



## IEAGHG Information Paper 2016-IP53: 5<sup>th</sup> Conference on Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers

The 5<sup>th</sup> Conference on Carbon Dioxide as Feedstock for Fuels, Chemistry and Polymers took place from 6<sup>th</sup> to 7<sup>th</sup> December in Cologne, Germany. The event was organised by nova-Institut and IEAGHG is a partner organisation of the conference series.

The first day started with some introductory talks and a long session on policy and visions, which are maybe the most important areas of work currently for carbon capture and utilisation (CCU).

Issam Dairanieh (Global CO<sub>2</sub> Initiative) presented on the work of the Global CO<sub>2</sub> Initiative, which consists of two organisations: CO<sub>2</sub> Sciences and Investment Vehicles, with the first having raised ca. €50 million so far. Although some CO<sub>2</sub> products are ready to go to market, the majority are not. On the way to commercialisation a unique set of tools will be required, including market assessments, environmental impact assessments, cognitive computing, lifecycle assessments (LCAs), techno-economic assessments (TEAs) and roadmaps. Market assessment of building materials and chemicals is a current priority of the initiative.

Ted Grozier (Climate KIC) and Niklas Meine (Covestro) gave an update on current projects. The vision of the ENCO<sub>2</sub>RE project is to use waste CO<sub>2</sub> for utilisation and sees this area as an opportunity for EU leadership. Climate KIC, as the EU's largest public private partnership (PPP) addressing climate change, assists with this. Covestro is currently commercialising its cardyon® technology, a polyol based polyurethane foam with a content of 20% reused CO<sub>2</sub>. They also started the CroCO<sub>2</sub>PETs project that aims to make cross linkable polyether polyols with 25% reused CO<sub>2</sub>. They see the unique selling point (USP) of these products clearly as technology innovation, rather than climate change mitigation. Knowledge sharing within these activities is almost more important than anything else.

The next speaker, Reinhard Büscher (EC DG Growth), stressed that due to ever stricter market conditions and environmental legislation, real game changers are required now for compliance. CCU will only be viable under very specific conditions, and this will partly depend on the degree of system relevance of the chemical industry. With regards to a potential inclusion of CCU in the EU Renewable Energy Directive (RED) and Emissions Trading System (ETS), there will be a price to pay and that is extensive LCAs and/or impact assessments. On the other hand, CCU can be a huge opportunity for revenue streams in energy intensive industries (EIs), and thus the European Commission (EC) is increasingly capitalising on CCU in terms of energy storage and feedstock security.

Søren Bøwadt (EC) provided some additional perspectives from the EC's point of view. A lot of member countries are interested in CCU. The EC's main objectives are triggering growth and jobs while building a sustainable economy and society. Several tools are available to help reaching this, e.g. strategic energy technology (SET) plan, circular economy package, H2020, and PPPs. The EC has already organised two workshops on CCU. However, a large scale integrated EU initiative is now necessary to defragment the existing activities. A €1.5 million prize for CO<sub>2</sub> utilisation has just been launched under H2020, for a start at the end of 2019.

Helmut Löwe (BMBF) presented on the three funding opportunities in Germany: the high tech strategy, the resource efficiency programme II, and the sustainable development framework (FONA<sup>3</sup>). CO<sub>2</sub>Plus covers the topics chemicals & polymers, electro-/photocatalysis, and CO<sub>2</sub> separation, with €17.5 million (plus an additional €5 million from industry) available for funding until 2019. A



requirement is that the projects undertake an LCA as part of their R&D. CO<sub>2</sub>Form will look into the direct production of formaldehyde (current market ca. 13 Mt/a) from CO<sub>2</sub> via acetal formation. CO<sub>2</sub>Lubricants will investigate biotechnological production of lubricants from micro algae and oil yeasts. eEthylen will cover direct electrochemical synthesis of ethylene (market ca. 150 Mt/a) from CO<sub>2</sub>. Finally, CO<sub>2</sub>Selekt will look into the capture part, i.e. the separation of pure CO<sub>2</sub> from hot and dust loaded industrial gases. BMBF have learnt their lesson in terms of public acceptance of carbon capture and storage (CCS), so dissemination and public engagement will be vital parts of all projects. Next, Peter Styring (University of Sheffield) presented on the value of CO<sub>2</sub> as a building block for the chemical industry. Carbon capture is currently the cost limiting step for CCU. Processes based on pressure swing (PSA) can be more favourable in terms of total energy consumption than temperature swing (TSA). However, PSA produces a relatively impure CO<sub>2</sub> stream, compared to TSA. Direct air capture (DAC) is not cost competitive at the moment but might be an alternative in the future. Selecting the location for CCU will be key, as it will largely affect availability of CO<sub>2</sub>, H<sub>2</sub>O, H<sub>2</sub>, etc. Because H<sub>2</sub> still comes mainly from steam methane reforming (SMR), there is a need for change if one wants to have a genuinely sustainable and carbon negative process. Overall, single processes only give part of the picture, so it is necessary to consider the whole supply chain. Fuels from CO<sub>2</sub> will also play a role in long distance transport, as batteries will likely be too large and heavy in this area. A very promising option could be accelerated mineralisation, which uses mining waste, produces usable waste heat and usually works with raw flue gas.

For the cement industry it will be mandatory to deploy CCS/CCU to reach the 2050 targets of the Cement Sustainability Initiative's (CSI) roadmap. CCS will be inevitable for full decarbonisation of cement, and CCU can significantly contribute to the goal. Several projects are underway, e.g. CAMCAP and LEILAC, which is building a 10 t/d pilot plant with Calix's MgO process in Belgium. Another demonstration project using Carbon8 technology is taking place in Tallinn, Estonia. The cement industry is further investigating natural mineralisation options, such as using basalt, olivine or steel slag, and putting them 1,200 m underground to decrease the reaction time to 1 h. Another approach includes growing micro algae on cement flue gas and producing fish feed (potential market ca. 16 Mt/a), preferably in solar rich locations to decrease costs.

Damian Dallemagne (GreenWin) reported on the aim to create a EU association on CCU. For the way ahead, collective action across sectors and along the value chain will become more and more important. The ambition is to become the reference organisation and voice of the CCU community and to build a large EU PPP until June 2017. Contributions are €15,000 for large and €5,000 for small organisations. 26 parties have already joined the founding consortium.

For Greenpeace, stopping climate change is priority, as Michael Keiffenheim (Greenpeace Energy) informed the audience. However, the actual speed of Energiewende (energy transition) is too slow to meet the Paris Agreement. Until 2040, non renewable energy consumption would need to go down to zero, energy efficiency improve dramatically and coal to be phased out. Energiewende will not work without Windgas (power-to-gas), so Greenpeace Energy is installing and operating electrolyzers with surplus renewables and selling the resulting Windgas to its customers. However, Germany would need around 80 GW of electrolyzers in the next decade to be up to the challenge. Renewable H<sub>2</sub> is seen as the currency of Energiewende. It is better in terms of costs and environmental impacts than CH<sub>4</sub>, so would be a good way to start with. Later on, CH<sub>4</sub> could be introduced as well, as it is better in terms of grid compatibility and energy storage capacity.

Michael Carus (nova-Institut) reminded the audience that technology processes can be much more efficient than natural ones, so there is hope in meeting the ambitious climate change and sustainability



targets. 94 supporters have signed a petition launched by nova-Institut to include renewable CCU (rCCU) in the EU RED. This approach is not well received by other organisations, e.g. Bellona. It would be important to keep in mind that EC decisions are generally based on science but could also be influenced by lobbying and public pressure.

The last speaker of this session was Christian Schweitzer (bse engineering), who presented on CCU for waste-to-energy (WtE). bse is currently pursuing various projects for methanol (MeOH) plants up to 100,000 t/a. Megatrends post-2020 will be: low carbon economy, circular economy, resource efficiency and re-industrialisation. In Germany, WtE plants are under threat, as they receive no fixed feed-in tariff and they must feed in their power even at negative prices. WtE with MeOH might help alleviate this situation. However, the investment cost for expanding a plant with CO<sub>2</sub> separation, electrolysis, MeOH synthesis and distillation is costly, i.e. €20 million for a 10 MW WtE. A first demonstration of a 10 MW plant is planned for 2019, using Aker technology for capturing the CO<sub>2</sub>. This pathway, however, might be limited by the availability of waste in times of ever increasing recycling quotas.

The first day closed with a more general panel discussion with all speakers. A main question was, without a clear answer though, what instruments are needed for the next steps in CCU? Several participants noted it was refreshing to see the diversity of CCU technologies and remained confident some worthwhile options were among them. No matter what technologies will go forward first, it would be very important to work together with industry as closely as possible. Others noted there would be no alternative to driving future society with solar energy, fuels and products. A large discussion with different viewpoints developed around the branding and marketing of CO<sub>2</sub> based products. Key questions in this regard were: How to increase interest in those products? What price increase would the consumer accept? Is CCU striving for mass acceptance or premium niches? Someone remarked in terms of public acceptance it might be better not to market the CO<sub>2</sub> content. Maybe CCU would need to find niche markets, where the CO<sub>2</sub> was invisible but the product still profitable. Agreement existed on the fact that there was enough CO<sub>2</sub> available from the industrial sectors alone, so CCU would not be dependant on efforts of CO<sub>2</sub> capture in the power sector. Then, there was a quick survey about what would likely be the hottest CCU product in the next decade. Promising candidates were CO<sub>2</sub> based kerosine, ligno-cellulosic ethanol (EtOH) and carbonated aggregates (not really hot but a large market). Learning from the experience with biofuels, proper and timely LCAs and sustainability criteria for CCU would be required for identifying those options that would lead to genuine CO<sub>2</sub> reductions. Currently, there was a lack of reference systems for anything other than fuels. In addition, results needed to be communicated very carefully, in order to not make any unsubstantiated claims. Finally, it would be necessary for industry to position itself with regards of CCU and for capture costs to fall well below 60 \$/t.

The remaining sessions of the conference went into more detail on the technological progress made in artificial photosynthesis, CO<sub>2</sub> based chemicals and polymers, and CO<sub>2</sub> based fuels.

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