Communication COM(2024) 62 of 6 February 2024:
Towards an ambitious Industrial Carbon Management for the EU

INDUSTRIAL CARBON MANAGEMENT

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LONG VERSION

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A. Key elements of the EU proposal

1 Context and objectives

- With its "European Climate Law" [Regulation (EU) 2021/1119; see cepPolicyBrief 3/2020], the EU has committed to reducing greenhouse gas (GHG) emissions to net zero by 2050 (climate neutrality) and by 55% by 2030 compared to 1990 levels (EU 2030 climate target).
- The Commission is proposing that GHG emissions should be reduced by 90% by 2040 (EU 2040 climate target). At the same time, it also emphasises the relevance of industrial carbon management for achieving climate neutrality by 2050 [Communication COM(2024) 63].
- Even if climate neutrality is achieved by 2050, it will be technically impossible or extremely costly to reduce GHG emissions to zero in some sectors. These "hard-to-abate sectors" include agriculture, aviation and various industries such as lime and cement production and waste incineration.
- Industrial carbon management includes [p. 3, 14 and 16]
  - capturing hard-to-abate CO_2 from industrial processes, before it is emitted into the atmosphere, in order to subsequently
    - use it as a raw material in industry, e.g. for the production of synthetic fuels, chemicals, polymers or minerals (Carbon Capture and Utilisation, CCU), or
    - transport it for permanent geological storage (Carbon Capture and Storage, CCS);
  - removing CO_2 from the atmosphere and permanently storing it, whereby the CO_2 is either extracted
    - directly from the atmosphere (Direct Air Carbon Capture and Storage, DACCS) or
    - indirectly via the capture of CO_2 that is produced when biomass is used as a raw material/energy source in power plants and industrial processes (Bio Energy Carbon Capture and Storage, BioCCS).
- The Commission estimates that around 400 million tonnes (t) of GHG emissions will have to be offset by means of carbon capture by 2050. In addition to natural carbon sinks, such as forests and moors, this will be achieved by way of industrial carbon management. [p. 14]
- The "CO_2 value chain" consists of emitters that capture CO_2 and companies that extract CO_2 from the atmosphere, the subsequent transport of CO_2 and finally the use of CO_2 as a raw material or the permanent geological storage of CO_2, which can take place onshore (i.e. on land) or offshore (i.e. in the sea) [p. 8].
- The Commission wants to [p. 6-7]
  - create industrial CO_2 storage capacity of 50 million tonnes of CO_2 per year by 2030 at the latest;
  - create a transport infrastructure for captured CO_2 using pipelines, ships, trains and lorries and ensure their interoperability by means of uniform EU rules;
  - create an internal market for industrial carbon management, in which CO_2 becomes a tradeable commodity that is shipped for geological storage or use, with one third of the captured CO_2 being used as a raw material.

2 Existing EU legislation

- Permit procedures and infrastructure access for geological CO_2 storage are governed by the CCS Directive [2009/31/EC; see cepPolicyBrief 5/2014 and CO_2 transport is regulated by the TEN-E Regulation [(EU) 2022/869].
- The EU Emissions Trading System (EU ETS I) [see cepPolicyBrief 5/2022] is a "cap and trade" system that places a cap on the maximum permissible GHG emissions of the sectors covered – energy sector, energy-intensive industries, intra-European aviation and shipping – by limiting the number of EU ETS I allowances.
  - In addition to avoiding GHG emissions, the EU ETS I also offers an incentive to capture and utilise CO_2 or store it geologically instead of emitting it. No allowances have to be surrendered for captured CO_2 that is stored in a geological storage site in accordance with the requirements of the CCS Directive 2009/31/EC. No allowances have to be surrendered for captured CO_2 that is used as a raw material in the manufacture of products if the CO_2 can be regarded as permanently chemically bound in the product. The specific conditions under which this assumption is considered to be fulfilled are defined in a delegated act.[1]
  - Revenue from the EU ETS I will be used to finance an EU Innovation Fund to promote low-carbon innovations, which also includes industrial carbon management, including CCU [p. 4].

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1 European Commission (2024). Commission Delegated Regulation (EU) of 30.7.2024 supplementing Directive 2003/87/EC of the European Parliament and of the Council as regards the requirements for considering that greenhouse gases have become permanently chemically bound in a product.

   – In addition, under the EU ETS I – In contrast to the other EU-wide GHG emissions – the cap will go down to zero as early as around 2039[2]. As a result, all remaining GHG emissions in the energy sector, energy-intensive industry, intra-European aviation and shipping will have to be offset by negative emissions.
- CCU and CCS are categorised by the EU Taxonomy Regulation [(EU) 2020/852, see cep**Input** 14/2021] as a significant contribution to climate protection, which facilitates their access to public and private capital for sustainable investments.
- In 2021, the "CCUS Forum" was established as a platform for dialogue between stakeholders. It deals, for example, with the creation of CO_2 infrastructure, with the public perception of industrial carbon management and with industrial partnerships.
- In its Communication on sustainable carbon cycles [COM(2021) 800], the Commission stipulates that by 2030 [see COM(2021) 800, p. 17]
   – at least 20% of the carbon used in the chemical industry should come from sustainable non-fossil sources;
   – 5 million tonnes of CO_2 should be removed from the atmosphere each year and stored permanently.
- On 19 February 2024, the Council and the European Parliament reached a provisional political agreement on a Regulation on the certification of carbon removals [Commission proposal COM(2022) 672], which is intended to ensure the environmental sustainability of certified carbon removals.
- In addition to a target annual injection capacity of 50 million tonnes of CO_2 by 2030, the Net Zero Industry Regulation [(EU) 2024/1735] also regulates support for implementation through regulatory measures, such as requirements for accelerating permit procedures.
- Member States must use the national energy and climate plans (NECPs) [Energy Union Governance Regulation (EU) 2018/1999; cep**Input** 2/2019] to demonstrate to the Commission how they are achieving their European energy and climate targets. 20 Member States have so far reported on measures for industrial carbon management with a planned total annual capture capacity of 34.1 million tonnes of CO_2 by 2030.

3 Carbon capture, utilisation and storage (CCUS)

- The capture and use or geological storage of CO_2 (CCUS) is intended to prevent emissions caused by the combustion of fossil fuels and industrial processes from even entering the atmosphere in the first place [p. 13].
- Whether CO_2 avoidance or capture is worthwhile for companies, especially in hard-to-abate sectors, depends on the respective costs. These are determined [p. 13]
   – by the availability and cost of capture technologies as well as transport, storage and utilisation options for CO_2 and,
   – on the other hand, by the demand for low-carbon or zero-carbon products.

3.1 Carbon capture and utilisation (CCU)

- The annual demand for carbon as a raw material in the chemical industry as substitute for fossil raw materials is estimated to be 125 million tonnes, which corresponds to 450 million tonnes of CO_2 equivalents [p. 17].
- According to the Commission, CCU promotes cooperation between neighbouring companies ("industrial symbiosis"), which is why infrastructure is to be implemented in a decentralised way. Industrial CO_2 emitters will be linked to local production sites acting as CO_2 consumers in joint supply chains, thereby reducing the need for a supra-regional CO_2 transport infrastructure. [p. 16]
- Access to hydrogen is a necessary prerequisite for the use of CCU technologies, which is why coupling CCU and hydrogen networks is important.
- The Commission is planning to [p. 10-18]
   – identify and remove existing structural and regulatory barriers to CCU deployment;
   – establish an accounting system that will give an incentive for action to all operators along the CO_2 value chain irrespective of the actions of upstream and downstream actors;
   – create a "framework for CCU" that builds on the accounting system so that the origin, transport and use of "several 100 million tonnes of CO_2" can be tracked, thereby ensuring environmental integrity and liability for carbon leakage;
   – develop strategies together with industry on how to increase the demand for captured CO_2 as a feedstock;

[2] European Commission (2024), Impact Assessment Report SWD(2024) 62 of 6 February 2024 accompanying Communication COM(2024) 63 of 6 February 2024, Securing our Future – Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society, S. 24; Pahle, M. / Günther, C. / Osorio, S. / Quemin, S. (2023). The Emerging Endgame: The EU ETS on the Road Towards Climate Neutrality, SSRN Electronic Journal.

- support CCU technologies regardless of their level of technological development, e.g. via the "Horizon Europe" programme as well as the European Innovation Council and the Innovation Fund.

3.2 Carbon capture and storage (CCS)

- ► The Commission currently believes that, in 2040, geological storage capacity for at least 250 million tonnes of CO_2 will be required in the European Economic Area (EEA) [p. 12].
- ► Application processes for storage permits are currently under way in four Member States, which are expected to enable a storage capacity of 15.2 million tonnes of CO_2 per year from 2025 [p. 11].
- ► The Commission wants to
  - establish a platform at EU level by 2026 that [p. 11]
    - allows CO_2 storage requirements and availability to be matched up in terms of time and location by improving coordination between the carbon capture companies and the storage and transport providers;
    - offers information on infrastructure planning, which should be of particular benefit to companies with less bargaining power;
  - work together with the geological services in the EEA, to create an EU-wide investment atlas by 2026, that classifies potential CO_2 storage sites according to their "storage readiness level", and thereby provide a digital inventory of underground CO_2 storage [p. 12];
  - develop guidelines for permitting CO_2 storage facilities [p. 13].
- ► Member States will [p. 11-12]
  - introduce transparent processes for storage permits to enable early-stage contact between applicants and the competent authorities;
  - analyse their carbon capture requirements and CO_2 storage potential as part of their NECPs and introduce measures that support the creation of a CO_2 value chain;
  - support CO_2 capture, transport infrastructure and storage sites – including across borders – as part of the Net Zero Industry Regulation and provide sufficient investment capacity;
  - provide their geological services with resources by 2025 allowing them to make an appropriate contribution to the creation of the investment atlas.

4 Removing industrial CO2 from the atmosphere

- ► The removal of industrial CO_2 from the atmosphere is not currently covered by the EU climate legislation to achieve the EU 2030 climate target, which is to be realised by way of the sub-targets of the EU ETS I, the Effort Sharing Regulation [(EU) 2018/842] and the Regulation on Land Use, Land Use Change and Forestry [(EU) 2018/841; LULUCF] [p. 14].
- ► While the EU ETS I is designed to reduce CO_2 emissions, negative CO_2 emissions are not taken into account, which is why investment in the removal of CO_2 from the atmosphere currently depends on public support and voluntary CO_2 markets [p. 14].
- ► The estimated future costs [p. 15]
  - for the direct removal of CO_2 from the atmosphere (DACCS) range from € 122 to € 539 per tonne of CO_2 and are therefore higher than the EU ETS I allowance price, which is currently well below € 100;
  - for indirect CO_2 removal via the capture of biogenic CO_2 (BioCCS) are comparable to the costs of CCS technologies and range between € 52 and € 134 per tonne of CO_2.
- ► The Commission wants to assess how existing or new EU legislation or instruments could be used to provide incentives for industrial CO_2 removal, e.g. through CO_2 removal targets that contribute to the planned EU 2040 climate target [p. 14].
- ► By 2026, the Commission wants to examine how industrial CO_2 removal can be integrated into the EU ETS I, while at the same time ensuring environmental integrity, particularly with regard to the sustainable use of biomass for BioCCS [p. 14].
  - To this end, it suggests using carbon removals – either with or without restrictions – e.g. to meet the GHG reduction under EU ETS I. Alternatively, a "separate compliance mechanism" linked directly or indirectly to the EU ETS I could be established. [p. 15]
  - However, the price difference between EU ETS I allowances and the cost of industrial CO_2 removal is still too great so there is insufficient incentive to utilise them. The Commission therefore wants to clarify how the Member States can support the further development of industrial CO_2 removal. [p. 15]

5 Transport infrastructure for an EU internal CO_2 market

- CO_2 transport is already operating commercially, but the volumes are very small compared with future demand. In addition, there is currently no EU legislation regulating a "functioning, cross-border, freely accessible network" for CO_2 transport. [p. 8]
- Pipelines are the most common transport option, but their construction involves high investment costs and long lead times. Consequently, CO_2 shipping will play an important role by 2030. This will require a fleet of specialised ships. [p. 8]
- The expansion of CO_2 transport infrastructure is hampered by [p. 8-9]
  - uncertainty about how much CO_2 will be captured in the future, the complicated coordination between operators along the value chain and lengthy permit procedures, and
  - the lack of interoperability when it comes to cross-border expansion, whereby the CO_2 transport infrastructure must be suitable for CO_2 streams from different sources (fossil, biogenic, direct from the atmosphere), obtained using a variety of capture technologies.
- Smaller CO_2 emitters and installations that are a long way from CO_2 storage sites risk being excluded from the market, which could undermine decarbonisation in the EU [p. 9].
- The Commission is planning [p. 8-15]
  - to work with the European standardisation bodies to develop minimum standards for CO_2 streams, taking into account composition, purity, pressure and temperature;
  - given the varying costs for different CO_2 purity levels, to develop guidelines for "incidental associated substances from the source, capture or injection process" and strike a balance between cost and risk;
  - to work with the CCUS Forum to develop EU harmonised mechanisms for planning CO_2 transport infrastructure and examining the possibility of repurposing or reusing existing electricity, gas and hydrogen infrastructure;
  - to nominate European coordinators to support the early development of cross-border CO_2 transport infrastructure by analysing barriers and contributing their findings to the legislative process.

6 Investment and financing

- The entire CO_2 transport infrastructure could potentially be expanded to 7,300 km by 2030 and 19,000 km by 2040, at a cost of € 12.2 billion and € 16 billion respectively [p. 8]. The costs for the planned annual CO_2 storage capacity of 50 million tonnes by 2030 amount to approx. € 3 billion [p. 19].
- There is currently a funding gap of around € 10 billion for CCS projects up to 2030 [p. 19].
- The estimated total economic value of the entire CO_2 value chain is between € 45 and € 100 billion [p. 19]
- The Commission points out that large-scale CO_2 projects can be funded via the EU ETS Innovation Fund. In addition, cross-border energy and infrastructure projects can be funded via the Connecting Europe Facility (CEF). [p. 20]
- Member States can support industrial carbon capture by [p. 20]
  - using funds from the Recovery and Resilience Facility;
  - introducing state aid, whereby this is defined for industrial carbon management, e.g. via the Guidelines on State aid for climate, environmental protection and energy [2022/C 80/01];
  - introducing Carbon Contracts for Difference (climate protection contracts) that use subsidies to close the gap between the actual costs of the CO_2 capture project and a competitive reference price.
- The Commission proposes to examine whether certain CO_2 capture plants are sufficiently technologically advanced to no longer require project-related funding [p. 21].
- Instead, "auctions-as-a-service" could be introduced across the EU under the Innovation Fund. This would enable EEA countries to promote projects on the basis of an EU-wide auction mechanism. The funds would come from the budgets of the Member States, and the guidelines on state aid for climate, environmental protection and energy would have to be adhered to. [p. 21]

7 Involvement of the public

- The Commission emphasises that it is essential for Member States to promote public debate on industrial carbon management and related infrastructure projects [p. 22].
- To this end, "public authorities, project developers, non-governmental organisations (NGOs) and civil society" should be involved throughout the entire process of political decision-making, project implementation and beyond [p. 22].
- The Commission wants to [p. 22]

- stimulate the public debate on industrial carbon management via the CCUS Forum, among others;
- share data and experience gathered from projects which it supports under the Innovation Fund and the Trans-European Energy Networks;
- monitor public opinion on industrial carbon management by way of Eurobarometer surveys.

► Member States will [p. 22.]
- consider how communities could be rewarded for hosting carbon management infrastructure;
- explain the economic benefits of carbon management technologies to the public;
- ensure that the costs as well as risks to safety and the environment are included in the public debate, and identify the regulatory measures to manage the risks;
- monitor public opinion on industrial carbon management by way of Eurobarometer surveys.

8 Cross-border and international cooperation

► Cross-border CO_2 transport is already possible within the EEA. The first commercial agreement on shipping CO_2 produced in the EU to Norway has already been signed. [p. 24]

► CO_2 produced in the EU could be geologically stored outside the EEA if the countries concerned operate an emissions trading system that is linked to the EU ETS I [p. 24].

► Without an emissions trading system, potential CO_2 storage sites outside the EEA would have to ensure the existence of conditions equivalent to those in the EU in terms of safety and environmental integrity. In addition, according to the Commission, geological CO2 storage must not be used to "increase the exploitation of hydrocarbons" – i.e. for the extraction of oil and gas. [p. 24].

► The Commission points out that the Paris Climate Agreement of 2015 [see cep**PolicyBrief** 13/2016] requires the parties to report on CO_2 removals effected by way of industrial carbon management. This is to ensure that CO_2 emissions and removals can only be claimed once in order to avoid double counting [p. 24-25].

► The Commission aims to accelerate international co-operation to promote reporting on industrial carbon management in greenhouse gas inventories under the United Nations Framework Convention on Climate Change (UNFCCC). International value chains are important if, for example, CCU-based fuels are imported. [p. 25]

► The Commission wants to work with partners worldwide to develop a common understanding on how to achieve permanent CO2 storage in geological storage sites or in products.

► The Commission also wants to cooperate internationally to work towards ensuring that the future focus of carbon pricing mechanisms is on reducing CO_2 emissions, and that CO_2 removals can be used to counterbalance emissions in sectors that are difficult to decarbonise [p. 25].

B. Legal and Political Context

1 Legislative Procedure

6 February 2024 Adoption by the Commission

2 Options for influencing the political process

Directorates General:	DG Energy
Federal Ministries:	Federal Ministry for Economic Affairs and Climate Action (leading)
Committees of the German Bundestag:	Climate Action and Energy (leading)

C. Assessment

The EU's goal of achieving climate neutrality by 2050 requires access to a variety of technological options to reduce net GHG emissions. This also includes technologies for the capture and subsequent geological storage (CCS) or utilisation (CCU) of CO_2. These can make hard-to-abate industrial processes climate-neutral and neutralise any remaining emissions by removing CO_2 from the atmosphere. Thus, industrial carbon management can contribute to achieving the EU climate target of climate neutrality by 2050. The Commission's intention to give careful consideration to potential safety and environmental risks in the development of industrial carbon management and to identify the regulatory measures needed to address them right from the start, is the right one, not least in view of concerns expressed by some sections of the public, particularly with regard to CCS technology.

1 Economic Impact Assessment

From an economic perspective, high costs and the lack of transport and storage infrastructure in particular are still preventing the ramp-up of technologies for industrial carbon management. The Commission rightly wants the EU to help remove these barriers by creating favourable conditions for a future EU internal market for captured CO_2. The considerations for specific measures set out in its Communication can be evaluated in detail as follows:

1.1 Carbon capture and storage measures

Industrial companies, that are thinking of using CCS in a new plant or converting an existing plant to it, face a number of economic challenges. The first is the long-term nature of investing in a CCS system. Studies generally assume an economic service life of 20-25 years. In addition to the high initial investment for setting up the necessary infrastructure, there are high operating costs for maintenance and energy consumption in the long term.[3] This means that the systems have a long amortisation period. Against this backdrop, political uncertainty about the level of future revenues and costs represents a major obstacle to investment. An expert survey by Abdulla et al. (2021) looked at the main reasons for the success or failure of CCS investment projects in the USA in recent years. They found that the credibility and stability of regulatory incentives was a key success factor – alongside the level of capital costs and technological maturity.[4] The risk of future changes in the ambition and focus of climate policy therefore poses a lock-in risk for current investments in CCS. On the revenue side, there is also uncertainty regarding the long-term development of the CO_2 price in the EU ETS.

Added to this is the uncertainty about the long-term reliability of storage and the associated cost risks. The level of transport and storage costs depends heavily on the geography and structure of the respective economic area. A sufficient number of suitable geological storage sites and the widest possible distribution of emission sources are decisive factors for ensuring short transport routes and thus low costs for pipeline construction and minimal transport losses. Regions with a strong industrial base and close proximity to geologically suitable formations for storage (former oil and gas production sites, salt caverns) therefore have an advantage when it comes to building CCS capacities.[5]

The development of storage capacities also involves high-risk initial investment, particularly in the case of greenfield projects with uncertain demand.[6] A general risk factor in the current cost estimates – apart from the economic factors – are the unknown ecological side effects of long-term storage and the resulting liability risks. In addition to possible carbon leakage, this may, depending on the location, involve the risk of acidification of the groundwater and geological instabilities.[7] The duration and administrative costs of state permit procedures, which are hard to calculate, also represent an obstacle to investment, especially as social acceptance problems are likely.

The simultaneous high level of profit uncertainty in capture and storage leads to coordination problems in the development of CO_2 supply chains. In the absence of established markets for captured CO_2, this coordination problem cannot be solved by means of scarcity pricing. It therefore has the character of a coordination externality, comparable to the challenges of establishing a European hydrogen economy.[8] One way of dealing with this coordination externality is the simultaneous planning and development of entire CO_2 supply chains as part of integrated projects. Such large-scale projects are currently being initiated in many EU Member States, usually in conjunction with direct state funding.[9] Such projects are essential for the necessary rapid scaling of CCS capacities. However, a one-sided orientation of state funding policy towards integrated projects also poses

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3 Boot-Handford, M. E., Abanades, J. C., Anthony, E. J., Blunt, M. J., Brandani, S., Mac Dowell, N. & Fennell, P. S. (2014). Carbon capture and storage update. Energy & Environmental Science, 7(1), 130-189.

4 Abdulla, A., Hanna, R., Schell, K. R., Babacan, O., & Victor, D. G. (2020). Explaining successful and failed investments in US carbon capture and storage using empirical and expert assessments. Environmental Research Letters, 16(1), 014036.

5 Martin-Roberts, E., Scott, V., Flude, S., Johnson, G., Haszeldine, R. S., & Gilfillan, S. (2021). Carbon capture and storage at the end of a lost decade. One Earth, 4(11), 1569-1584.

6 CATF (2023). Map of CO2 sources and abatement costs. Clean Air Task Force.

7 Schmelz, W. J., Hochman, G., & Miller, K. G. (2020). Total cost of carbon capture and storage implemented at a regional scale: northeastern and midwestern United States. Interface focus, 10(5), 20190065.

8 Wolf. A. (2023). A bank to boost renewable hydrogen. cepInput No.13/2023.

9 Wolf, A. (2024). Paving the way for a European carbon market. cepInput No.1/2024.

risks. Infrastructure expansion that is tailored to the needs of internal CO_2 producers and users (e.g. size and location of storage sites) may run counter to the idea of an open-source CO_2 infrastructure that is competition-neutral and compatible with the internal market. In the worst case scenario, this could lead to path dependencies in market formation that hinder the realisation of cost-effective solutions for CO_2 supply chains in Europe.

The EU is therefore called upon to implement market-orientated support instruments in order to cushion the consequences of coordination problems, even for small investment projects that are limited to capture or storage. The establishment of a platform for the exchange and aggregation of data on capacities and demand for storage, as announced by the Commission, represents a first step in this direction. It could accelerate the development of transparent supra-regional markets for trade in storage capacities. In addition, the Commission should examine the possibilities of using such a platform for market coordination over and above the pure exchange of information. Thus, the platform could be used to initiate an auction mechanism for storage capacities which constantly sends out market price signals as a guide for estimating future storage costs. By defining transparent participation requirements and the uniform treatment of contractual risks (e.g. insufficient supply of CO_2, dealing with carbon leaks), such a mechanism could also help to reduce risk-related capital costs.

In order to reduce the costs associated with national permit procedures for storage facilities, the Commission should commit the Member States to a standard treatment of storage projects that recognises the importance of CCS in terms of climate policy. The development of common guidelines for the implementation of permit procedures is a first step in this direction. Above all, however, with respect to CO_2 storage capacities, it is important that the Commission monitors EU-wide implementation of the requirements for permit procedures set out in the Net Zero Industry Regulation. These include a maximum duration of 18 months for all necessary permits for storage projects that are recognised as strategic projects and the establishment of central administrative points of contact (one-stop shops) for project developers. The Commission should consult with the Member States on how to eliminate any resource-related bottlenecks in the implementation of these requirements.

Finally, a key long-term factor in reducing investment risks is confidence in the stability of regulation, particularly climate policy targets and instruments at European and national level. In this case, this relates in particular to the future of the CO_2 price. The new Commission is called upon to demonstrate reliability in the future organisation of emissions trading and its final end date.

1.2 Carbon utilisation measures

The use of CO_2 as a raw material not only avoids the restrictions and long-term risks associated with geological storage but can also help to conserve resources by replacing fossil or mineral raw materials in production. Although the use of CO_2 results in additional material and energy costs, these must be compared with the costs saved by conventional production processes. The time horizon of carbon sequestration in the products is decisive for the CO_2 balance. Using CO_2 in products that are characterised by a long average lifespan or a high degree of reusability or recyclability makes the most sense in terms of mitigating climate change. In this way, on average, CO_2 is removed from the atmosphere for a relatively long period of time and the climate effect thus comes closest to emission avoidance.

CO_2 is currently used in two main processes: in the production of urea in the chemical industry and in tertiary oil production processes. With regard to future utilisation potential, the International Energy Agency (IEA) has identified four product categories: Fuels, plastics, building materials and fertilisers.[10] The production of CO_2-based fuels generally requires the additional use of hydrogen. Given the current state of technology, this is not yet competitive in terms of cost compared to fossil alternatives. Unless the hydrogen is produced exclusively using green electricity, the process as a whole is not climate-neutral. In the chemical industry, in addition to its established use in urea production, the use of CO_2 in plastics production is a technically feasible option. Some of the new polymers produced in this way have favourable material properties. However, the high stability of CO_2 means that a high energy input is required in the reaction chain, so the cost factor is currently still an obstacle to market launch.[11]

The use of CO_2 for the production of building materials is particularly attractive from the perspective of climate protection due to the long product life cycles. The technologies currently being researched for this purpose do

[10] IEA (2019). Putting CO_2 to use – creating value from emissions. International Energy Agency.
[11] Muthuraj, R., & Mekonnen, T. (2018). Recent progress in carbon dioxide (CO2) as feedstock for sustainable materials development: Co-polymers and polymer blends. Polymer, 145, 348-373.

not require the cost-driving use of hydrogen. At the same time, they offer sectors that are particularly difficult to decarbonise the opportunity to recycle the captured CO_2 using their own waste products. For example, intensive research is being carried out into the mineralisation of CO_2 emissions in the steel industry, with steel slag being used as the basis for the production of building materials. This technology is already considered market-ready and climate-friendly.[12] In the cement and concrete industry, the use of CO_2 for curing concrete based on secondary raw materials is being trialled. Injection into this building material offers the potential for particularly long-term storage.[13]

In order to provide an incentive for the realisation of these diverse usage options, the EU should first develop a uniform, transparent definition of climate policy's requirements for the recognition of CCU. For example, the framework for certifying carbon removals adopted this year defines an expected minimum storage period of 35 years for the certification of CO_2 storage in products.[14] Under the EU ETS, however, CCU is only recognised as a contribution to emission avoidance with an assumed storage period of several centuries.[15] A uniform definition, that is as easy as possible to handle for monitoring purposes, would reduce investment uncertainty and at the same time synchronise future carbon credit markets more closely with the EU ETS.

In addition, the EU should not impose any artificial restrictions on the geographical organisation of future CO_2 supply relationships. The Commission's requirement for local utilisation of captured CO_2 represents an unjustifiable restriction on the development of an internal market for CO_2. It restricts the operation of CO_2 capture facilities by companies that do not have sufficient local demand potential or sufficient access to geological storage capacities. Rather than placing restrictions on the necessary infrastructure expansion with a priori requirements, the Commission should be striving to minimise costs by way of the cross-border coordination of network planning on the basis of EU-wide requirements (see C.1.3 below).

1.3 Measures for development of a CO_2 transport infrastructure

Significant quantities of CO_2 are currently transported both onshore and offshore almost exclusively by way of pipelines, the most technically advanced form of transport. Pipelines will probably continue to dominate long-distance transport in the future, as they offer considerable economies of scale[16]. They play a particularly important role for Europe due to the large average distance between industrial CO_2 emitters and suitable geological storage sites[17]. Current large-scale projects involving the construction of geological CO_2 storage facilities in the North Sea, such as Porthos[18] in the Netherlands and Longship[19] in Norway, rely on offshore pipelines as a means of transport. Prompt development of an EU-wide regulatory framework for pipeline transport is necessary for several reasons. Firstly, grid-dependent CO_2 transport, like natural gas and electricity transport, is a natural monopoly in economic terms. Transparent fee regulation is needed to prevent operators of CO_2 networks from exploiting their monopoly position in future by imposing excessive transmission fees. Such tariff regulation should be based on uniform EU-wide principles to ensure fair competition in the internal market. This will also create planning certainty for investors and thus contribute to the rapid expansion of pipeline capacity.

Secondly, the establishment of an internal market for CO_2 requires binding technical standards to be defined, particularly regarding the properties (temperature, pressure, degree of purity) of the transported CO_2. The diversity of the existing CO_2 capture technologies[20] gives rise to material flows of differing compositions. In order to obtain pure, transportable CO_2 from this, cost-intensive purification and compression steps are subsequently required. Transparent EU-wide quality standards will facilitate transport management and avoid cost

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[12] de Kleijne, K., Hanssen, S. V., van Dinteren, L., Huijbregts, M. A., van Zelm, R., & de Coninck, H. (2022). Limits to Paris compatibility of CO2 capture and utilization. One Earth, 5(2), 168-185.

[13] Liang, C., Pan, B., Ma, Z., He, Z., & Duan, Z. (2020). Utilization of CO2 curing to enhance the properties of recycled aggregate and prepared concrete: A review. Cement and concrete composites, 105, 103446.

[14] Council of the European Union(2024), Press release of 20 February 2024, Climate action: Council and Parliament agree to establish an EU carbon removals certification framework.

[15] European Commission (2024), Commission Delegated Regulation (EU) 2024/2620 of 30 July 2024 supplementing Directive 2003/87/EC of the European Parliament and of the Council as regards the requirements for considering that greenhouse gases have become permanently chemically bound in a product.

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[19] Northern Lights (2024). About the longship project.

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competition that would otherwise reduce quality. The Commission is therefore setting the right priorities in its proposed regulatory package.

The envisaged EU-wide coordination of grid planning is also essential for a genuine internal market for CO_2. A purely decentralised pipeline structure based on individual major projects bears the risk that the capacity and location of pipelines will be based solely on the interests of individual major emitters. Instead, grid planning should take account of the broad range of CO_2 emitters in the sectors that are central to CCS applications. This is a key prerequisite for ensuring comprehensive avoidance of process emissions in sectors that are difficult to decarbonise (see above A.1) and for the creation of competition in a future internal market for CO_2. To this end, the Commission should initiate the development of a joint planning mechanism with the Member States as quickly as possible.

The objective of joint planning should be to achieve non-discriminatory and cost-effective cross-border CO_2 transport in the EU. In addition to taking into account the diversity of emitters, non-discrimination also requires recognition of the various CO_2 utilisation options. Network planning should not be based exclusively on the location of future geological storage sites, but should also take account of future industrial CCU requirements. This requires reliable forecasting tools. The fundamental restriction of CCUs to local supply chains, as favoured by the Commission, is the wrong approach as it may rule out efficient recycling routes.

In order to limit the costs of pipeline construction, planning must consider possible synergies with the existing natural gas network and the future hydrogen network. This not only applies to the technical potential and regulatory requirements for rededicating natural gas pipelines for CO_2 transport. The benefits of synchronising geographically with the expansion of hydrogen pipelines should also be included in the planning. This is because, in the future, hydrogen and CO_2 could increasingly be used together as raw materials in the production of synthetic fuels and other hydrogen derivatives. To enable even small CO_2 emitters to implement CCS, the transport system must also be multimodal. In addition to a pipeline infrastructure, short distances require flexible transport options by ship, rail or lorry, and fair competition between these alternatives. To this end, reliable technical standards should be defined for all modes of transport and promising pilot projects should receive support.

1.4 Measures to promote CO_2 removals (negative emissions)

Even with determined implementation of technically possible decarbonisation options, it is highly unlikely that all areas of society will be climate-neutral by 2050. Residual emissions will remain in some sectors that are difficult to decarbonise. In order to achieve the overall goal of climate neutrality by 2050, it will be necessary to compensate for this by directly or indirectly removing CO_2 from the atmosphere. In principle, a variety of more or less tried and tested technology options are available for this purpose. In addition to nature-based solutions, the Commission believes that two artificial forms are also necessary: direct extraction of CO_2 from the air (DACCS) and the capture of CO_2 produced during the industrial combustion or processing of biomass (BioCCS). This is consistent with the results of the long-term emission reduction scenarios, published by the Commission as part of the impact assessment on its proposal for a 2040 climate target, which already envisage these two technologies, and particularly DACCS, making significant contributions to emissions reduction by 2040.[21]

The Commission is correctly focussing on these technologies because both of them are controlled processes that enable reliable balancing and monitoring of CO^2 flows. However, two factors still stand in the way of their large-scale use: their lack of technological maturity compared to established CO_2 capture technologies and expected resource limitations. The lack of maturity is reflected in the current costs, which are still high, especially in the case of DACCS. The meta-analysis by Bednar et al. (2023) indicates current price estimates of USD 1,120 (approx. € 1,018) per tonne of CO_2 for DACCS and USD 300 (approx. € 270) per tonne of CO_2 for BioCCS.[22] This means that both technologies are well above the current EU ETS-I price level.

A major cost advantage of BioCCS is that it is based on a combination of already established technologies: the combustion or fermentation of biomass and the subsequent application of industrial carbon capture technologies. Its greater technological maturity, as compared with DACCS, facilitates scaling and at the same time enables more flexible construction of plants depending on the individual sales opportunities for the

[21] European Commission (2024). Securing our future – Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society. Impact Assessment Report to the Communication – Part I. COM(2024) 63.

[22] Bednar, J., Höglund, R., Möllersten, K., Obersteiner, M., & Eve, T. (2023). Role of removals in contributing to the long-term goals of the Paris Agreement. IVL Report C807.

resulting bioenergy. A further advantage of this concept is the fact that the resulting bioenergy represents a second direct source of income, which can also be used to diversify the CO_2 market price risk. BioCCS plants are net energy suppliers and their activities help to reduce the shortage of renewable energies. However, this advantage is reduced if the energy required to grow and harvest the biomass is taken into account.[23] There are also clear limits to this form of climate technology in terms of land consumption. The production of bioenergy from food and feed crops also leads to competition for land with the food sector. Currently, around 20% of bioenergy (in energy units) in Europe is obtained from agricultural sources. The industry association believes that this share will increase significantly in future in line with the growth of the bioenergy market.[24] Simulations show that a significant expansion of BioCCS capacity may lead to strong price correlations between carbon and agricultural markets. A long-term increase in CO_2 prices could therefore be reflected in rising food prices.[25]

In the case of DACCS, the resource constraints relate to the high level of energy consumption required for the filtration and concentration of CO_2, a consequence of the low CO_2 concentration in the atmosphere. This not only affects the economic viability of the technology but, depending on the electricity mix, could also have a potentially significant impact on the carbon footprint.[26] The availability of sorbents could also be subject to bottlenecks. These are energy intensive to produce and, up to now, have often been obtained as by-products. A strong increase in demand triggered by DACCS could change this role leading to market distortions and a further increase in energy use in the production of these chemicals.[27]

At the same time, both technologies offer the prospect of significant future efficiency gains and cost reductions through learning effects. However, these will not materialise by themselves but will only result from operational experience. Therefore, the earlier these technologies are introduced, the greater the expected reduction in costs by 2040. A rapid start requires clear commercialisation prospects for the captured CO_2. One option could be to offer carbon credits on markets for voluntary carbon offsetting. However, due to the lack of uniform global standards, the current market platforms are characterised by major price fluctuations, low transparency and high levels of fragmentation,[28] resulting in high risks in terms of sales and price. Another alternative would be to commercialise the captured CO_2 as an industrial raw material. However, CO_2 from DACCS and BioCCS competes with CO_2 obtained more cost-effectively using established capture technologies.

The creation of targeted investment incentives at political level will be necessary for a rapid increase in capacity. Such intervention is also basically justifiable in terms of welfare economics as the hoped-for learning effects are (positive) externalities, at least in part. The optimisation successes of individual plant operators will lead to imitation by the competition. The acceleration of learning effects through public investment incentives will thus contribute to efficiency increases throughout the industry. "First-mover" investors would be rewarded for their fast action. However, it is important that such additional incentives do not counteract previous political market signals, in particular the steering effect of the allowance price in the EU ETS.

The Commission's idea of integrating CO_2 removal technologies into the existing EU ETS is correct. Combining CO_2 avoidance, CO_2 capture and industrial CO_2 removal technologies under the umbrella of allowance trading would align the cap-and-trade system even more closely with the overarching long-term net emissions targets. The greater variety of technological options for complying with the cap would also further increase the efficiency of the EU ETS, i.e. its ability to achieve a given (net) emissions target at minimum cost via allowance trading.

However, integration into the EU ETS first requires the clarification of some practical problems. On the one hand, this concerns the development of binding standards for balancing and monitoring CO_2 emissions. The Commission is called upon to develop a certification framework for CO_2 removals, as quickly as possible, in order to provide a reliable methodology that meets the requirements of the respective technologies. On the other hand, it concerns the handling of the current cost gap. Without accompanying measures, a short-term integration of CO_2 removal technologies into the EU ETS would hardly have any supportive effect. For example, the model

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23 Creutzig, F., Breyer, C., Hilaire, J., Minx, J., Peters, G. P., & Socolow, R. (2019). The mutual dependence of negative emission technologies and energy systems. Energy & Environmental Science, 12(6), 1805-1817.

24 Bioenergy Europe (2021). Bioenergy Europe Statistical Report 2021 Biomass Supply.

25 Muratori, M., Calvin, K., Wise, M., Kyle, P., & Edmonds, J. (2016). Global economic consequences of deploying bioenergy with carbon capture and storage (BECCS). Environmental Research Letters, 11(9), 095004.

26 Terlouw, T., Treyer, K., Bauer, C., & Mazzotti, M. (2021). Life cycle assessment of direct air carbon capture and storage with low-carbon energy sources. Environmental Science & Technology, 55(16), 11397-11411.

27 Realmonte, G., Drouet, L., Gambhir, A., Glynn, J., Hawkes, A., Köberle, A. C., & Tavoni, M. (2019). An inter-model as-sessment of the role of direct air capture in deep mitigation pathways. Nature communications, 10(1), 3277.

28 Dawes, A., McGeady, C., Majkut, J. (2023). Voluntary carbon markets: A review of global initiatives and evolving models. CSIS Brief. Center for Strategic & International Studies.

of allocating free CO_2 allowances to the operators of CO_2 extraction plants would not in itself give rise to any profitable business models as the allowances could not be sold at cost-covering prices. This is why accompanying support is needed. This could, for example, consist of time-limited fixed premium payments to the operators of CO_2 extraction plants, for each tonne of CO_2 extracted. Alternatively, the agreement of Carbon Contracts for Difference, i.e. contracts with a guaranteed CO_2 price in the medium term, could be considered as a suitable means of both covering costs and hedging risks. This would cover the temporary cost difference compared to established technologies and thus provide the impetus for long-term cost-reducing investments in CO_2 removal technologies.

Any form of additional funding should only be granted on the basis of competitive tendering between projects so as not to undermine cost competition between extraction solutions. In order for such competition to be fair, a technologically nuanced assessment methodology for CO_2 removals is required that also takes into account indirect emission effects, e.g. in the case of BioCCS, CO_2 emissions during biomass cultivation, as would a genuine net assessment. Here too, the Industrial Carbon Management Strategy still lacks clarity.

2 Legal Assessment

2.1 Legislative Competence

Unproblematic. The EU is empowered to issue measures to protect the climate (Art. 191 et seq. TFEU]. In addition, it can also establish uniform EU-wide requirements for captured CO_2 in order to ensure the free movement of goods in the EU internal market and to prevent its fragmentation and the distortion of competition by national requirements [Art. 26 and 114 TFEU].

2.2 Subsidiarity

Unproblematic. Climate change is not only a cross-border problem but also a global one which cannot be solved by individual countries. In addition, the definition of uniform EU-wide requirements for captured CO_2 to create an internal market for industrial carbon management is only possible at EU level. EU action is therefore justified.

D. Conclusion

The use of technologies for the capture and subsequent geological storage (CCS) or utilisation (CCU) of CO_2 as part of industrial carbon management could make an important contribution to achieving the EU climate target of climate neutrality by 2050. These technologies can make hard-to-abate industrial processes climate-neutral and neutralise any remaining emissions by removing CO_2 from the atmosphere.

The Commission's intention to give careful consideration to potential safety and environmental risks in the development of industrial carbon management and to identify the regulatory measures needed to address them right from the start, is the right one, not least in view of concerns expressed by some sections of the public, particularly with regard to CCS technology.

From an economic perspective, high costs and the lack of transport and storage infrastructure are still preventing the ramp-up of technologies for industrial carbon management. Therefore, the Commission rightly wants the EU to help remove these barriers by creating favourable conditions for a future internal market for captured CO_2. Many of the proposals made in the Communication are pointing in the right direction. Thus, the planned central coordination platform will effectively be able to minimise the existing coordination problems in the development of CO_2 supply chains and thereby accelerate the development of transparent markets for trade in transport and storage capacities. The proposed development of a transparent and scientifically informed accounting system creates the basis for fair competition between the different utilisation options for captured CO_2. The envisaged EU-wide coordination of grid planning is also a key prerequisite for a future internal market for CO_2.

At the same time, however, some aspects of the strategy have not yet been fully developed. Thus, the aforementioned idea of restricting CCU applications to the local dimension is contrary to market development because some industrial companies could be cut off from an economically viable way of reducing their emissions. In addition, there is no clear concept for supporting CO_2 removal technologies, which will become particularly important in the long term. The envisaged integration into the EU ETS cannot (yet) be the right solution in the short term due to the large cost differential when compared to avoidance technologies. The Commission should make improvements in this respect and design new intelligent support instruments as quickly as possible to support the scaling and market development of CO_2 removals.