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COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Towards an ambitious Industrial Carbon Management for the EU

1. Why the EU needs an industrial carbon management strategy

The European Union is committed to achieving economy-wide climate neutrality by 2050 to limit global warming to 1.5 °C. It is implementing a comprehensive policy framework to reduce emissions by at least 55% by 2030 and the Commission has now laid out the groundwork for the EU's climate ambition for the next decade[1].

Achieving these targets and weaning off our reliance on fossil fuels requires decisive climate action across all sectors of the economy. An EU industrial carbon management strategy is in itself an essential complement to the mitigation of greenhouse gas (GHG) emissions that is necessary in the first place. As a global frontrunner, the EU has the opportunity to create an economic edge in industrial carbon management technologies providing global business opportunities[2]. Industrial carbon management can help to decarbonise production processes in industrial sectors that are important for the European economy, complementing other decarbonisation efforts. Industrial carbon management is therefore a sound and important building block for a sustainable and competitive economy in Europe.

In 2040, the consumption of fossil fuels for energy would reduce by approximately 80% compared to 2021.[3] This reduction will be achieved through rapid development and integration of renewable energy sources, circularity and resource efficiency, industrial symbiosis, energy efficiency, alternative production processes and material substitution, with the reuse of carbon contributing to this major shift. In addition, it will be driven by the latest reform of the EU Emissions Trading System (ETS), through which industrial emissions will have to decline at an accelerated pace to reach the 2030 target and which has introduced the new EU ETS, covering CO_2 emissions from fuel use in road transport, buildings and additional sectors[4]. But in some sectors, a limited use of fossil fuels will remain also in 2040, for example in the form of oil in the transport sector and some gas for heating and industrial purposes (including as feedstock). This Communication recognises that industrial carbon management technologies are part of the solution towards achieving climate neutrality by 2050. These technologies are needed to continue reducing and managing carbon emissions in industrial processes in the EU, notably where mitigation options are limited.

However, additional measures are needed to continue reducing and manage carbon emissions in industrial processes in the EU, notably where other mitigation options are limited[5]. During this decade, the main focus will be on capturing CO_2 from process emissions as well as some emissions from fossil and biogenic CO_2 sources (see Figure 1). Besides natural carbon sinks and carbon farming[6], reaching economy-wide climate neutrality by 2050 will require industrial

[1] Communication "Securing our future – Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society", COM(2024) 63 ('EU's 2040 climate target communication").
[2] See: Progress on competitiveness of clean energy technologies (COM(2023) 652 final).
[3] Impact Assessment for the EU's 2040 climate target Communication, SWD(2024) 63.
[4] This will be operational as of 2027; Directive (EU) 2023/959.
[5] IPCC, 2022. Climate Change 2022: Mitigation of Climate Change; IEA, 2021. *Net Zero Roadmap A Global Pathway to Keep the 1.5 °C Goal in Reach;* ESABCC 2023, Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050 (link).
[6] See Communication on Sustainable Carbon Cycles (COM(2021) 800 final).

carbon removals from biogenic and atmospheric sources already before 2040, to counterbalance hard-to-abate emissions in the EU and to achieve negative emissions thereafter.

The EU is relatively well-positioned on CO_2-capture technologies and in terms of research and innovation, with a number of companies supplying different capture technologies on commercial terms[7]. The geological knowledge and know-how of companies in building pipelines and ships, drilling wells will be essential when developing carbon management projects.

The EU already has a number of policies in place to support the capture of CO_2. However, to reap its full economic potential in line with the ambition of the EU's 2040 climate target Communication[8] and to reach climate neutrality by 2050, the EU will need to significantly scale up efforts. In the Net Zero Industry Act, the Commission has proposed that at least 50 million tonnes of CO_2 per year can be stored geologically by 2030.

Modelling results for the EU's 2040 climate target Communication indicate that approximately 280 million tonnes would have to be captured by 2040 and around 450 million tonnes by 2050[9] (see Figure 1). These results provide the context for further discussions with industry and other stakeholders on pathways for these technologies. By 2040, close to half of the CO_2 that is captured annually would have to come from biogenic sources or directly from the atmosphere. This would play an important role to remove carbon from the atmosphere and to provide a climate-neutral source of carbon for various industrial applications as well as for the production of sustainable fuels for hard-to-abate emissions in transport, such as in aviation and in the maritime sector, where CCS on-board of ships is also an option to explore.

The scale of this endeavour is large. Storing 50 million tonnes in 2030 is the equivalent of the annual CO_2 emissions of Sweden in 2022[10]. Industry stakeholders expressed that, by 2030, they could capture up to 80 million tonnes of CO_2 per year in Europe if the necessary investment conditions are in place[11].

Carbon capture will also require significant additional energy to power this energy-intensive process[12], and, in the case of biogenic carbon, the sustainable sourcing of biomass. Furthermore, while CCS and CCS industrial projects should develop and operate on commercial basis, some financing support providing bridging solutions will be needed especially at the first stage of creating the European market and infrastructure.

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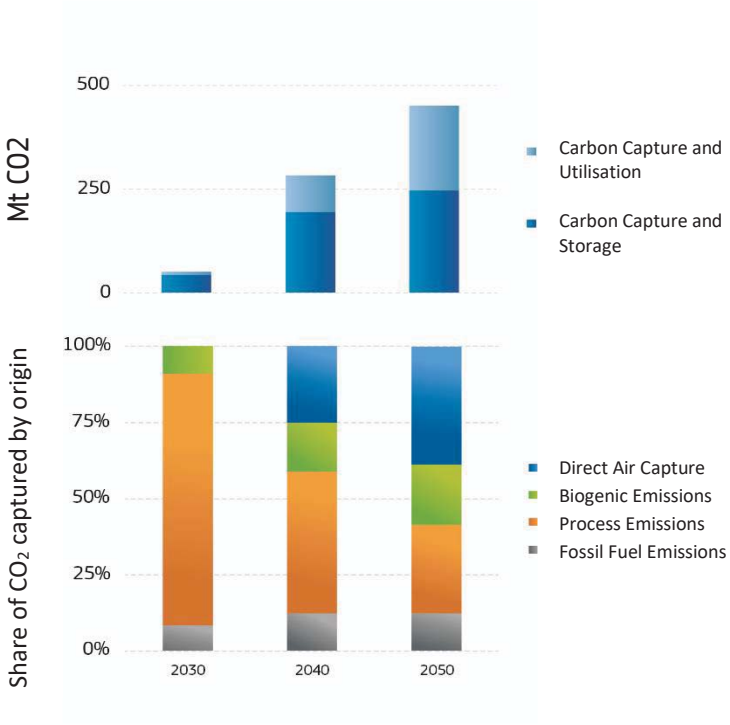
[7] JRC CETO CCS 2023 report: (link).
[8] COM(2024) 63.
[9] SWD(2024) 63.
[10] Total greenhouse gas emissions of Sweden were 49.5 Mt in 2022, based on Eurostat 2023 (link).
[11] Calculated by CCUS Forum stakeholder coalition (industry, NGOs), these projects have not taken final investment decisions due to among other factors a lack of CO_2 value chain services (transport, storage) and insufficient financial support, see CCUS Vision Working Group, April 2023 (link).
[12] Typically, carbon capture processes consume 1-3 MWh/tonne of CO_2. Data based on IEA (2022) Direct Air Capture and IEA (2023) The Oil and Gas Industry in Net Zero Transitions.

Figure 1: Volume of CO_2 captured for storage and utilisation in the EU (above chart) and share of the CO_2 captured by origin (below chart)[13]



The scale of this challenge requires an EU-wide industrial carbon management strategy, which will be based on three pathways:

- Capturing CO_2 for storage (CCS): where CO_2 emissions of fossil, biogenic or atmospheric origin are captured and transported for permanent and safe geological storage.
- Removing CO_2 from the atmosphere: where permanent storage involves biogenic or atmospheric CO_2 and it will result in removing carbon from the atmosphere.
- Capturing CO_2 for utilisation (CCU): where industry uses captured CO_2 in synthetic products, chemicals or fuels. Whilst initially using all types of CO_2, over time a strategic focus of utilisation value chains on capturing biogenic or atmospheric CO_2 will yield higher climate benefits.

CO_2 transport infrastructure is the key enabler common to all pathways. Where the captured CO_2 is not used directly on-site, it will need to be transported and either used in industrial processes (e.g. for construction products, synthetic fuels, plastics or other chemicals) or permanently stored in geological formations.

[13] The numbers included in this figure are based on the modelling of the impact assessment for EU's 2040 climate target Communication (SWD(2024) 63). The volumes of CO_2 captured, stored and utilised and the shares by origin of CO_2 are scenario dependent, values representing the average of scenarios S2 and S3 are reported in this figure. The small increase in the share of captured fossil CO_2 for 2040 reflects a broader deployment of CO_2 capture power installations in a context where the overall use of fossil fuel in power installation is significantly lower towards 2050.

The aim of this strategy, therefore, is to bring together different policy strands to create an enabling environment to develop and scale up industrial carbon management approaches. It describes the current state of play for industrial carbon management, the envisioned pathway towards 2050, the policy framework for industrial carbon management, and the necessary pre-conditions to support industrial carbon management approaches.

2. The state of play on industrial carbon management in Europe

The EU already has a number of policies that are supporting carbon capture and storage and/or utilisation, and the associated infrastructure needs. Since 2009, geological storage of CO_2 is regulated by the CCS Directive, which sets permitting rules to ensure the safety and environmental integrity of CO_2 storage and prescribes transparent and non-discriminatory access to the infrastructure[14]. Furthermore, CO_2 transport projects are supported under the revised TEN-E Regulation[15] and the current list of 14 projects of common interest (PCIs) or projects of mutual interest (PMIs)[16] add up to an overall planned capacity up to 103 million tonnes per year of CO_2 through four onshore storage sites and eight or more offshore locations.

The EU Emissions Trading System (ETS)[17] has put a price on CO_2 emissions and, since 2013, has incentivised the capture of CO_2 for permanent storage in the EU and the European Economic Area (EEA). Recently, the EU ETS reform brought in several changes to support industrial carbon management, including a broadened scope of CO_2 transport for storage and incentives for the uptake of synthetic fuels in the aviation sector. Furthermore, allowances for emissions considered to have been permanently captured and utilised do not need to be surrendered[18], providing more options for emitters to capture CO_2. The EU Innovation Fund, established with revenue generated by the EU ETS, already supports carbon capture and storage projects in the order of approximately 10 million tonnes of CO_2 per year becoming operational as early as 2027.

In 2021, the Commission set out aspirational 2030 objectives to reach a share of at least 20% sustainable carbon in the carbon used as feedstock in the EU chemical industry and to remove and permanently store at least 5 million tonnes of CO_2[19]. An EU certification framework for carbon removals[20], soon to be adopted by the co-legislators, is expected to ensure the environmental integrity of certified carbon removals.

[14] See Article 21 Access to transport and storage infrastructure of Directive 2009/31/EC.
[15] Regulation (EU) 2022/869.
[16] Projects of Common Interest (PCIs) are key-cross border infrastructure projects that link the energy systems of EU countries (link).
[17] Directive 2003/87/EC.
[18] This includes the CO_2 used for the production and use of renewable fuels of non-biological origin.
[19] COM(2021) 800.
[20] COM(2022) 672 final.

Furthermore, the proposed Net Zero Industry Act (NZIA)[21] recognises carbon capture and storage as strategic net-zero technologies and supports project deployment with regulatory measures, including accelerated permitting procedures. The proposal also includes a target for the EU to have available capacity to annually store 50 million tonnes of CO_2 by 2030 and mandates oil and gas producers to invest in those initial infrastructures, recognising the sector's specific know-how in this field.

Based on these policies, 20 Member States have already included industrial carbon management solutions in their draft national energy and climate plans (NECPs).[22] In their draft plans, Member States project that annually a volume of up to 34.1 million tonnes of CO_2 will be captured in 2030, of which 5.1 million tonnes from biogenic sources[23]. This compares with an overall injection capacity estimated by Member States of 39.3 million tonnes per year in 2030[24]. According to the submitted draft NECPs, CO_2 would be captured mainly from process emissions, especially in the cement, steel and natural gas processing sectors. Member States also prioritise carbon capture in the production of electricity, especially from biomass, and in the production of low-carbon hydrogen. Other applications for carbon capture reflected in the NECPs are in the refining sector, waste incineration and thermal heat production.

Seven Member States have also included these technologies in their recovery and resilience plans. Denmark and the Netherlands already have functioning national subsidy schemes for carbon capture and have accelerated action to make CO_2 storage available. Together with Norway and Iceland, these four countries are pioneering the geological storage of CO_2 on an industrial scale and are seeing increasing commercial interest in both onshore and offshore storage licenses. France, Germany and Austria are currently developing carbon management strategies.

To support carbon capture and use, a stakeholder dialogue platform, the CCUS Forum[25], was set up in 2021. Working groups under the CCUS Forum focused on key issues in connection with the development of the carbon management market: infrastructure (including an expert group on CO_2 specifications/standards), public perception and industrial partnerships[26]. The Commission intends to continue drawing on this platform in the future work on industrial carbon management.

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[21] Proposal for a regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act), COM(2023) 161.

[22] Member States have different priorities, Germany, Hungary, Lithuania, Portugal (CCS & CCU), Cyprus, Czechia, Denmark, Estonia, Greece, Spain, France, Croatia, Italy, Netherlands, Romania, Sweden, Slovenia, Slovakia (CCS), Finland, Luxembourg (CCU).

[23] Based on the draft National Energy and Climate Plans (NECP) submitted by 30 June 2023 (COM(2023) 796 final), Belgium, Czechia, Denmark, France, Greece, Italy, Lithuania and Netherlands project annually capture of CO_2 from as early as 2025, in total Member States project to capture 34.1 Mt CO_2 annually by 2030, of which 5.1 Mt CO_2 from biogenic sources.

[24] In their draft NECPs, only Denmark, Italy and Netherlands have estimated annual CO_2 injection capacity available in 2030, additional Member States are currently undergoing or planning to conduct assessments of their potential geological capacity.

[25] Link.

[26] Link.

Despite the policies supporting industrial carbon management and the projects planned, operational large-scale projects are limited in Europe. Furthermore, today's experience reveals a number of challenges, notably;

- difficulties in building a viable business case, including because of significant up-front investment capital required, uncertainty of future CO_2 prices and the need for extra attention for matching supply and demand for low-carbon products,
- the lack of a comprehensive regulatory framework across the entire value chain, notably for industrial carbon removals and for certain CO_2 uses.
- The first businesses involved in building carbon value chains also face CO_2-specific cross-value chain risks, such as liability for leakages or the unavailability of transport or storage infrastructure.
- Insufficient coordination and planning, especially in cross-border contexts.
- Insufficient incentives for private and public investment to proof the business case for industrial carbon management.

In general, governments across the EU still need to recognise carbon capture and storage as a legitimate and necessary part of the solution to decarbonise.

This strategy addresses each of these challenges, based on the steps already undertaken and the political and economic case for a more ambitious industrial carbon management in Europe.

3. A vision for the European approach to industrial carbon management

A common approach and vision are needed to establish a single market for industrial carbon management solutions as a key building block to achieve climate-neutrality in 2050. This includes an enabling business and investment framework, boosted with more ambitious and well-coordinated policies at national level, as well as strategic infrastructure planning at EU level, underpinned by close cooperation between the EU and national administrations and also businesses, civil society and research communities.

To achieve this, Europe will have to deploy large-scale carbon value chains in Europe to support the different stages of industrial carbon management.

The EU's strategic objective for 2030 is the deployment of CO_2 storage capacity of at least 50 million tonnes per year[27] together with related transport modes consisting of pipelines, ships, trains and trucks, depending on each business case.

The 2030 targets for the uptake of renewable hydrogen in industry and transport will incentivise the use of CO_2 for the production of methanol and e-fuels. The first CO_2 infrastructure hubs and industrial clusters are expected to emerge in Europe, serving CO_2 capture projects supported by national and EU funding programmes, for which many rely on cross-border CO_2 transport. In this early phase of CO_2 transport development, the majority of CO_2 transport will take place

[27] COM(2023) 161 final.

through alternative forms of transportation to the coast, followed by shipping to offshore storage locations. Alongside these CO_2 infrastructure hubs, the first commercial off-take agreements for CO_2 capture and storage are being signed, especially for the industrial facilities where carbon capture costs are relatively low. Investments in these hubs will be facilitated by new EU-wide CO_2 transport infrastructure interoperability rules, including minimum CO_2 quality standards to ensure it can flow freely across the EEA.

By 2040, most carbon value chains should become economically viable to meet EU climate objectives based on CO_2 as a tradable commodity for storage or use within the EU's single market. Up to a third of the captured CO_2 could be used. These value chains would need EU-wide transport and storage infrastructure with pipelines being the main means of transport, as well as shipping options. Infrastructure enables the cross-border transport of captured CO_2 either for storage or for use, based on a regulatory environment that guarantees non-discriminatory access to competitive services of transport and storage. Capturing hard-to-abate CO_2 emissions in industrial sectors would become the norm, including all relevant remaining sources of industrial process emissions. To meet the 2040 net GHG emission reduction objective, the capture levels of biogenic and atmospheric CO_2 should already be comparable to the capture of fossil CO_2 by 2040, and eventually exceed those levels (see Figure 1).

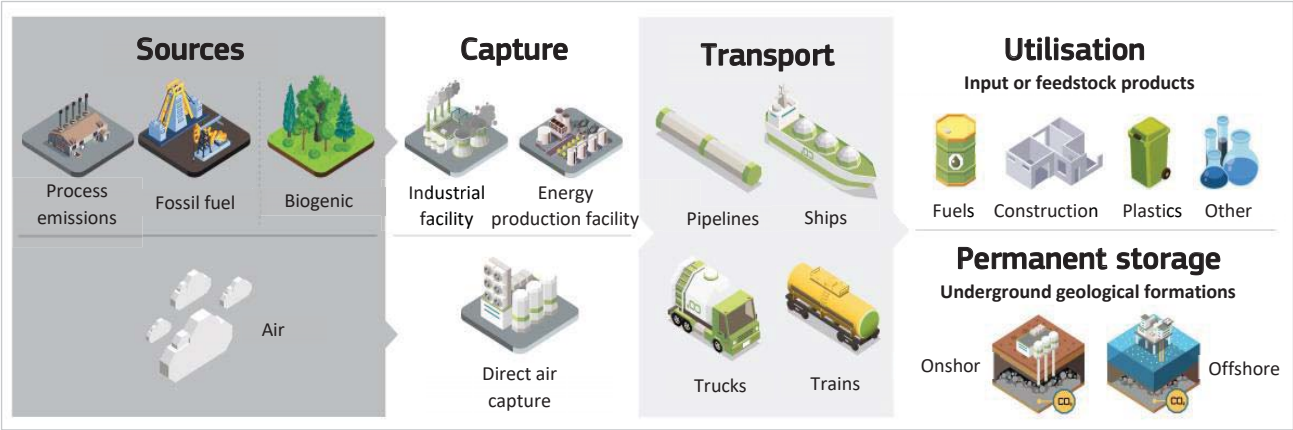
After 2040, industrial carbon management should be an integral part of the EU's economic system, and biogenic or atmospheric carbon should become the main source for carbon-based industrial processes or transport fuels. Any remaining fossil-based CO_2 would need to be captured, and a strong business case for negative emissions would be in place.

Achieving this vision of a well-functioning and competitive market for captured CO_2 requires partnership with industry and Member States, and ressources to develop a coherent policy framework that provides regulatory certainty and incentives for investments in carbon capture, storage, use and carbon removals. They are technologies indispensable to achieve climate neutrality and to underpin efficient infrastructure investments in transport and storage infrastructure.

4. Envisaging a policy framework to deploy industrial carbon management solutions

The capture of CO_2 emissions is the common starting point for all industrial carbon management pathways: carbon capture and storage (CCS), carbon removals and carbon capture and utilisation (CCU). In addition, CO_2 transport infrastructure is needed, on top of local use and storage of CO2, to enable the establishment of the different pathways and to create a single market for CO_2 in Europe.

Figure 2: Description of the CO_2 value chains



4.1 Deploying transport infrastructure for a single market for CO_2

Transport of CO_2 is already a commercial activity, however, the volumes moved by various modes of transport and local networks are very small compared with the future needs of industrial carbon management.

Emitters capturing CO_2, utilisation companies and storage site operators should be able to rely on a functioning cross-border, open-access CO_2 transport network as such networks are currently not regulated at EU level. All CO_2 transport modes are covered by the EU ETS, but accounting and liability rules need to be developed for emissions from all modes within this framework.

To build a market catering for the needs of developing CCS, CCU and industrial carbon removals, significant investments will be needed. A Commission study estimates that CO_2 transport network, including pipelines and shipping routes, could span up to 7300 km and deployment could cost up to EUR 12.2 billion in total by 2030, rising to around 19 000 km and EUR 16 billion in total by 2040[28]. Several challenges need to be overcome to mobilise investment and deploy such an extensive transport network.

While pipelines are in many cases the most common transport option for CO_2, initial capital costs of building them are high and with long lead times. Before 2030, shipping of CO_2 will be an important option, but this requires the availability of a fleet of specialised CO_2 transport ships. Uncertainty regarding future CO_2 volumes, complicated coordination across the value chains, and long permitting procedures constitute significant barriers for investors to move ahead with the projects. In addition, large-scale cross-border transport infrastructure will require handling

[28] The medium estimates provided here, for the purpose of this strategy, are based on the 2040 modelling figures. For the overall JRC study, estimates also include Fit-for-55 modelling, and could therefore be different. Tumara, D., Uihlein, A. and Hidalgo González, I. Shaping the future CO_2 transport network for Europe, European Commission, Petten, 2024, JRC136709.

CO_2 streams from different sources, captured with different technologies and using different transport means and different storage sites, which calls for ensuring interoperability.

Going forward, minimum CO_2 stream quality standards will be needed to avoid market fragmentation[29]. The standardisation work should address issues such as composition, purity, pressure and temperature. In addition, common guidelines are needed regarding 'incidental associated substances from the source, capture or injection process' that can be accepted in CO_2 storage permits[30]. This would support a fair market by creating a balance between cost effectiveness and risks, as different CO_2 purity levels come with different costs, while preventing significant risk to the environment.

Carbon capture installations located away from industrial hubs and storage sites and smaller emitters lacking sufficient CO_2 volumes to interest transport operators risk being excluded from the market altogether, which could significantly undermine decarbonisation. Specific solutions are needed to meet the needs of such sites and of vulnerable regions and increase their negotiating power with network operators and to ensure a just transition leaving no one behind.

Transport infrastructure is required to create a single market for CO_2 in Europe. Developing a non-discriminatory, open-access, transparent, multimodal, cross-border CO_2 transport and storage infrastructure requires coordination across the value chain, contract and price transparency and timely permitting.

Given the potential size of this market as evidenced in the analytical work[31], a dedicated policy and regulatory framework will be necessary to optimise its development and ensure harmonisation across Europe, in line with EU competition rules.

To optimise the benefits of capital spent on infrastructure, a future framework would also need to look at interactions with the electricity, gas and hydrogen sectors and the need for future spare capacity, including the mapping of the potential repurposing and re-use of existing infrastructure for CO_2 streams. The aim is to ensure system integration and to promote flexibility and resilience in the EU energy system. Such network planning across the EU should be based on a participatory approach, as taken in the electricity and gas sectors, where stakeholders provide input through consultation processes. To support early CO_2 (cross-border) infrastructure projects, the Commission will consider, in close engagement with industry, nominating European coordinators to address issues such as particular difficulties or delays and to inform the development of fit for purpose regulatory framework. The CCUS Forum will provide input to this work with the JRC underpinning the process with its work on pan-European CO_2 transport infrastructure development[32].

The Commission foresees to:

[29] An interoperable CO_2 transport network – towards specifications for the transport of impure CO_2 (link).
[30] In line with Article 12(2) of Directive 2009/31/EC.
[31] ENTEC study - EU regulation for the development of the market for CO_2 transport and storage (link).
[32] Tumara, D., Uihlein, A. and Hidalgo González, I. Shaping the future CO_2 transport network for Europe, European Commission, Petten, 2024, JRC136709.

- *from 2024, initiate preparatory work in view of a proposal for a possible future CO_2 transport regulatory package; it will consider issues including market and cost structure, cross-border integration and planning, technical harmonisation and investment incentives for new infrastructure, third-party access, competent regulatory authorities, tariff regulation and ownership models.*

- *from 2024, work towards proposing an EU-wide CO_2 transport infrastructure planning mechanism in cooperation with Member States and the CCUS Forum stakeholder platform. The work related to network planning will also assess to what extent it is possible to reuse/repurpose existing infrastructure for CO_2 transport and storage, when considering the priority for infrastructure needs of renewable gases, and if so, what regulatory changes are needed.*

- *from 2024, consider, in close engagement with industry, nominating European coordinators to support the early development of (cross-border) infrastructure projects.*

- *develop emissions accounting rules in the context of the EU ETS to enable all means of transport of CO_2, and ensure liability for leakage.*

- *work with the European standardisation bodies to establish minimum standards for CO_2 streams to be used in a network code, applicable to all industrial carbon management solutions, and in addition in cooperation with Member States to consider guidelines on 'incidental associated substances" to ensure the integrity of the infrastructure and reservoirs.*

- *promote through the International Maritime Organization the development of any necessary guidelines on safe transportation of CO_2 by sea.*

4.2 Capturing and storing CO_2 emissions instead of releasing to the atmosphere

Carbon capture and storage includes applications where CO_2 is captured and permanently stored. According to the Impact Assessment underlying the EU's 2040 Climate Target Communication, CCS must be deployed at large scale to complement other mitigation actions to address hard to abate emissions, in particular industrial process emissions, and to achieve climate neutrality by 2050.

As for most other industrial carbon management pathways, it starts with capturing hard-to-abate industrial CO_2 emissions instead of releasing them to the atmosphere. The ETS carbon price provides an incentive to capture CO_2 generated from fossil fuel and industrial process emissions. This incentive is expected to grow as a result of the last reform, as the ETS emissions cap is steadily decreasing further, setting a strong price expectation for carbon in the EU.

Today industrial companies throughout the EU are reviewing strategic options to transform their production processes into net-zero emission operations in order to lower costs and offer low- or zero-carbon end products to the market. Industrial sectors whose process emissions are hard-to-

abate (e.g. cement) are increasingly developing investment plans to capture CO_2 either for reuse to produce fuels/chemicals (CCU) or to permanently store it (CCS)[33].

Investment decisions depend on the development of markets for low- or zero-carbon end products and the availability of a full CO_2 value chain with capture, transport, utilisation or storage services offered at competitive prices.

The Commission will work towards establishing by 2026 an EU CO_2 aggregation platform that supports companies capturing CO_2 to procure CO_2 value chain services. The objective is to facilitate matching storage demand and storage availability in terms of time and locations, while contributing to security of storage supply in terms of volume and affordability[34]**.** This platform could also provide contracting and procurement transparency and give transport and storage providers information on infrastructure planning. This is particularly relevant for capturing companies with less bargaining power.

Carbon capture and storage requires not only capturing the CO_2 but also storing it permanently. Developing storage sites to meet the 2030 target for injection capacity will need support from and dialogue with permitting authorities. The application processes for storage permits are ongoing in only four Member States,[35] but eight Member States project that in total 15.2 million tonnes CO_2 annually will be captured starting as early as 2025, which underlines the urgent need to open operational CO_2 storage capacity before 2030[36].

This underlines the importance of early engagement between permit applicants and competent authorities during the preparatory phase of strategic net-zero CO_2 storage projects and highlights the need for further economic incentives to identify and build more storage capacity. It will also be important that all Member States complete their analysis of capture needs and storage options in the final National Energy and Climate Plans in line with the Commission recommendations.[37]

The business case for developing critical CO_2 storage infrastructure extends beyond the immediate goal to reduce emissions over the next decades as it has the potential to contribute to economy-wide negative emissions even after 2050. As a first step, Member States should recognise and support storage sites and related capture and transport infrastructure as net-zero strategic projects under the NZIA to ensure sufficient access to injection capacity for hard-to-

[33] This includes companies that have applied to the Innovation Fund, which in total have plans to capture more than 20 million tonnes of CO_2 by 2030.

[34] In comparison to AggregateEU for LNG and gas, which relies on existing gas market infrastructures (e.g. virtual trading points or LNG terminals), the CO_2 platform will have to address longer timelines, as the deployment of new CO_2 infrastructures and capture installations takes time, but also relies on contractual certainty.

[35] The latest Implementation Report of the CCS Directive (COM(2023) 657 final) shows that as of April 2023 two thirds of Member States allow CO_2 storage on their territories, and half of them have engaged in discussions about cross-border cooperation in view of ensuring CO_2 flows to the planned storage sites in the EEA.

[36] Based on the draft National Energy and Climate Plans (COM(2023) 796 final), Belgium, Czechia, Denmark, France, Greece, Italy, Lithuania and Netherlands project annually capture of CO_2 from as early as 2025, while in total Member States project to capture 34.1 Mt CO_2 annually by 2030, of which 5.1 Mt CO_2 from biogenic sources.

[37] For more information see section "2.5 Integrating long-term geological storage of CO_2" in the Commission Notice on the Guidance to Member States for the update of the 2021-2030 national energy and climate plans (2022/C 495/02).

abate CO_2 emissions. This would incentivise industrial carbon management value chain clusters aimed at pooling initial capture volumes to de-risk storage site investments.

To lower the upfront costs for storage investors, Member States can consider aggregating financial security required from CO_2 storage operators in the form of levies per volume of CO_2 stored, taking account of the low-risk degree CO_2 storage in comparison with, for instance, hydrocarbon production operations[38].

Detailed CO_2 emission reduction roadmaps should be co-designed and implemented at sectoral level, taking into account the complexity of industrial processes. The knowledge-sharing platform for industrial CCUS projects is the appropriate platform for sectoral roadmaps if the use of industrial carbon management is involved.

Based on the modelling of the impact assessment for the 2040 climate target, an increase in the annual CO_2 injection capacity for geological storage to at least 250 million tonnes of CO_2 per year in 2040 in the European Economic Area would be needed[39]. To do this, the EU needs to identify and develop its potential CO_2 storage capacity and to ensure that CO_2 transport and storage infrastructure capacities are scaled to meet the growing needs of industrial capture and storage post 2030.

The Commission will therefore kickstart work to create an EU-wide investment atlas of potential CO_2 storage sites. Following a stocktake of data needs and human and fiancial resources already available, the Commission will compile a digital inventory of the underground storage of CO_2, building on the work of European geological surveys.[40] Each potential storage site will be labelled according to its 'storage readiness level' and matched with public data to speed up the work to identify and assess the storage capacities.[41]

Geological services in the EEA should be resourced and able to aggregate all existing subsoil knowledge. Where available, this should include technical information such as well samples, geophysical behaviour, seismic data from hydrocarbon production sites and early CO_2 storage sites. Investors should be able to use this atlas to identify potential storage opportunities as part of CO_2 value chains.

In addition, CO_2 storage permitting procedures need to be well-defined, made transparent and comparable across the EU. The Commission will support Member States in rolling out recognised net-zero strategic projects for industrial carbon management, including in tackling CO_2-specific cross-value-chain liability risks for operators.

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[38] In line with Article 19 of Directive 2009/31/EC Member States can decide relevant arrangements.

[39] Modelling results from Impact Assessment underlying the EU's 2040 Climate Target Communication (SWD(2024) 63) show that the EU needs to capture 200 million tonnes of CO_2 annually for storage by 2040 with the need for a higher annual CO_2 injection capacity to take account of normal maintenance downtimes. This annual injection capacity requires an aggregated geological storage capacity of several giga-tonnes of CO_2 in the EEA.

[40] For example, the European CO_2 Storage Atlas developed in 2013 by the CO_2 Storage Potential in Europe Project (CO_2StoP project) and hosted by the JRC (link) presents a good basis, but also shows that data gaps need to be closed.

[41] Which could be made available through the Commission's Energy and Industry Geography Lab, (link).

On the basis of the strategic sites that will provide the first 50 million tonnes of annual storage capacity by 2030, the Commission will develop guidelines for CO_2 storage permitting, balancing site-specific flexibility with investment predictability to facilitate and speed up the roll out of CO_2 storage.

The Commission foresees to:

- *develop, with Member States, by early 2026 at the latest, a platform for demand assessment and demand aggregation for CO_2 transport or storage services, with the aim of matching CO_2 suppliers with storage and transport providers and providing contract and procurement transparency*

- *aim to create and make available by early 2026, in cooperation with the geological services of the EEA, an investment atlas of potential CO_2 storage sites based on a common storage readiness level format.*

- *use the knowledge-sharing Platform for industrial CCUS projects to develop together with industry sectoral roadmaps for industrial carbon management.*

- *develop, with Member States, by 2025 step-by-step guidance for permitting processes for net-zero strategic projects for CO_2 storage, notably regarding:*
    - *the transfer of responsibility from operators back to the competent authorities and the corresponding financial security and financial mechanism requirements;*
    - *transparency on the permitting requirements and risk-based approaches to facilitate final investment decisions by storage operators.*

Member States should:

- *include in their updated National Energy and Climate Plans their assessment of capture needs and storage capacity/options and identify actions to support the deployment of a CCS value chain.*

- *by 2025, ensure that they have transparent processes in place for storage permit applicants to engage with the competent authorities during the preparatory phase.*

- *from 2024 onwards, support the development and roll out of cooperative net-zero strategic projects under the NZIA to create full carbon capture, transport and storage value chains, including across borders.*

- *by 2025 at the latest, enable their geological services to contribute existing data and to generate new data to contribute to an EEA-wide investment atlas of potential CO_2 storage sites.*

4.3 Removing CO_2 from the atmosphere

Industrial carbon removals value chains are key to achieving the carbon neutrality objective enshrined in the European Climate Law.[42] To reach net-zero economy-wide GHG emissions by 2050, the EU could need carbon removals to balance out around 400 million tonnes CO_2 equivalent of residual emissions in hard-to-abate sectors such as agriculture, aviation and some industries.[43] Nature-based carbon removal solutions will play an essential role in this, but they will not be sufficient. Industrial carbon removals will also be needed to achieve this goal.

Industrial carbon removals based on CCS technology capture CO_2 directly from the atmosphere (DACCS) or capture biogenic CO_2 from power plants or industrial processes (BioCCS) and store it permanently contrary to non-permanent removal solutions such as reforestation, soil carbon sequestration, or bio-based building material. However, industrial carbon removals face high costs and entail large energy requirements (DACCS) or strong needs for natural resources (BioCCS) that can raise concerns around sustainability if not properly addressed. The deployment of both permanent and non-permanent carbon removals requires incentives that consider their specific characteristics.

Industrial carbon removals are not currently covered by the EU ETS Directive nor the Effort Sharing[44] or the Land, Land Use Change and Forestry (LULUCF)[45] regulations. Since the EU ETS does not recognise negative emissions, capture and storage of biogenic and atmospheric CO_2 is not incentivised by the EU compliance carbon market price, and currently the only incentive at EU level comes from the Innovation Fund. In this context, investment decisions for this type of operations mainly rely on state subsidies or voluntary carbon markets. The voluntary EU carbon removal certification framework, accounting for life cycle emissions of carbon removals activities, will help mobilise financing while ensuring the environmental integrity of carbon removals but it is important that the Commission assesses how best to provide incentives for industrial carbon removals in existing EU legislation or through new instruments.

As carbon removals will be instrumental in achieving the 2040 objective and climate neutrality by 2050, setting specific objectives for carbon removals could be considered, if necessary, in line with the overall EU net GHG emission reduction objective for 2040.

The Commission has already been mandated by the co-legislators to assess by 2026 if and how the CO_2 removed from the atmosphere and safely and permanently stored could be accounted for and covered by emissions trading[46]. This must be achieved without offsetting emission reductions and while ensuring environmental integrity, especially regarding the use of sustainably sourced biomass for BioCCS.

This could be done either by integrating industrial carbon removals in the EU ETS (a single market where the generation of industrial removals to comply with surrender obligations is

[42] Regulation (EU) 2021/1119.
[43] Impact Assessment underlying the EU's 2040 Climate Target Communication (SWD(2024) 63).
[44] Regulation (EU) 2023/857.
[45] Regulation (EU) 2018/841.
[46] See Article 30 of Directive 2003/87/EC.

allowed with or without restrictions) or by creating a separate compliance mechanism for such removals, connected directly or indirectly to the EU ETS. As a result, this would create price-based incentives for the generation of industrial carbon removals.

Initially, one of the main challenges would be to overcome the significant current difference between the prevailing carbon price and the cost of removing CO_2 through industrial solutions. Although the cost for some BioCCS installations may not be much higher than for capture and permanent storage of fossil fuel and process CO_2 emissions[47], for other types of removals, such as direct air carbon capture and storage, the estimated future costs range from EUR 122 to EUR 539 per tonne of CO_2[48], well above the current ETS price. Integration in the EU ETS pricing system alone might thus be an insufficient incentive for industrial removals. At an early stage of deployment, additional support will be required to accelerate technological learning and reduce costs further. In this context, it would also be important to look at the role of the Member States in developing industrial carbon removals.

At the same time, it will be important to accelerate research, development and demonstration to advance new carbon removal technologies and lower their costs. Since different removal technologies are at different stages of maturity, tailored programmes will be needed to guide the development. The Commission will use its existing instruments to support industrial carbon removal technologies. Specifically, the Horizon Europe programme will focus on stepping up research to improve the efficiency and feasibility of removal technologies, notably direct air capture technologies, as well as their commercialisation and scale-up to market with support from the European Innovation Council. The Innovation Fund will continue to support clean technologies to help scale up carbon removals.

The Commission foresees to:

- *assess overall objectives for carbon removals needs in line with the EU's 2040 climate ambition and the goal to reach climate neutrality by 2050 and negative emissions thereafter.*
- *develop policy options and support mechanisms for industrial carbon removals, including if and how to account for them in the EU ETS.*
- *in parallel, boost EU research, innovation and early-of-a-kind demonstration for novel industrial technologies to remove CO_2 under Horizon Europe and the Innovation Fund.*

[47] For example, current estimates suggest a future cost of BECCS (including storage) of around EUR 52-134/tCO_2 (original values in USD. 1 USD = EUR 0.92). In Bednar, Johannes & Höglund, Robert & Möllersten, Kenneth & Obersteiner, Michael & Tamme, Eve. (2023). The role of carbon dioxide removal in contributing to the long-term goal of the Paris Agreement.
[48] Ibid.

4.4 Using captured CO_2 as a resource to replace fossil fuels in industrial production

Capturing CO_2 and recycling it to produce advanced synthetic fuels, chemicals, polymers or minerals is another important and innovative aspect of an industrial carbon management value chain. It also contributes to the circular economy model, which will gain further importance under the climate action framework up to 2040. The production of chemicals and materials still relies heavily on fossil-based feedstocks, which will be gradually substituted by alternative feedstocks, like sustainable biomass, recycled waste and captured CO_2[49]. So, by replacing fossil-based feedstocks, CCU can contribute to emission reduction, energy security and autonomy of the EU.

Moreover, CCU promotes industrial symbiosis and better integration of processes within industrial clusters. To this end, CCU related infrastructure should be implemented in a decentralised way, connecting sources of industrial emissions to production sites across value chains at local level, without necessarily requiring large CO_2 transport infrastructure. Access to hydrogen is also needed to enable CCU technologies. Therefore, synergies between CCU applications and hydrogen networks can play a key role to boost decarbonisation. However, the benefits of these CO_2 utilisation technologies are not yet fully recognised, nor is their capacity to provide an alternative source of carbon to replace fossil carbon in specific sectors of the EU economy that are carbon-dependent. The assessment of the full climate benefit of each CCU application as alternative to a fossil-based product will have to take into account the energy consumption to power this energy-intensive process.

Certain uses of captured CO_2 in products are supported by legislation[50]. These rules encourage the deployment of CCU-based fuels to replace fossil fuels in key sectors, with safeguards in place to ensure that they provide the required minimum GHG emission savings.

The ETS Directive provides a maximum of 20 million allowances from 2024 to 2030 to be allocated for free to aircraft operators to cover the remaining cost-difference for the deployment of renewable fuels of non-biological origin and sustainable alternative fuels[51]. The ReFuelEU aviation[52] rules also require, from 2030, renewable fuels of non-biological origin (RFNBO) to cover also synthetic fuels produced with renewable energy through CCU. Similarly, the FuelEU Maritime Regulation[53] puts in place a special incentive regime to support the uptake of RNFBOs[54]. The use of such CCU fuels will also be recognised in the EU ETS to avoid double counting the embodied carbon emissions.

The 2023 revision of the EU ETS Directive also acknowledges the permanence of carbon storage in certain types of products. The Commission is preparing a delegated act to specify the conditions under which permanent storage can be recognised, to put permanent CCU and CCS

[49] Transition pathway for the chemical industry (link)
[50] Directive (EU) 2018/2001 and Commission Delegated Regulation (EU) 2023/1185.
[51] Article 3c(6) of Directive 2003/87/EC.
[52] Regulation (EU) 2023/2405.
[53] Regulation (EU) 2023/1805.
[54] The FuelEU Maritime Regulation also provides a review clause for the possible inclusion of carbon capture and temporary storage onboard ships.

on an equal footing in the ETS. Consistent with the EU ETS framework, the EU carbon removal certification framework will give the option to certify carbon removals generated by industrial activities storing atmospheric or biogenic carbon in products in a manner that prevents the carbon to be re-emitted to the atmosphere.

However, additional measures are needed to recognise the potential climate benefits of using sustainable carbon from captured CO_2 rather than fossil carbon for other applications. In the chemical industry, captured CO_2 could be used as feedstock to substitute fossil-based feedstocks, e.g. in the manufacturing of polymers, plastics, solvents, paints, detergents, cosmetics and pharmaceuticals. The annual carbon demand for the chemical sector alone in Europe is currently estimated around 125 million tonnes, or about 450 million tonnes CO_2 equivalent, more than 90 % of which is supplied with fossil carbon[55].

It is crucial to promote sustainable carbon cycles and significantly decrease the reliance of the chemical industry on fossil feedstocks and to make use of sustainable carbon sources in those sectors where they are most needed and can achieve the highest climate benefit. It can be done by supporting circular models, harnessing a circular and sustainable EU bioeconomy and stimulating the use of captured CO_2 as a new carbon resource, while taking into account the related energy requirement and cost challenges.

To play a significant role in the EU economy, existing structural challenges and regulatory barriers to the deployment of CCU technologies need to be identified and addressed. There needs to be a framework for CCU that tracks the source, transport and use of several hundred million tonnes of CO_2. It should ensure environmental integrity, including liabilities for CO_2 leakage, and create a price incentive that accurately reflects the climate benefit of a solution across the industrial carbon management value chain.

To provide an efficient and effective incentive, the framework must build on a robust and transparent accounting system that gives every operator in the value chain a clear and direct incentive for action that is not dependent on the actions of other upstream or downstream operators.

The 2026 review of the EU ETS will assess several issues, including whether the EU ETS accounting system ensures that all emissions are accounted for and avoids double counting when CO_2 captured is used in products that are not considered as permanent in an ETS context. It will assess whether the CO_2 potentially released from non-permanent CCU products and fuels should be accounted at the point of emission to the atmosphere (‘downstream accounting’) or when the CO_2 is initially captured (‘upstream accounting’).

The 2026 review of the EU ETS will also assess the feasibility of including municipal waste incineration installations in the EU ETS, and the possibility of including other waste management processes, in particular landfills, taking into account relevant criteria such as environmental integrity and alignment with the objectives of the circular economy and the Waste

[55] Kähler, F., Porc, O. and Carus, M. 2023. RCI Carbon Flows Report: Compilation of supply and demand of fossil and renewable carbon on a global and European level. Editor: Renewable Carbon Initiative, May 2023. (link).

Directive[56]. It would assess in particular whether including these sectors in in the EU ETS could help recognise non-permanent CCU as a pathway to reduce surrender obligations by pricing emissions downstream.

The Sustainable Carbon Cycles Communication[57] also set the objective of achieving 20% of the carbon used in the chemical and plastic products originating from sustainable non-fossil sources by 2030. To achieve this objective, action is needed to develop with the chemical industry a pathway for production routes that substitute fossil carbon with sustainable carbon.

Achieving these objectives will require support for innovative technologies that capture CO_2 from the atmosphere or from industrial waste streams and turns it from a pollutant into a valuable resource. The captured CO_2 can then be converted to all sorts of sustainable products, including fuels, chemicals or mineral materials.

Such support should be available for technologies at all levels of technological readiness. It should draw on the Horizon Europe programme for exploratory research, the European Innovation Council for CCU applications that have already achieved a certain level of maturity and the Innovation Fund for pre-commercial projects with the potential for scale-up.

The Commission foresees to:

- *assess demand pull options, in concertation with industries, to increase the uptake of sustainable carbon as a resource in industrial sectors in full consideration of the Commission's upcoming Biotech and Biomanufacturing initiative.*
- *use the knowledge-sharing Platform for industrial CCUS projects to co-develop with industries sector specific roadmaps on CCU activities.*
- *draw up a coherent framework to account for all industrial carbon management activities that accurately reflect the climate benefits across their value chains, and to incentivise the deployment of innovative and sustainable permanent and non-permanent CCU applications, while removing barriers.*

5. Creating an enabling environment for industrial carbon management

To unlock the full potential of industrial carbon management, favourable conditions need to be created for the development of every element of the carbon value chain. This implies not only fit-for-purpose regulation, but also investment and funding, both for research, innovation and early deployments. Certainty for investors and viable business cases also requires public understanding and awareness of industrial carbon management solutions. Finally, as the cross-border dimension is crucial for the scale up of industrial carbon management, international

[56] Directive 2008/98/EC.
[57] COM(2021) 800 final.

cooperation will be necessary to maximise the potential of mitigating emissions in Europe and beyond.

5.1 Investing and funding the clean carbon transition

The proposed NZIA target of 50 million tonnes of annual CO_2 storage capacity by 2030 requires approximately EUR 3 billion investments in carbon storage facilities, depending on the locations and capacity of the geological storage sites[58]. Furthermore, a Commission report estimates investment needs for the transport infrastructure of pipelines and ships associated with the NZIA target at between about EUR 6.2 and 9.2 billion by 2030[59]. Finally, the capture costs from point sources are estimated to range from EUR 13/t and EUR 103/t of CO_2 depending on the industry, capture technology and CO_2 concentration. In addition, a report prepared by industry stakeholders for the CCUS Forum estimates a funding shortfall of cumulatively EUR 10 billion by 2030 for currently announced CCS projects[60].

Beyond 2030, the Commission estimates that the required investment needs in CO_2 transport infrastructure would rise to between EUR 9.3 and 23.1 billion in 2050 to meet the 2040 and 2050 objectives, set out in the EU's 2040 climate target communication.

Despite increasing investment needs, the CCUS Forum report expects that a commercially viable market will begin to take shape after 2030, where investors can earn a competitive return on invested capital based on the EU carbon price. The carbon price signal in the EU ETS will be key to make CCS projects commercially viable, factoring in the costs of capture, transport and storage of CO_2 on the one hand and the price of emitting the same amount of CO_2 on the other hand.

Additionally, the introduction of tariffs, new financing instruments, guarantees and risk instruments would be required to facilitate investments. Ultimately, these investment needs are set against an estimated extrapolated theoretical market potential of captured CO_2 in the EU of between 360 and 790 million tonnes of CO_2, which could generate between EUR 45 billion and EUR 100 billion in total economic value of the future CO_2 value chain in the EU from 2030 onwards and help create between 75 000 and 170 000 jobs[61].

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[58] SWD(2023) 68 final, Investment needs assessment and funding availabilities to strengthen EU's Net-Zero technology manufacturing capacity.

[59] Tumara, D., Uihlein, A. and Hidalgo González, I. Shaping the future CO_2 transport network for Europe, European Commission, Petten, 2024, JRC136709.

[60] These projects add up to 80 million tonnes of CO_2 captured. A Vision for Carbon Capture, Utilisation and Storage in the EU prepared for the European Union's CCUS Forum by the CCUS Vision Working Group, April 2023 (link). The analysis is based on existing European and national funding available for CCS projects, and the investment needs based on the net present value of capture, transport and storage costs of projects in the CATF European carbon capture and storage database.

[61] SWD(2023) 219 final, staff working document for a Regulation of the European Parliament and of the Council on establishing a framework of measures for strengthening Europe's net-zero technology products manufacturing ecosystem (Net Zero Industry Act), based on "The potential of a European CCS market viewed from a Danish perspective", Kraka Advisory, March 2023.

In the period up to 2030, additional support at EU and national level is critical to developing and scaling up industrial carbon management solutions, including investments to develop the necessary skills. First-of-a-kind industrial carbon management projects are costly and final investment decisions depend on many factors. This includes the ability to combine public and private finance. Furthermore, coordination is needed between such projects and other stakeholders, in particular energy and transport operators, to lay the ground for final investment decisions.

Today, bridging grant funding mechanisms, including the EU ETS Innovation Fund, remain available to provide some financing for deployment of selected innovative large scale CO_2 projects. To date, the Innovation Fund has allocated support under the EU ETS Directive to 26 large- and small-scale CCS and CCU projects with more than EUR 3.3 billion in grants.

The Connecting Europe Facility (CEF) Energy is another key EU support mechanism for the development of cross-border energy and transport infrastructure projects. So far, CEF has granted around EUR 680 million to CO_2 projects of common interest.[62] Market-based finance for economically viable CCS and CCU projects can, in principle, also be supported under the InvestEU Fund[63].

Furthermore, the Recovery and Resilience Facility is available to Member States to support investments in carbon capture[64]. On State aid for industrial carbon management solutions, the Guidelines on State aid for climate, environmental protection, and energy[65] and the General Block Exemption Regulation[66] include conditions under which State aid for CCS and CCU investments would be permissible. CCS is also included in the EU sustainable finance taxonomy, a classification system developed to identify and define economic activities that are considered environmentally sustainable.[67] The European Investment Bank has included carbon capture and storage in its EUR 45 billion financing package to support the Green Deal Industrial Plan[68].

To close the gap between the carbon price and the cost of industrial carbon management projects, Member States can look at proposing 'Carbon Contract for Difference' (CCfD) schemes with subsidies covering the difference between a carbon reference price and an agreed 'strike price' representing the project's true costs[69]. This method of support provides a predictable revenue stream for project developers and is a good solution to de-risk investment.

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[62] Regulation (EU) 2021/1153.
[63] Due to the higher-risk nature of CCS and CCU projects, InvestEU Fund-supported finance of financial institutions could complement grant funding from other EU or national sources or could be provided as 'blending operations' combining resources from InvestEU and other Union programmes.
[64] For example, Denmark and Greece have included carbon capture projects in their resilience and recovery plans. State aid rules apply in the framework of the Facility.
[65] Communication from the Commission (2022/C 80/01). Guidelines on State aid for climate, environmental protection and energy 2022.
[66] Regulation 2014/651/EC.
[67] Regulation 2020/852/EC.
[68] EIB to support Green Deal Industrial Plan with EUR 45 billion in additional financing (link).
[69] Certain Member States have implemented CCfD schemes to provide targeted and necessary support for decarbonisation projects, including for carbon management deployments, in line with the applicable State aid rules.

To move beyond the initial stage with large-scale net-zero strategic projects, the carbon price signal in the EU ETS will be key to make CCS projects commercially viable, factoring in the costs of capture, transport and storage of CO_2 on the one hand and the price of emitting the same amount of CO_2 on the other hand.

Where public support is needed, an EU-wide mechanism under the Innovation Fund could be envisioned as a joint "auctions-as-a-service" support mechanism that would enable EEA countries to use their national budget to award support to projects located on their territory based on a EU-wide auction mechanism. This could accelerate projects in the single market and identify the most competitive and environmentally effective projects, in line with State aid rules and with sufficient competing national projects. A first competitive bidding mechanism is being pioneered under the Innovation Fund's pilot auction for renewable hydrogen production in the EU[70]. To participate in joint support mechanisms, interested countries must follow the State aid notification process[71].

In addition, the successful adoption of battery and hydrogen as important projects of common European interest (IPCEI) has shown that close cooperation with Member States and companies willing to undertake ambitious innovative or open infrastructure projects brings good results on complex cross-border integrated projects that are important due to their contribution to EU objectives.

In October 2023, the Commission launched a Joint European Forum for Important Projects of Common European Interest (JEF-IPCEI) to focus on identifying and prioritising strategic technologies for the EU economy that could be relevant candidates for future IPCEIs[72]. Member States may therefore make use of the JEF-IPCEI, which brings together experts from Member States and the Commission services, as a platform for coordinated and transparent selection and design of a possible IPCEI in the area of industrial carbon management.

The Commission foresees to:

- *work, as of 2024, with Member States in the transparent and coordinated design of a possible important project of common European interest for CO_2 transport and storage infrastructure via the JEF-IPCEI. To start the process as soon as possible, use the existing CCUS Forum platform to ensure good coordination, set the timing, monitor progress and maintain the pace of the project. Consider establishing a dedicated high-level platform to work beyond 2030.*

- *assess by 2025 whether certain CO_2 capture installations, such as cement or lime production facilities, are mature enough and sufficient competition may be expected to move from project-based grant support to a market-based funding mechanisms, such as competitive bidding auctions as a service under the Innovation Fund.*

[70] See: Competitive bidding: A new tool for funding innovative low-carbon technologies under the Innovation Fund, (link).
[71] In addition to joint support mechanisms, Member States retain the possibility to set up independent support schemes, in line with State Aid rules.
[72] Link.

- *engage, as of 2024, with the European Investment Bank on financing of CCS and CCU projects.*

- *facilitate investment needs in industrial carbon management up to 2040 and 2050, including by making smart use of public funding to leverage private investment.*

5.2 Public awareness

As industrial carbon management infrastructure projects are necessary for Europe to reach net-zero and will need public funding at least in the initial deployment phase, it is essential that Member States stimulate and support an inclusive, scientifically informed and transparent debate on all industrial carbon management technologies. Moreover, ensuring social, environmental, and health safeguards will be key in supporting responsible implementation and public adherence. The engagement of public authorities, project developers, NGOs and the civil society should take place before, during and after the policymaking and project implementation. It is essential to involve all stakeholders proactively so that it is not a one-way information process and to consider awarding local populations for hosting carbon management infrastructure.

Based on their identified decarbonisation objectives, Member States should engage all stakeholders working on national industrial carbon management strategies. In addition to stimulating a national debate on industrial carbon management in the context of the climate targets, such discussions should also set out the economic rationale behind the support for the technology and its application, the resulting opportunities and also the costs, safety and environmental concerns and risks, and regulatory actions addressing these concerns. These discussions should also take place internationally.

The Commission will use the CCUS Forum and other Commission fora, including the European Sustainable Energy Week, to stimulate public debate and increase public understanding and awareness on industrial carbon management. It will also contribute to the public debate at national and local levels by sharing data and experience from projects it supports, including under the Innovation Fund and the Trans-European Energy Networks.

The Commission will monitor public opinion on industrial carbon management, including through Eurobarometer surveys, and it will encourage Member States to measure public awareness at national level. EU research funding programmes on industrial carbon management will include topics on public perception.

The Commission foresees to:

- *work with Member States to specify operating conditions for CO_2 transport and storage projects that can reward local communities for hosting them.*

- *work with Member States and industry to increase knowledge, awareness and public debate on industrial carbon management.*

5.3 Research and innovation

Investments in research and innovation yield significant cost reductions. Stakeholders highlight a clear potential for innovation to drive efficiency and cost reductions and to improve integration. During the period 2007-2023, the Commission has invested more than EUR 540 million in innovative CCUS solutions through its successive framework programmes for research and innovation (FP7, Horizon 2020 and Horizon Europe). The Commission will continue to invest in research and innovation for all industrial carbon management technologies, including new solutions, to increase the availability of technologies on the market as well as meeting mid- and long-term targets.

Pre-normative research based on open data can contribute to standardisation work. For example, we currently lack a complete picture on the physical and chemical behaviour of impure CO_2. Research and innovation are needed to further optimise carbon capture technologies (e.g. purification) and increase its energy efficiency. Fundamental research is therefore needed, and concepts are also needed to track or monitor all relevant impurities. In cases such as this, access to readily available and open data is needed for research to support components for standardisation and help avoid overly strict limitations.

As a growing number of CCUS projects are on track to become operational before 2030, there is great value in aggregating these industrial-scale projects into a knowledge-sharing platform to facilitate the collection and sharing of information and best practices on and between CCUS projects in the EU. The Innovation Fund has already started this work with the projects that have received a grant. The current focus of the knowledge sharing is on lessons learned on how to reach final investment decisions, including matching capture and storage volumes, permitting and addressing inter-value chain risks.

In future, knowledge sharing will encompass capture technologies, transport and storage infrastructure, storage site characteristics, regulatory aspects, needs for standards, access to funding and stakeholder management. This will also cover lessons learned on public engagement and on sharing best practice of dialogues between project developers, local and national authorities. The knowledge sharing platform will be open to all projects that are ready to share information and cooperate without disclosing commercially sensitive information and in full compliance with single market competition rules.

The lessons learned from the industrial projects should feed back into national and European programmes for research and innovation to close knowledge gaps and accelerate the development of new technologies.

The Commission foresees to:

- *support a new collaboration and knowledge-sharing platform for industrial CCUS projects.*
- *continue to invest in R&I for industrial carbon management technologies, including*

energy and cost efficiency optimisation of processes and pre-normative research to contribute to standardisation.

5.4 Cross-border and international cooperation

The successful deployment of scalable industrial carbon management systems will also be required for our global partners and critical for meeting their targets under the Paris Agreement. For example, the United States uses its Bipartisan Infrastructure Law to support direct air capture and has increased the tax credits for carbon capture and permanent storage under the Inflation Reduction Act. The UK published its vision for carbon capture, use and storage in 2023, and aims to develop a market to capture 20-30 Mtpa of CO_2 by 2030.[73] The business opportunities for EU industries are therefore global in scale. Cooperation with other frontrunner countries with the aim of pricing carbon and reducing the costs of value chains will also provide opportunities to accelerate the pace of GHG emission reductions world-wide.

At the same time, there are clear opportunities to cooperate across borders. The first commercial cross-border agreement to capture CO_2 produced in the EU and ship it for storage in Norway has already been signed[74]. For Member States of the European Economic Area (EEA), the implemented EU legal framework is the relevant 'arrangement' between the Parties in the meaning of Article 6(2) of the international 1996 Protocol to the Convention on the Prevention of Maritime Pollution by Dumping of Waste and Other Matter, 1972 (the 'London protocol'). Accordingly, any operator of CO_2 transport networks and/or CO_2 storage sites can draw the full benefit of the EU's legal framework to import or export captured CO_2 within the EEA.

For the time being, the only way of extending such benefits to non-EEA countries would be to operate storage sites under an ETS that is linked with the EEA ETS[75] and under a framework that provides legal safeguards equivalent to the EU's CCS Directive.

A potential future recognition of CO_2 storage sites in third countries without a linked ETS would depend on there being equivalent conditions to ensure permanently secure and environmentally safe geological storage of captured CO_2, provided that the storage is not used to increase hydrocarbon recovery and that this leads to an overall reduction in emissions. EU candidate countries considering temporary carbon pricing systems - if linked with the ETS - present particular welcome potential for cooperation in the pre-accession period.

Internationally, the Paris Agreement requires parties to measure and report progress on their GHG emission reduction targets, and to account for their nationally determined contribution. This includes reporting on carbon removals by sinks and other industrial carbon management

[73] The White House (2023) Clean Energy Economy: A Guidebook to the Inflation Reduction Act's investments in clean energy and climate action, Jan. 2023 & Department for Energy Security and net Zero (2023), Carbon Capture Use and Storage: A vision to establish a competitive market, December, 2023.
[74] Yara invests in CCS in Sluiskil and signs binding CO_2 transport and storage agreement with Northern Lights (link).
[75] By agreement under Article 25 of Directive 2003/87/EC.

activities. Emissions and removals must be counted and claimed only once and by one party to avoid double counting.

The reporting of industrial carbon management activities in GHG inventories under the United Nations Framework Convention on Climate Change (UNFCCC) is a key topic to tackle. Particular attention should be given to international value chains where the CO_2 is captured, transported, stored or used in different countries. These include imported CCU-based fuels used in the EU as well as international carbon removal value chains, for instance in BioCCS or DACCS operations. The Intergovernmental Panel on Climate Change (IPCC) will play an essential role in providing clear guidelines and methodologies to properly report all type of CCS, CCU and industrial carbon removal operations in the UNFCCC GHG inventories

International collaboration will also be necessary to maximise the potential of industrial carbon management in mitigating CO_2 emissions on a global scale, such as through the Carbon Dioxide Removal Mission under Mission Innovation[76]. In particular, developing a common understanding on how to permanently store CO_2 away from the atmosphere geologically or in durable products could help accelerate and scale up projects, and make them more economically viable and efficient.

The EU should contribute to international exchanges and workshops with industry, academia and government as well as international organisations on industrial carbon management to mitigate CO_2 emissions on a global scale and also to enable EU companies to operate on third country markets. It will also be important to engage with third countries to ensure that third country markets remain open for the access of EU industry and technologies and vice versa, notably public procurement markets.

The G7 confirmed that while the immediate, sustained and rapid reduction of GHG emissions remains a key priority, to achieve the net-zero targets, rolling out carbon removal processes with robust social and environmental safeguards, such as strengthening natural sinks, BioCCS and DACCS, will be essential to help counterbalance residual emissions from sectors that are unlikely to achieve full decarbonisation. The G7 also recognised that '*CCU/carbon recycling and that CCS can be an important part of a broad portfolio of decarbonization solutions to achieve net-zero emissions by 2050*'.

The Commission foresees to:

- *work towards accelerated international cooperation to promote harmonised reporting and accounting of industrial carbon management activities, to ensure they are accurately accounted for under the UNFCCC transparency framework;*

- *work to ensure that internationally carbon pricing frameworks focus on the necessary emissions cuts while providing for carbon removals to tackle emissions in the hard-to-abate sectors.*

[76] Co-led by Canada, US and Saudi Arabia, with participation of the European Commission, Australia, India, Japan and Norway (link).

6. Conclusion

To reach climate neutrality by 2050 and provide EU economy with all the means to reach the 2040 climate ambition, the EU needs to develop a common and comprehensive policy and investment framework for all aspects of industrial carbon management. Industrial carbon management will be needed to complement mitigation efforts for hard-to-abate emissions and to achieve negative emissions after 2050.

The technological solutions to capture, transport, use and store CO_2 are available, but they need to be rolled out commercially and at scale, both in existing industries and to start removing CO_2 from the atmosphere. Yet, companies that deploy them today identify high costs of carbon capture, storage and use, and multi-faceted market failures that need to be addressed with an integrated European approach to industrial carbon management.

Many Member States have mapped theoretical geological storage sites, but these sites now need to be turned into bankable CO_2 storage capacity. This requires not only investments, but also building a broad public understanding that storing CO_2 underground can be a reliable climate solution and a profitable business. It also requires putting in place CO_2 transport infrastructure.

Once captured, CO_2 becomes a valuable commodity, especially if it is captured from bio-sources or the atmosphere. It should be used more widely in manufacturing processes, in particular for chemicals and plastics that today use crude oil and natural gas, as well as the production of sustainable fuels to tackle hard-to-abate transport.

To create an ambitious industrial carbon management in the EU, support is needed for projects that use these technologies and share knowledge. Member States and the Commission need to work together to develop and put in place the policy framework needed to increase certainty for investors, while engaging local communities in areas where geological CO_2 storage can be used to help the economy decarbonise.

All such solutions must first and foremost produce real and quantifiable benefits for citizens, the environment and the climate. With this Strategy, industrial carbon management is a legitimate and economically promising pathway for the EU towards climate-neutrality by 2050. Concerted efforts of the Commission, Member States, industry, citizen groups, research communities, social partners and other stakeholders will be essential to its swift implementation.