SUMMARY

CO_2 RE-USE WORKSHOP

DG JRC and DG CLIMA

INTRODUCTION

The Joint Research Centre of the European Commission, Institute for Energy and Transport, and the Directorate General for Climate Action co-hosted a workshop on CO_2 re-use technologies in Brussels on the 7th June 2013.

The aim of the workshop was to present how the most promising pathways for CO_2 re-use are related to climate and energy technology policies, facilitate a dialogue between stakeholders (industry, academia and policy makers) and address the challenges for a possible large scale roll-out of CO_2 re-use technologies. A number of sSeven presentations from experts focused on the state-of-the art of the technology, the needs of the sector for large scale deployment and the impact of the CO_2 re-use products on the market. In particular, the workshop focused on three promising pathways, i.e.namely, methanol production, mineralisation and polymer production.
The workshop introductory session provided the framework for the following presentations and sessions of discussions on CO_2 re-use.

- A panoramic overview on the current state of play of CO_2 re-use technologies in the European Union was given. Science and research will be instrumental to understand the challenge in this respect.

- DG Research and Innovation Directorate Industrial Technologies (DG RTD) addressed the CO_2 challenge in the Horizon 2020 framework and the way in which it will include interesting possibilities for CO_2 innovation.

- CO_2 should be perceived as a valuable resource. CO_2 re-use technologies may achieve a reduction of greenhouse gases and foster innovation. However, CO_2 re-use is a niche application. The large scale deployment of Carbon Capture and Storage continues to be the priority for the decarbonisation of the European economy.

- CO_2 re-use technologies may provide revenues to cover some parts of the costs of CO_2 capture. The Commission is very open for discussions with the stakeholders both at a multilateral and bilateral level in order to understand and address the specific and individual challenged faced by the different sectors and technologies.

- CO_2 re-use is an option and one of several technological pathways for reducing CO_2 emissions. It will by no means substitute geological storage of CO_2. Horizon 2020, being one of the strongest and most important instruments in order to enhance innovative approaches and climate change mitigation will offer R&D opportunities for CO_2 technologies.

Three technological pathways were chosen for in-depth analysis in particular and addressed the following aspects:

- State-of-the art of the CO_2 re-use technology

- The impact of the CO_2 re-use product on the energy system and related markets

- The needs of the sector for large scale industrial deployment and links with other technologies

- The current framework concerning the Fuel Quality Directive, Renewable Energy Directive and the ETS.

TECHNOLOGICAL PATHWAYS

Renewable methanol: A presentation by Carbon Recycling International (CRI)

The hot water from geothermal plant in Iceland contains carbon dioxide (CO_2) and hydrogen sulphide (H2S). The CO_2 is captured, cleaned and combined with hydrogen (H2). The CO_2 that would have been released to the atmosphere is captured and bound to the hydrogen. Vulcanol has been chosen as the brand name for methanol as a product and brought to the market. The replacement of fossil fuels enhances the CO_2 emission savings considerably. CRI has tested high Vulcanol blends in Flex Fuel Vehicles (E85) which requires no modification. The next phase is the production of electro-fuels and the conversion of renewable energy into a liquid fuel that will lower the CO_2 footprint.

It is possible to convert methanol to both gasoline and diesel. The use of hydrogenation in the renewable methanol production provides an added value to the decarbonisation of the transport sector. In Iceland, energy and feedstock are available and can be locked in with long-term contracts for power and other utilities. Scale-up and sustained operation of production plant has been demonstrated under industrial conditions. Scale-up risk is contained and predictable. The technology is cost competitive and has a scaling potential which will impact the market over a long term horizon. In the medium term, producers are price takers based on current economics of 1st generation biofuels. The technology is cost competitive and has scaling potential which will have impacts on the market over a long term horizon. However, the main challenge for deployment of technology in mainland EU is to compete with feed-in tariffs and RED framework for electro-fuels. The value of CO_2 reductions is not taken sufficiently into in the legislative framework nor by the market. The current framework does not promote in a satisfactory manner the development of non-biological sources. The current quadruple counting is a good incentive but does not translate into a quadruple price. In order to convert cars to run on methanol, the practical solution is simple to implement and costs are estimated at $100 per new car. The engine control is a marginal problem and can easily be modified. However, current legislation for gasoline does not address this opportunity and the blending rate for methanol allowed is too low.

Question and answer session

Internal renewable methanol consumption in Iceland: Need to convince the oil companies and provide the right incentives.

Scaling could bring revenues: Need to make the same components many times. Scaling up the technology could bring more revenues by just replicating the production and multiplying the technological units without involving any further R&D challenges.

Energy efficiency: The use of oxygen, now vented into the atmosphere, can improve the energy efficiency and the economics of the process.

Polymer development: A presentation by Bayer

Bayer is currently developing raw material for Polyurethanes using CO_2, branded as "Dream Production". This project has an overall volume of 9 M€, accounting for nearly half of the CO2rrect project total sum funding (18 M€). Energy is scarce and in particular when the production of polymers from CO_2 is competing with materials produced with a fossil base. The polymer related industry has to take this scarcity into account and look for sustainable solutions that are marketable and useful for the customer. The importance is the use of the right catalyst for this process. The production of petrochemicals requires significant amounts of energy. For instance, the epoxide can be reduced in this new approach. This is the amount of epoxide usually associated with petrochemicals. The integration of CO_2 as a raw material is assessed using a pragmatic approach considering the reasonable amount of CO_2 in the product.

The technology fits into the existing markets and there is a window of opportunity if additional efforts are taken by policy makers as well as industries. The reduction of the carbon footprint with regards to conventional technology is considerable and the material can be perceived as more sustainable. However, the process is in its very beginning and there is a need for incentives and investment. The polyurethane market is considerable and differs from other related markets. There are considerable efforts to be made in order to address the "valley of death" issue. It is important to start piloting projects with a customer, a push for industrial trials and technology readiness. Commercialisation could be possible after 2015. There is a need for fundamental research and Life Cycle Assessment (LCA). An interesting project in this respect is the B-COR project initiated by the EIT Climate-KIC between the TNO, Imperial College London, MinesParisTech, Bayer Technology Services and RWTH Aachen.

Regarding the energy storage potential of the technology, there is a need for incentives to enhance the cooperation between the energy and the chemical sector. There is a possibility to take the excess of energy and store it in an intermediate polymer material. In general, the key issue is to facilitate the development of demonstration facilities.

Chemical production: A presentation by BASF and Catalysis Research Laboratory (CaRLa)

BASF and CaRLa are currently focusing on the development of the monomer sodium acrylate from CO_2, ethylene and a base. The chemistry has not been known until the team at CaRLa started its basic research efforts – a dream reaction. A dream reaction is an economically highly attractive transformation, which was until present unfeasible due to technological challenges. BASF and CaRLa have changed this situation and made the Dream Reaction possible.

The potential of this technology based on CO_2 and (bio-) ethylene is a reduction of 30% in raw materials and a significant reduction in investment costs. BASF and CaRLa have managed to create the first full catalytic cycle. Nevertheless, more basic research is necessary to increase catalyst efficiency and lifetime. More details concerning the various chemical reactions are to be found in the presentation.

Question and answer session

Funding: 18 million € have been allocated to the Bayer foam project. The challenge is to calculate the price of electricity.

Sustainability: Promoting chemical reactions should not be sacrificed to high volume applications.

Mineralisation: A presentation by Cambridge Carbon Capture Ltd.

Mineral carbonation refers to the industrial ex-situ conversion of magnesium or calcium containing minerals or wastes to carbonates, mimicking the natural process by which CO_2 is removed from the atmosphere. Mineral carbonation is an exothermic (energy-releasing) and alternative to CCS. It sequesters CO_2 directly from flue gas into stable & solid mineral products, and as such can stand alone without CCS infrastructure. At small scales, Mineral Carbonation can deliver immediate commercial deployment of industrial CO_2-sequestration without a carbon price.

Mineral carbonation is potentially a highly scalable CO_2 capture/utilisation option. For example, Oman, in one accessible geological deposit, has sufficient magnesium silicate to sequester 30 trillion tonnes of CO_2, if fully carbonated. USA and other countries have similarly large resources. The low-value aggregate products of large-scale mineral carbonation could service existing gigatonnes scale international markets for construction aggregates.

Today, economic feasibility is slowly driving worldwide mineral carbonation development. It is already commercially deployed in niche applications without a CO_2 price, where revenues come from by-products. However, R&D on processes suited to large-scale application is in the very slow lane and research funding is still needed.

Policy mechanisms are also needed to valorise CO_2-sequestration independently of emission reductions. There is excellent potential for a cost-reduction learning-curve based on market-driven volume growth, but it is necessary to get the support and enabling policies right.

Future outlook: Presentations by CO2Chem Network and the Norwegian University of Science and Technology (NTNU)

The CO2Chem Network presentation focused on off-setting the costs of CCS and providing a route to renewable energy storage. In order to facilitate the uptake of the storage potential of the technology, there is a need to design a solid to the captured CO_2 and especially to the atmospheric CO_2. The latter remains a main challenge.

The breaking of CO_2 bonds may not in some cases have a huge impact on the climate. However, it will have an impact on the supply chain by reducing the reliance on fossil fuels and thus increase the security of fuel supply. The commonality between all renewable sectors is the production of electricity, or simply a supply of electrons stored in the chemical process.

Life Cycle Assessment was the other topic addressed in this session. Life cycle assessment is critical for identifying which options make sense. There is a need to identify these options on a case-by-case basis as well as from a climate mitigation perspective. Thermodynamics and system analysis are key for conducting LCAs for CO_2 re-use technologies.

Life Cycle Assessment: In this case, the research question was if we can produce formic acid through the electrochemical reduction of CO_2 with less CO_2 emissions than the current commercial production routes. If yes, go on and investigate. How does it affect the CO_2 balance in the power plant? Does it make sense as a fuel? In general, we try to investigate the full chain. CO_2 was available for free because the alternative was to pump it into the storage. Did not take the up-stream into account.

Renewable Resource used: The main results are assuming that this comes from a fossil fuel plant with CO_2 captured. The concentration of the formic acid is so low so it requires a lot of energy to be purified.

HORIZONTAL ISSUES DISCUSSED

Regulatory framework: Although critics have argued that there is currently no satisfactory legislative framework for these technologies, the history of EU law making shows that there is a relatively strong tradition for amendments to existing laws to drive innovation forwards. Some of the main issues raised were the current framework concerning the Fuel Quality Directive, Renewable Energy Directive and the ETS. Specific feed-back has been given on this in the questionnaires and will be reflected in the summary.

CO_2 re-use as a term: CO_2 re-use is used as a term in order to underline the cyclic aspect of this technology.

Funding criteria for Horizon 2020: Horizon 2020 will go closer to market activities and use the Technology Readiness Scale as a reference point. However, there will be no financing of product development and the innovative aspect is crucial. There is also a possibility to enhance the link between innovation funding and financial instruments. This will provide a basis for a possible pooling of funds from the European Investment Bank.

The CCS and CO_2 re-use debate: One of the drivers to look at CO_2 re-use technologies is the lack of CO_2 storage in the Member States. However, CO_2 storage capacity is far larger than re-use volumes. There is also a need to assess the different CO_2 re-use technologies on a case-by-case basis because of their applicability to several industrial processes and applications. CO_2 re-use can provide excellent support for CCS technologies. The cost of the captured CO_2 needs to be addressed.

Labelling: The participants at the workshop also discussed the possibility and need to introduce one CO_2 label for CO_2 re-use technology related products, or the introduction of an eco-labelling such as EU Ecolabel to recognise the potential benefits of products made using captured CO_2.

Energy storage potential of CO_2 re-use technologies: Electricity can be converted into chemical energy by taking the excess of renewable electricity production in times of low demand. It will be converted into a liquid fuel either stored or used locally, e.g. to take an amount of energy from a waste plant and convert it into diesel which will be used to power the waste collection trucks. It means that it is possible to store the energy in a usable form, but your transportation costs through the immediate use of the final product. In the case of kerosene or diesel, it is possible to cut out the refining costs. This underlines its local usability potential rather than distribution of a resource.

Intermittent sources of energy: One of the recurring questions was whether wind and solar will be able to cope with intermittent sources of energy and if this could reduce the potential of CO_2 re-use technologies and it was established that needs further consideration. Plants are capital intensive and will likely need to be operating well over 80-90% to payback capital in commercially acceptable periods of time, whereas surplus renewable energy may only be available for 10-30% of the time. The geothermal energy has strong potential as well as tidal in the UK. By the use of simple electrolysers the possibility exists to take excess wind energy from the net. The European system is not easy with all the different part of the regulated chain.

Annex 1: Main findings of the questionnaire

Questionnaires provided a possibility for the participants to state in writing the main obstacles at EU level for the successful commercialization of their CO_2 re-use technologies/products.

Renewable Energy Directive

Renewable methanol (not based on biomass) can be eligible under the Renewable Energy Directive only when 100 % is obtained from renewable energy sources. However, this framework is not sufficient and will in practice this will the uptake of CO_2 re-use technologies. The legislative framework was written for biomass.

ETS

CO_2 re-use is not currently included in the ETS system. Within the EU-ETS technologies delivering temporary storage of CO_2 cannot be accounted for as non-emitted. Also transferring CO_2 to installations outside the ETS does not qualify and need to be accounted for, i.e. one is obliged to surrender emissions allowances for the transferred CO_2. Nevertheless, there is scope for changes in this requirement as it is suggested that this development should not "…exclude future innovations".

Public acceptance and perception

Stakeholder consultation on CO_2 re-use should also include public perception and acceptance of the technology. Several projects on public perception of CO_2 re-use are currently running or planned.

Life cycle assessment

LCA for the substitutable product is also needed.

CO_2 capture costs

The key issue which should be addressed is the chain process of CO_2 re-use. In the innovation it is essential to discuss the cost of CO_2 capture and of transport or storage is needed in a subsequent process. There is also a need to clearly bridge the valley of death and provide initial investment in piloting and technology readiness trials. More financial incentives are needed to make CO_2 re-use competitive with traditional production methods (e.g. eco-labelling, feed-in tariff). The funding and support for basic research can in turn make the EU a global leader on CO_2 re-use technologies

Fuel Quality Directive

There is lack of legal certainty on all legislation on products produced with CO_2 re-use technologies. There is a need for clarification of the Fuel Quality Directive in order to adapt the framework to CO_2 re-use technologies.

Annex 2: List of participants

NO.	ORGANISATION	NAME
1.	ALSTOM	Juliette Langlais
2.	BAYER	Martina Peters
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4.	BASF - CARLA	Nuria Huguet
5.	CAMBRE	Tania Pentcheva
6.	CAMBRIDGE CARON CAPTURE	Michael Priestnall
7.	CARBON COUNTS	Paul Zakkour
8.	CARBON RECYCLING INTERNATIONAL	Kees Hettinga
9.	CEA	Thibault Cantat
10.	CEFIC	Sophie Wilmet
11.	NEWCASTLE UNIVERSITY	Lidjia Siller
12.	CO_2 CAPTURE PROGRAMME	Pedro Otero
13.	CO_2 CHEM NETWORK CHAIR	Peter Styring
14.	DIFFER	Richard van de Sanden
15.	DIFFER	Adelbert Goede
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17.	DG CLIMA	Torsten Woellert
18.	DG CLIMA	Thea Sveen
19.	DG CLIMA	Beatrice Coda
20.	DG ENER	Marion Wilde
21.	DG ENER	Ilinca Balan
22.	DG ENTR	Aurelien Genty
23.	DG JRC	Evangelos Tzimas
24.	DG JRC	Andrei Bocin Dumitriu
25.	DG JRC	Efstathios Peteves
26.	DG RTD	Helge Wessel

27.	DG RTD	Vassilios Kougionas
28.	DG RTD	Franco Cozzani
29.	ECN	Rob Kreiter
30.	EIDHOVEN UNIVERSITY OF TECHNOLOGY	Stefan Welzel
31.	EVONIK	Jennifer Julis
32.	FONA	Caroline Hain
33.	FUNDACION CIUDAD DE LA ENERGIA	Nelly Castilla García
34.	FORSCHUNGSZENTRUM JUELICH GMBH	Stephanie Roth
35.	HAVEN ANTWERPEN	Karen Callebaut
36.	IFP ENERGIES NOUVELLES	Laurent Forti
37.	INFRASERV GMBH	Pierre Kramer
38.	INNOVATION CONCEPTS BV	Pol Knops
39.	LAFARGE	Michel Gimenez
40.	MINISTERIUM FUR INNOVATION, WIRTSCHAFT UND FORSCHUNG, NRW	Sandra Hilbert
41.	NORWAY MISSION TO THE EU	Knut Kroepelien
42.	NOVA INSTITUT	Fabrizio Sibilla
43.	NTNU	Edgar Hertwich
44.	PMV	Frank Gerard
45.	RWTH AACHEN	Thomas Ostapowicz
46.	SHELL	Donald Reinalda
47.	SINTEF	Richard Heyn
48.	SOLVAY	Eric Dubois
49.	TNO	Coen Schuurbiers
50.	TNO	Earl Goetheer
51.	VITO	Mieke Quaghebeur
52.	VITO	Dirk Vangeneugelen
53.	VITO	Srikath Sandipam
54.	VERBAND CHEM. INDUSTRIE	Jörg Rothermel