
CARMOF
MEMBER
MOF4AIR
Toward 2030:
New pathways
to
CO2
capture
HORIZON
RESULTS
BOOSTER
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Executive Summary

The European Union has set an ambitious objective to be climate-neutral by 2050, that is, to be an economy with net-zero greenhouse gas emissions. The European Green Deal codifies this objective, and all economic sectors are participating in its realisation. In April 2021, the EU set a target of cutting greenhouse gas emissions by 55% by 2030.

CARMOF, MEMBER and MOF4AIR are three European-funded projects geared to demonstrate innovative CO_2 capture technologies in real industrial conditions. Promising new material solutions are under development for the next generation of CCUS technologies that are expected to reach the markets in the next few years.

The CARMOF project group has come together under the umbrella of the Horizon Results Booster programme (HRB) of the European Commission to jointly collaborate on addressing common goals toward the 2050 targets of reducing CO_2 emissions in energy-intensive companies.

The Context

Carbon Capture, Utilisation and Storage

To mitigate climate change, the European Union (EU) has accelerated the goal of cutting greenhouse gas emissions to reach 55% reduction relative to 1990 by 2030[1]. **Power supply and carbon-intensive industries** (e.g., cement, steel, limestone, petrochemical and chemical plants and waste incineration) account for a large share of CO_2 emissions. **Carbon Capture Utilisation and Storage (CCUS)** is one of the only technology solutions that can significantly reduce emissions from key industrial processes (all of which will remain vital building blocks of modern society) as well as from coal and gas power generation, for which, however, a range of other solutions can be considered.

CCUS consists of the **separation of CO_2** from industrial and energy related sources, and either its **transportation** to a geological storage location for final long-term isolation from the atmosphere (CCS, with a focus on storage) or its **transformation** to other molecules, which can be valorised (CCU, with a focus on utilisation).

The International Energy Agency (IEA) states that CCUS is an essential technology to reduce CO_2 emissions and achieve net-zero emissions by 2050[2]. According to the IEA plans, 1.6 Gigatons of CO_2 should be captured per year by 2030, and 7.6 Gigatons by 2050. However, the progress of R&I on CCUS technology is still too slow to reach these objectives. In 2018, the Advisory Council of the European Zero Emission Technology and Innovation Platform concluded that CCUS is crucial to achieving deep reductions in CO_2 emissions in the most affordable and economically sustainable way.[3]

CO_2 Capture Technologies

CO_2 capture is one of the first steps of CCUS. Different technologies have been developed during the last 25 years. Currently, different processes exist for carbon capture from large point source emitters, and they are divided into three process categories: pre-, post-, and oxy-combustion, although new processes integrating the CO_2 capture in the reaction process are also being developed.

Post-combustion CO_2 capture has the benefit that the carbon capture process is more easily integrated into existing facilities, so it has been widely researched and developed. Absorption by liquid (typically amine-based) solvents is already commercially available. However, many drawbacks have been associated with the state-of-the-art amine-based CO_2 capture process, leading to other liquid solvents being developed as an alternative. The Technology Readiness Level (TRL) spans from 3 up to 9 for the different liquid solvents, where amine solvents and physical solvents are the most developed (TRL 9).

Adsorption by solid sorbents (such as zeolites, carbon and metal organic frameworks) is a CO_2 capture technology with certain options at TRL levels of 9, such as pressure and vacuum

1 EU economy and society to meet climate ambitions (europa.eu)
2 About CCUS – Analysis - IEA
3 ZEP-Role-of-CCUS-in-below-2c-report.pdf (zeroemissionsplatform.eu)

swing adsorption (PSA and VSA) in a pre-combustion setting, as well as TRL levels of 6 for post-combustion CO_2 capture. Other technologies are Sorbent Enhanced Water Gas Shift (SEWGS), Sorption Enhanced Reforming (SER) and enzyme catalysed adsorption but at lower TRL than PSA / VSA technologies.

In addition to liquid and solid sorbents, other CO_2 capture technologies are being developed such as membrane separation, chemical looping, low-temperature cryogenic separation, fuel cells and hybrid processes combining several capture technologies. In general these technologies are less mature than absorption with amine solvents and, to some extent, solid sorbent adsorption.

The cost and energy requirements of CO_2 capture must be further reduced to make it more attractive as an emissions reduction pathway. To meet the European climate objectives for 2030, more operational CCUS projects at commercial scale are needed in a short timeframe. Commercial technological solutions exist and will need to be deployed. However, technological development is essential to reduce the cost and energy requirements of CCUS and make it more attractive as an emissions reduction pathway.

This policy brief aims at formulating recommendations that are deemed essential for the development of CCUS solutions in Europe, to ensure CCUS can play its role in the reduction of CO_2 emissions by carbon intensive industries.

Recommendation 1: Include provisions for key technological advancements in the future roadmap for CO_2 capture technology

Technological advancements are needed for process intensification, modularisation, and cost-effective, upscalable materials as they can reduce the cost and energy demand of the CO_2 capture process by process intensification. Technology development and the identification of suitable capture technologies for a specific industrial application should be guided by considerations of accessibility to clean and sustainable energy sources and the potential for heat integration at the plant site. In addition, large-scale and long-term demonstration of the developed technologies is needed to go to the market. Policymakers can promote these needed advancements by including support for them in future calls on the European research roadmap.

Recommendation 2: Provide investment incentives to increase the manufacturing readiness levels of the CCUS industry

Manufacturing readiness and producibility are as important to the successful development of a system as the technologies intended for the system. Therefore, support for the improvement of manufacturing readiness levels should be provided together with the technology advancement to facilitate the supply chain development for the replication at large scale of the successful technology and the go-to-market strategy.

Recommendation 3: Provide financial support for the formation of industrial CCUS clusters

National, local and EU government financial support is currently being given (e.g., Northern Lights project, Porthos) but government-backed loans and grants for developing shared CO_2 transport, storage and/or (local) CO_2 utilisation infrastructure are currently insufficient to promote industrial clustering and fill the cost-revenue gap to address the full scale of the global challenge (e.g., the EU Innovation Fund is oversubscribed by a factor of 20 times).

Recommendation 4: Support CCUS through regulatory and strategic policy

The adjustment of the regulatory context will be important to frame the development of CCUS technologies and infrastructures in the coming years, and remove barriers to the important role CCUS can play in CO_2 emissions mitigation. In particular, a European strategy and policy for carbon capture, transport, storage and utilisation is needed that coordinates with regions and member-state strategies and policies. This involves incentives for the proactive development of strategic CO_2 transport and storage infrastructure solutions, including highways, railways, pipelines, and shipping infrastructure. In addition, regulatory instruments such as incentives to promote the use of captured CO_2 for new products, carbon taxes on direct CO_2 emissions as well as taxes taking into account the carbon footprint of a product throughout its lifetime should be further implemented to make CCUS more competitive.

Recommendation 5: Boost the social acceptance of CCUS technologies

Overcoming negative perceptions of CCUS technologies in local societies is crucial to develop CCUS solutions[4]. Public engagement should be fostered through various instruments such as public consultations, formation of local groups interacting with authorities, and financing for public awareness-raising activities such as site tours, websites, and media releases. Public debate forums should be provided for discussion of the European Strategy for CCUS, both at national levels and then at local levels. Technical and safety specifications (e.g. environmental and hazard studies) should be financed ahead of CCUS projects to foster acceptance and trust. Local communities should be invited to participate in the technical specification of, e.g., storage sites, in order to engage them in issues of critical interest to them such as leakage and environmental impact.

4 L'acceptabilité au prisme du stockage géologique de CO2 : retour sur un débat non émergé [☆] | Cairn.info ; GÉFISS - Social Governance for Subsurface Engineering (gefiss.eu)

Project Group

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CARMOF: New process for efficient CO_2 capture by innovative adsorbents based on modified carbon nanotubes and MOF materials

www.carmof.eu

Grant Agreement No. 760884

MEMBER: Advanced MEMBranes and membrane assisted procEsses for pre- and post-combustion CO_2 captuRe

www.member-co2.com

Grant Agreement No. 760944

MOF4AIR: Metal Organic Frameworks for carbon dioxide Adsorption processes in power production and energy Intensive industRies

www.mof4air.eu

Grant Agreement No. 837975

Annex

The HRB CARMOF project group has organised a joint webinar in support of the Horizon Results Booster team, which took place on 24 February 2022, addressing the common goals toward reducing CO_2 emissions in energy-intensive companies.

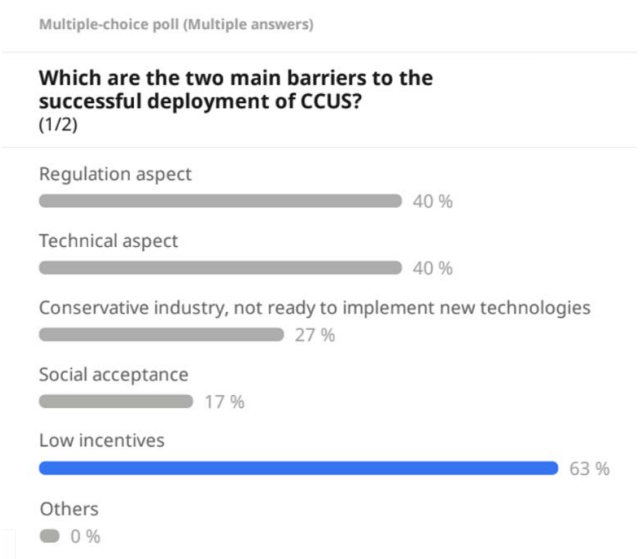
The webinar, entitled "Toward 2030: new pathways to CO_2 capture", aimed at providing exhaustive updates on the current developed methods and solutions coming from the three European funded initiatives (CARMOF, MEMBER and MOF4AIR). This webinar highlights the following:

- Insight into innovative capture processes (membranes, adsorption & hybrid) and their possible impact.
- Upscalability of the processes from grams-to tons-scale.
- Policy recommendations.

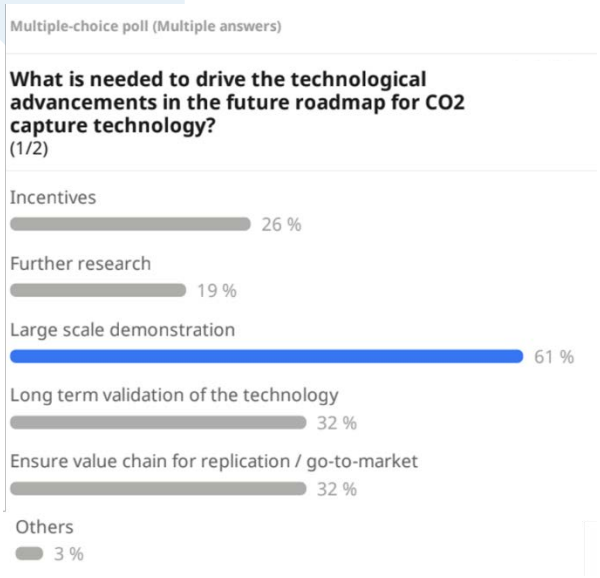
During the webinar, some Poll-questions were posed to the audience to better understand the priority of the suggested recommendations provided by the PG members. The following graphs below depict the main figures pulled out from the short surveys:

Poll question 1:

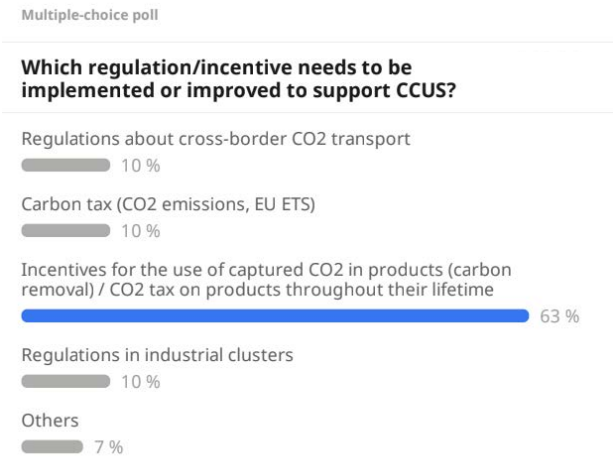
Poll question 2:



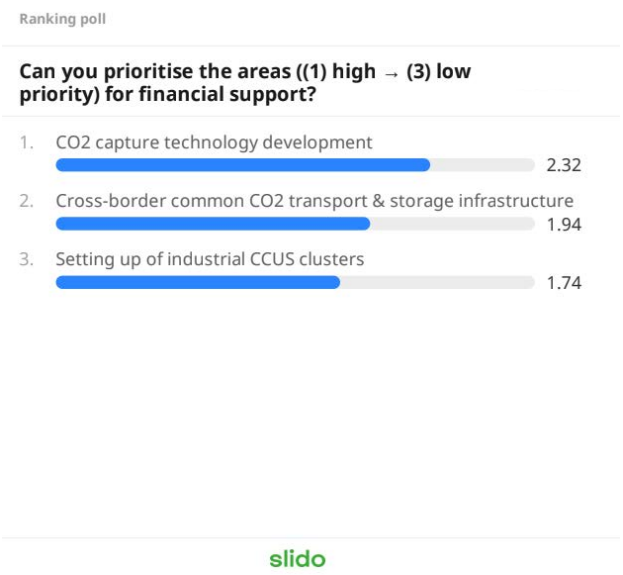
Poll question 3:



Poll question 4:



Poll 5:



The live poll session was conducted using the Sli.do platform provided by the HRB team.

The recorded webinar video is available at the HRB YouTube channel:

https://youtu.be/fYMgtxzmDTg

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