Scientific Advice Mechanism

Scoping paper:
Novel carbon capture and utilisation technologies: research and climate aspects

27 June, 2017

Novel carbon capture and utilisation technologies: research and climate aspects

Issue at stake

A number of novel Carbon Capture and Utilisation (CCU) technologies are under development for the production of low-carbon fuels, chemicals and building materials. They use CO_2 as a feedstock, therefore storing it in products temporarily or for longer periods of time. These technologies are subject currently to important policy debates as they may offer a promising potential for decarbonisation, industrial innovation and competitiveness of energy-intensive industries.

However, CCU technologies face a range of technical, environmental and economic challenges. Research in novel technologies can overcome some of these challenges. Their climate mitigation potential is as yet unclear, as it is dependent on a number of factors, which may be specific to each technology and resulting conversion product, as well as the location and characteristics of the installation.

Based on existing research, the climate mitigation and economic potentials of CCU technologies need to be carefully considered from a scientific point of view to inform future policy decisions in this field, including financial support. In particular, there is a need to ensure that support is limited to technologies that are environmentally-safe and provide substantial climate benefits.

Policy context

The CCU technologies should be placed in the broader context of the implementation of the Paris Agreement. The EU has committed to an economy-wide domestic target of at least 40% greenhouse gas (GHG) emission reduction for 2030 compared to 1990. Implementing the EU 2030 energy and climate framework is a priority in follow up to the Paris Agreement.

The Commission has therefore tabled a number of proposals for revising the current regulatory framework, *inter alia* legislative through proposals on the EU emissions trading system (EU ETS), on an Effort Sharing Regulation setting national 2030 GHG targets. *The Clean Energy for All Europeans* package[1] also contains proposals to revise the Renewable Energy and the Energy Efficiency Directives. All these proposals are currently subject to co-decision.

Carbon Capture and Utilisation fuels can be supported under the current Fuel Quality Directive and in future under the Renewable Energy Directive provided they deliver greenhouse gas savings.

Shifting and rapidly scaling up private investment is essential to support the transition to a low emission and climate resilient economy, and for avoiding the "lock-in" of high emissions infrastructure and assets.

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1485341914564&uri=CELEX:52016DC0860%2801%29

EU funds will play an important role for mobilising the markets. In the proposal for a revised EU ETS, the Commission has proposed an Innovation Fund to extend existing support for the demonstration of low carbon innovative technologies to breakthrough innovation in industry. Carbon capture and utilisation technologies will be in principle eligible but the selection criteria still need to be determined in the implementing legislation. One important selection criterion for any of the technologies supported will be the climate mitigation potential.

Current situation

For the purpose of this scoping paper Carbon Capture and Utilisation is defined as those technologies that use CO_2 as a feedstock and convert it into value-added products such as fuels, chemicals or building materials.[2]

These CCU technologies may offer a range of potential opportunities for European industry and the pursuit of European Union policy objectives, including:

- Supporting climate change objectives, by replacing crude oil and gas in chemicals and fuels but also through fixation of the CO_2 in materials;
- Supporting the circular economy, by converting waste CO_2 to products, industrial innovation and competitiveness, particularly important for energy-intensive industries, developing new and more efficient processes and creating new market opportunities;
- Supporting energy security and renewable energy deployment, through utilising excess renewable electricity and providing energy storage alternatives;
- Supporting the evolution of CO_2 capture systems, which may help deployment of CCS[3] technology, which in turn provides permanent and large-scale storage of CO_2.

CCU technologies are however at different stages of technological readiness - from laboratory testing to commercial demonstration. Technology improvements to increase efficiency, to reduce energy and materials consumption and to prove the technologies at large scale and in different settings are needed.

The Commission provides a wide range of research and development grants in the field of CCU. Furthermore, CCU demonstration projects will be eligible to bid for support from the future Innovation Fund, *inter alia*, as one of the technologies and processes for decarbonisation of energy-intensive industries.

However, CCU still faces a number of technical challenges: advancement of knowledge is essential to improve the economic and environmental feasibility and the potential of the technologies. It includes for instance research in CO_2 catalytic science, novel CO_2 reaction pathways, novel reactor designs and the translation of this research into breakthroughs in processes.

[2] Technologies that use CO_2 as a working fluid or solvent such as for enhanced oil recovery or in supercritical CO_2 power cycles are out of scope of the request.
[3] Carbon Capture and Storage

Information on the environmental performance of the technologies is currently limited and scattered. While some studies are available that assess the climate change mitigation potential of CCU applications based on Life Cycle Analysis (LCA), this approach is not coherent with the monitoring and reporting framework that is applied within the large installations that are covered by the Emissions Trading Scheme (EU ETS), which is based on annual monitoring, reporting and verification of emissions from each specific installation at the site of the installation. In addition, the most promising CCU technologies appear to require significant amounts of energy. This means that even in situations where an LCA could potentially capture relevant impacts for a CCU technology, the climate mitigation potential, in particular, would also depend on the availability of low-carbon electricity, the efficiency of the technologies, the greenhouse gas intensity of inputs, how long and stable the CO_2 remains bound in its new form, and what products are replaced. As a result, a LCA can lead to very different results depending on the specific technologies and plants considered.

EU international climate obligations require detailed monitoring and reporting of greenhouse gas emissions. Currently, the EU ETS only provides a derogation from greenhouse gas emissions for CCS involving geological storage in accordance with the CCS Directive[4]. CCU technologies bind the CO_2 molecule in a multitude of different products for different periods of time. Currently, unless captured carbon dioxide is permanently stored, it is counted as emissions under the ETS Directive, due to the lack of a methodology for accounting for possible CO_2 releases in the future. The absence of such an approach reflects the novelty of the technologies as well as the multitude of different products and end-of-life possibilities.

The economic feasibility of CCU technologies also depends on a number of factors, such as the costs of inputs (CO_2, electricity, catalysts, etc.), technological improvements and the price of products they substitute. CCU technologies like many innovations offer alternative processes and pathways to produce substitute products in the market, and therefore face commercial challenges in replacing long-established market incumbents.

CCU technologies can provide storage of intermittent renewable energy but the need for such storage is in competition with other storage and grid management solutions and therefore potential in the future is unclear.

Some mineralisation pathways are already competitive (e.g. reacting CO_2 with industrial and municipal solid waste to produce building blocks) but their market potential is limited by the volume of waste or by the need for close-by sources of CO_2 and other raw materials.

The quality and quantity of CO_2 could also be a challenge. CO_2 needs to be captured, concentrated and purified before it can be used at least for some of the processes. This can be energy intensive and costly. However, certain industrial processes offer nearly pure CO_2 and some conversion technologies can use the flue gases without much purification or

[4] Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide

concentration. The volumes of available CO_2 may not match the needs of utilisation unless clusters of capture, utilisation and storage are developed.

Request to SAM HLG

In this context, the Scientific Advice Mechanism High Level Group (SAM HLG) is asked by the end of April 2018 to provide scientific opinion on the challenges and opportunities of novel carbon capture and utilisation technologies in particular with respect to their climate mitigation potential.

Questions to be addressed by SAM HLG

In this context, SAM High Level Group is asked to provide scientific advice based on existing research on the climate mitigation potential of CCU technologies to inform future policy decisions in this field over the next couple of years, including financial support. In particular, there is a need to ensure that support is limited to technologies that are environmentally safe and provide substantial climate benefits.

- *Under what circumstances CCU for production of fuels, chemicals and materials can deliver climate benefits and what are their total climate mitigation potential in the mid- and long-run?*

- *How can the climate mitigation potential of CO_2 incorporated in products such as fuels, chemicals and materials be accounted for considering that the CO_2 will remain bound for different periods of time and then may be released in the atmosphere?*

Further procedures and actors in support of the SAM High Level Group

EU academies and the wider scientific community: The EU academies are a key provider of scientific evidence to the SAM HLG. The relevant EU academies will be asked for their inputs. The engagement of leading scientists will be organised.

The European Commission's Joint Research Centre (JRC) will also provide scientific evidence to the SAM HLG.