs a transdisciplinary approach that encourages dialogue to understand sustainability issues and generate potential solutions in cooperation with partners from academia, civil society, policymaking, and the business sector. A strong network of national and international partners supports the work of the institute. Its central research topics include the energy transition, emerging technologies, climate change, air quality, systemic risks, governance and participation, and cultures of transformation.

IASS Workshop Summary

Towards a common understanding of LCA and TEA for CO_2 utilization technologies

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