IEAGHG Information Paper 2016-IP50; Update on business opportunities in CO_2 utilisation

The Carbon Capture Journal organised an event on 28th November at the Geological Society in London, with the aim to explore whether a CO_2 utilisation industry could help drive a carbon capture industry. More than 60 participants from a variety of backgrounds (i.e. industry, academia, NGOs, GOs, consultancies) attended the meeting.

Hans Bolscher, Senior Consultant at Trinomics, was the first speaker and gave an introduction to the potential and hurdles for carbon capture and utilisation (CCU). A reality check reveals that there is currently no business case for most CCU options, apart from a few exemptions. It should not be about CCU vs carbon capture and storage (CCS) but about doing them both reasonably. Whereas the overall potential for CCS is much bigger, CCU seems to have a higher likelihood of implementation at the moment, taking into account that for some countries geological CO_2 storage is a no-go. However, CCU is not a significant means of climate change mitigation, it is more about alternative carbon and raw material sources, as we likely won't be able to make chemicals and materials from fossils forever. Although the ide of a circular economy goes down extremely well with policy makers, Hans cautioned that in reality it will be a very expensive dream, which will be in addition highly dependant on renewable electricity and/or hydrogen. Another challenge is the intermittency of the required renewables input, as current chemical plants are usually designed to run continuously, 24/7, so new design and operating concepts would be necessary. Hans then moved on to share his view on the feasibility of specific CCU pathways. Mineralisation appears to be underestimated and is one of the options that is closest to market. Fuel production via hydrogen will be very expensive but benefits from an easy implementation due to the existing infrastructure. At least in the short to medium term. In the long term, combustion engines might be phased out, so investing in this leg could result in a lock-in. Making chemical building blocks is already technically feasible and can come with environmental benefits if they replace nastier process routes (think phosgene). However, more policy support and incentives would be required, and without them, neither CCU nor CCS will be feasible.

An update on making aggregates (building materials) from waste and CO2 was provided by Colin Hills, Technical Director at Carbon8 Aggregates. These mineralised aggregates are valuable, as they avoid the potential concern of liquid or gaseous CO_2 storage, due to their high stability. Among the different existing mineralisation options, a business case based on waste treatment currently seems to be the option that is easiest to implement. Any approach, however, needs to consider the end of waste requirements, such as fit-for-purpose product, market need, risk management, suitable replacement. Carbonated aggregates are now in their 5th year of commercial use, with two plants running in the UK. Opportunities for further expansion and improvement exist, as a variety of different waste streams would be suitable. According to Colin it will be important to keep in mind that the carbon content in the different carbonated materials can vary when assessing potentials. Another upcoming approach is to mix the carbonated aggregates with biomass, e.g. woody materials. This can optimise the heat properties of the resulting building material as well as deliver negative emissions if the biomass is sustainable. Current challenges for these mineralisation technologies are that there is no market advantage for low-carbon building materials and that the supply of cheap CO_2 is limited. A lot would need to be done in the field of policy and regulations to accelerate implementation of waste mineralisation, e.g. level playing field, review of materials standards, landfill taxes, end of waste requirements.

CCm Research have developed a solid, pelletised, nutrient-enriched fertiliser from biogenic cellulosic material and waste CO2 that comes from the combustion of land fill gas (LFG). Pawel Kisielewski and Peter Hammond, CEO and CTO at CCm Research, introduced the basics of the process and stressed it is profitable on a standalone basis without government subsidy. Compared with a reference system

(conventional fertiliser) less of the CO_2-based fertiliser is needed to achieve the same crop yield. Research on the quantification of soil carbon sequestration for the new systems is ongoing, so the jury is still out. However, in general CO2 sequestration in soil from fertilisers is not that large, the main benefits come from replacing conventional fertiliser (with a footprint of 5-7 tCO_2/t) and avoiding methane emissions due to collection and combustion of LFG. A limitation of the process is the availability of nitrogen, so the efforts are aiming at sourcing it from waste materials rather than the industrial market. Impurities are generally not a big issue, only larger amounts of heavy metals could be an issue in terms of product quality.

Next, Katy Armstrong, CO_2Chem Network Manager at the University of Sheffield, presented on the understanding of CCU from a policy perspective. The complexity of CCU pathways is further exacerbated by the different viewpoints on CCU, even within the community, which can give rise to issues when discussing CCU's potential. Although technically feasible, synthetic fuels from CO_2 are not economically viable yet. Assessments of how much CO_2 we can use vary greatly, spanning a range from 300 Mt/yr to 7 Gt/yr. More agreement exists on the supply side, i.e. there are plenty of CO_2 sources available. Regarding the question on how CCU fits into the EU Emissions Trading System (ETS), Katy replied this would be very hard and complex, and mineralisation would be the only recommended option for inclusion due to its permanence of CO_2 sequestration. For a potential inclusion in the Fuel Quality Directive (FQD) and Renewable Energy Directive (RED) comprehensive life cycle assessments (LCAs) and techno-economic assessments (TEAs) with the broadest possible boundaries would be necessary to identify suitable candidates. Those assessments are however lacking for almost all CCU options today. According to Katy's personal opinion, CO_2-derived fuels should not be used in personal transport but only for mitigation in sector that are challenging to decarbonise, such as aviation and shipping.

Mark Lewis, Low Carbon Manager at Tees Valley Unlimited, discussed the CCU option for Teesside. The good news is that the clustering activities at Teesside can deliver both CCS and CCU as complementary solutions. Currently, the most practical CCU options for Teesside are mineralisation, synthetic fuels, commodity chemicals and specialty chemicals. The Teesside Collective and Tees Valley Combined Authority are working together with engineering companies, like Costain, on a CCU demonstration and have identified Carbon8 Aggregates, CCm Research and Novomer as potential candidates for supplying the technology. The next step will be to set up a dedicated CCU demonstration centre.

Skytree's Co-founder Max Beaumont gave the last presentation, introducing his company's business model. Skytree is a spin-off of the European Space Agency (ESA) developing and commercialising direct air capture (DAC) technology for CCU. Challenges they need to overcome are the relatively high energy demand for CO_2 capture from air compared with other capture technologies, scaling issued and the high costs of the process, making it uncompetitive for industrial CO_2 supply. Thus, Skytree is focussing on the urban farming sector as a first application and is currently working on a proof-of-concept (500 g/d) for launch in January 2017. Key aspects of the design include a plug-and-play design, continuous delivery of CO_2, and independence in terms of location. The capture process uses an amine-based ion exchange resin with a lifetime of 3-5 years and a cost of 8-16 €/l. Next steps include various improvements, e.g. the preventing the off-gassing of amines, improving the resistance towards pollutants like cigarette smoke and increasing the certainty of the energy consumption predictions. The ultimate aim is to scale the technology up to 1000 t/d.

During the final discussion it became apparent, as mentioned by some of the presenters before, that the CCU community does not have one voice. Some participants also made reference to a noted recent language of battle between CCS and CCU, which might be down to a struggle for popularity and

funding. Thus, different views were voiced whether CCS and CCU should share a common narrative. The only or main argument for CCS is climate change mitigation, whereas CCU can have various different benefits, often not including large climate benefits, but rather jobs, innovation, circular economy, resource and energy efficiency. This situation is exacerbated by creating and using the term CCUS. Merging CCS and CCU might not be the best idea as they refer to completely different approaches. The conclusion was that CCS and CCU will likely require different narratives. However, both should be complimentary, work together and be part of the solution.

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