IEAGHG Information Paper 2016-IP55: The ICEF CO2 Utilisation Road Map

The Innovation for a Clean Earth Forum (ICEF) was launched two years ago by the Japanese Prime Minister. The ICEF is an annual conference series that aims to address climate change through innovation. The ICEF investigates what innovative measures should be developed, how the innovation should be promoted, and how cooperation should be enhanced among the stakeholders[1]. One activity that ICEF undertakes is to develop roadmaps on global industry-academia-government initiatives for sharing visions and facilitating discussions for the development and dissemination of innovative low carbon technologies. One such road map on CO_2Utilization (CO2U) was released at COP22, Marrakech, Morocco[2]. The road map can be downloaded at:

http://www.icef-forum.org/platform/upload/CO2U_Roadmap_ICEF2016.pdf.

A summary of the report, as given on the web site is set out in the text box below.

Background:

This study presents a roadmap for commercialization potential of carbon dioxide utilization (CO2U) technologies through 2030. CO2U technologies can play an important role to achieve the agreed global goal of keeping temperature increases well below a 2°C increase over pre-industrial level, but have not yet received much attention nor have their potential been explored in a comprehensive fashion.

A detailed market assessment study that was completed earlier in 2016 found that CO2U has the potential to reduce global carbon emissions over 10% by 2030. One goal of this work is to create greater awareness concerning the potential for developing and deploying profitable, emissions-negative CO2U technologies on a mass scale.

The study: Identifying and forecasting market opportunity

This study analyses the current state of CO2U technology, assessing almost 180 global technology developers on the basis of their technology feasibility, readiness, markets and momentum. Research revealed that significant progress in CO2U has been made in the past five years (2011-16), with many technologies shown to be scalable. Momentum is favourable for four major markets – building materials, chemical intermediates, fuels and polymers.

Within those markets, the study further identifies eight product categories to pursue, based on the maturity of their technology, market promise, and potential impact on the mitigation of carbon emissions. Those categories are:

- Building materials: Concrete & Carbonate aggregates
- Chemical Intermediates: Methanol, Formic acid & Syngas
- Fuels: Liquid fuels & Methane
- Polymers: Polyols and polycarbonates

It is notable that the study also eliminated two markets, algae and novel materials, from further consideration.

[1] http://www.icef-forum.org/what_icef/what_icef.html

[2] http://www.icef-forum.org/platform/article_detail.php?article__id=109

Comments:

The main premise for this study is that:

"Renewable power generation and other low- and zero-carbon technologies are an important part of the solution. Carbon negative technologies (those that reduce atmospheric CO_2 concentrations) are also needed to achieve the agreed global goal of keep temperature increases well below a 2^0 C increase over pre-industrial level. CO2U technologies can play an important role, but have not yet received much attention nor have their potential been explored in a comprehensive fashion".

The first part of the basic premise is correct, whether CO2U can play an important role in GHG mitigation is questionable. There seems to be two sides in this argument that a poles apart; those that feel CO2U role is very limited and the technology advocates who could be deemed to be playing up the technologies importance.

Based on a detailed market assessment study completed earlier in 2016 by the Global CO_2 Initiative (see box below) the CO_2 utilisation roadmap makes an ambitious claim that 10% of global carbon emissions can be reduced by 2030 by this route.

The Global CO_2 Initiative

The Global CO_2 Initiative was launched in January 2016 annual meeting of the World Economic Forum. The Initiative, and its research funding arm CO2 Sciences, Inc., aims to catalyse innovative research in carbon capture and utilization (CCU). It aims to accelerate commercialization of CCU products. Preliminary estimates put the annual market for CCU products at $800 billion - $1.1 trillion by 2030 with potential annual reduction of CO_2 in the range of two to three Gt.

McKinsey & Company previewed preliminary findings from an unprecedented and comprehensive market assessment conducted on behalf of CO_2 Sciences, Inc. The assessment catalogued the many existing and potential CCU products, including fuels, materials, chemicals, plastics, agriculture, food and industrial gases. The market assessment is based on rigorous projections of the potential revenues and carbon capture.

The Global CO_2 Initiative was created to realize the ambitious goal of capturing 10% of global CO_2 emissions and transforming them into valuable products. CO_2 Sciences, its innovative research and development platform, is structured to aggressively catalyse funding in carbon capture and use by granting up to $400 million over ten years to many qualified research applicants throughout the world. In parallel, the Global CO_2 Initiative will accelerate the commercialization of CO_2-based products and services. It will use different financial vehicles to invest in companies, enabling them to grow market demand for CO2-based products.

For more information, visit **www.globalco2initiative.org** and follow the Global CO_2 Initiative on Twitter: @reuseCO2

One of the goals of the roadmap is to create greater awareness concerning the potential for developing and deploying profitable, emissions-negative CO2U technologies on a mass scale.

It is fair to say that a number of the products identified are at an early stage of technical development and are being developed by entrepreneurial; companies rather than corporations. In the building's sector these innovator companies will come up against an established industry that is decarbonising itself and its products meet building industry standards. So there is a gamble associated here with establishing market share in sectors. But innovation must be recognised.

The report underlines the need for LCA on these new products:

"*The climate benefit of a CO2U product depends not just on how much CO_2 the product contains. The amount of CO_2 emitted in making the product also matters. So does the amount of CO_2 emitted in making any competitive products that may be displaced? To the extent that climate benefits are a goal of those promoting CO2U products, life cycle analysis (LCA) is essential. Considerable work is needed to standardize life cycle analysis methodologies for CO2U.*

However, the report does not present any information on LCA on the novel products it suggests. It only calls for Governments to fund LCA analyses on these products. The absence of any supporting data on the CO_2 reduction benefits could be deemed to undermine the climate benefits of CO2U claimed in the report. In an ideal world such data would have been presented as part of the report to support the claims being made. Playing devil's advocate – doing the LCA after investing in developing a new product is not the best route forward.

The report is quite open in that it recognises challenges and problems with the approach presented. Namely it clearly states that:

- Conversion of CO_2 into CO2U products requires more energy than conversion from conventional feedstock's because of the thermodynamic stability of carbon dioxide. R&D is therefore required on catalysis and other conversion processes to reduce the amount of required energy.
- Thermo-catalytic conversion of CO2 has been commercialized for several applications. In general, yields, half-life, and selectivity of catalysts need to be further increased. In addition, operating temperatures should be reduced to lower operating costs. Funding should go into applied research in catalysis.
- A hydrogen feed is needed in many processes. Generation of H_2 by electrolysis using renewable energy at a low cost is necessary to make CO2U cost-competitive. Funding also should go into applied research in electrolysis.
- Funding also should be applied to research on alternative processes to thermo-catalytic conversion: fermentation, electrochemical, and photocatalytic means. These processes typically demand less energy usage. And additionally, funding support is needed for research that enables CO_2 feeds with contaminants to be used in CO2U technology, which currently requires relatively high-purity CO_2 to optimize catalyst life.

This implies that a lot more work is needed to bring these technologies to the market some of which is required in fundamental research areas to allow these products to develop and be cost effective.

The report also calls for funding (it is assumed Governmental) be made to "*establish collaborations among research institutes, start-ups, governments and corporations for process integration of CO_2 conversion, hydrogen generation and carbon capture".*

All that "*Consortia should be established to enable the CO2U value chain, integrating carbon capture; the supply of affordable hydrogen from sources such as a chemical plant or a technology like electrolysis; access to low-cost* renewable energy (such as over-capacity electricity); and physical plants for CO_2 conversion and CO2U product manufacturing".

If the CO2U technology requires special support i.e. "free electricity", or "cheap hydrogen" to be provided to make market competitive, one can imply that the technology is not economically viable in its own right. This makes one and question why CO2U should be the recipient of such subsidies when its potential to mitigate global greenhouse emissions is not clearly established.

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