RESEARCH PAPER

November 2024

Chemical Industry access to Carbon Capture and Storage (CCS)

Carbon Capture and Storage (CCS) is a key net-zero technology for the chemical industry which offers a pathway to significantly reduce CO_2 industrial emissions at scale in the short term contributing to the EU climate targets. By capturing carbon dioxide at its source, where it is most concentrated, and sequestering it underground, CCS paves the way to unlock the chemical industry abatement potential. In particular, such potential lies in addressing the unavoidable emissions stemming from chemical processes that are inherently part of the industry and will still be present by 2050. However, the chemical industry's access to CCS is challenged by a series of factors which need to be prioritised and addressed by creating a supportive environment for investments.

The Importance of CCS for the Chemical Industry

The Net Zero Industry Act has recently introduced a CCS target of 50 Mt of annual CO_2 injection capacity in the EU by 2030. In parallel, the European Commission 2040 Climate Target and Industrial Carbon Management Communications envisage a considerable role for carbon capture and storage technologies, highlighting that 243 Mt of industrial CO_2 will have to be captured and stored by 2040[1]. As outlined by the European Commission's Long-term strategic vision for climate neutrality[2], **the chemical industry is as a hard-to-abate sector, which to transition needs access to all available technologies to address combustion emissions and especially unavoidable process emissions**[3]. In 2021, process emissions represented 42% of the chemical industry's total emissions[4] and stemmed from chemical reactions that occurred in production processes and therefore represent a by-product that is not intentionally produced, nor can be avoided in current processes (e.g. from petrochemicals,

[1] Scenario 3 – at least 90% emissions reduction by 2040.
[2] European Commission, *In-depth analysis in support of the Commission Communication COM(2018) 773 A Clean Planet for all*, November 2018.
[3] The 2040 climate target Communication clearly shows that fossil-based feedstock will play a considerable role up to 2050. European Commission, *Securing our future. Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society*, February 2024.
[4] Cefic, *Facts and Figures of the European Chemical Industry*, available at https://cefic.org/a-pillar-of-the-european-economy/facts-and-figures-of-the-european-chemical-industry/environmental-performance/.

European Chemical Industry Council - Cefic aisbl
Rue Belliard 40 b.15 B-1040 Brussels Belgium
Tel. +32.2.436.93.00 mail@cefic.be www.cefic.org
EU Transparency Register n° 64879142323-90

ammonia, carbon black, soda ash production[5]). The industry needs the enabling conditions in place to access CCS to abate such emissions at scale.

CCS should be recognised as **a complementary technology to other emissions abatement options**, such as CCU, which would also benefit from a swift deployment of CO_2 infrastructure. However, while the transition of the industry requires continuous access to alternative (CO_2-based, bio-based and recycled) carbon feedstock, investments in these technologies will most probably mutually exclude one another. Moreover, as regards CO_2-based feedstock, not all carbon that is captured can be used (CCU) for the production of circular chemicals due to practical and economic reasons.

The Challenges

Currently, the deployment of carbon capture technologies in industrial chemical plants is challenged by limitations that should not be underestimated in the path towards net zero. CCS costs and deployment highly depend on building a business case which is impacted by **(1) CO_2 concentration and specification** of the emission stream captured, and on the **(2) availability and financing of infrastructure** for its transport and underground storage.

1. CO_2 concentration and specification

In the chemical industry, plants often have a multitude of emission points, and the carbon dioxide concentration levels in the emission streams can vary widely. When CO_2 concentration is low, purification costs drastically increase. Therefore, capturing carbon dioxide at point sources with the highest concentration is the most efficient approach to limit both emissions and the energy needed for the capture and purification phases[6].

The CO_2 concentration can vary depending on several factors, including the efficiency of the industrial process and the purity of the feedstock used. Examples of technologies with high carbon dioxide concentration (>80%) in the chemical industry are featured in Table 1.

High CO_2 concentration	Product (NACE code)
Steam methane reforming (SMR)	Hydrogen (20.11)
Autothermal reforming (ATR) from natural gas	Hydrogen (20.11)
Autothermal reforming (ATR) from fuel gas	Hydrogen (20.11)
Partial Oxidation (POx) from fuel gas	Hydrogen (20.11)
SMR with catalytic methanol synthesis	Hydrogen (20.11) and methanol (20.14)
Enzymatic hydrolysis and fermentation	Bioethanol (20.14)
Fermentation-based ethanol production	Bioethanol (20.14)

[5] The European Environmental Agency (EEA) publishes process emissions data for ammonia, adipic acid, caprolactam, glyoxal and glyoxylic acid, carbide, titanium dioxide, soda ash, petrochemicals and carbon black production. An additional entry named "Other chemical industry" is featured.

[6] Capturing carbon directly from the air is for example way less efficient considering that the CO_2 concentration in the atmosphere is 0.04%. NASA, *Carbon Dioxide measurement* available at: Carbon Dioxide | Vital Signs – Climate Change: Vital Signs of the Planet (nasa.gov).

Catalytic ethylene oxidation	Ethylene oxide (20.14)
Haber-Bosch ammonia synthesis	Ammonia (20.15)

Table 1: This table is not exhaustive and is intended to provide examples of the high CO_2 concentration processes in the chemical industry. Moreover, the paper primarily focuses on existing assets where CCS could be technology option with retrofitting potential in light of a EU climate-neutral outlook.

Based on the CO_2 concentration of emission streams in Table 1, processes that have the most potential for the deployment of CCS technologies are those producing hydrogen (NACE 20.11 industrial gases), methanol, bioethanol and ethylene oxide (NACE 20.14 organic basic chemicals), and ammonia (NACE 20.15 fertilisers and nitrogen compounds). As such, in the next part of this paper, access to CCS infrastructure for plants falling under NACE codes 20.13, 20.14 and 20.15 will be assessed.

42%

Unavoidable process emissions in the chemical industry

Source: European Environment Agency

>80%

CO_2 in high concentration chemical processes' emissions streams

Source: Cefic iC2050

90%

CCS emissions abatement potential

Source: International Energy Agency

0.4-2 GJ/tCO_2

Energy consumption for CO_2 capture technology

Source: Global CCS Institute

2. Availability and financing of infrastructure

During the project planning and feasibility assessment phases, emitting companies investigate the **availability of the necessary infrastructure** to transport the CO_2 (domestically and cross-border) and to store it underground. If availability is scarce, the project cannot be considered feasible. In parallel, infrastructure developers will look at **potential volumes of CO_2 to be captured, transported and stored** before investing in the transport network. This chicken-and-egg situation should be avoided by swiftly developing and deploying a harmonised CCS value chain across the EU. Moreover, in chemical plants CO_2 purity levels can differ between assets, simultaneously carbon dioxide specifications in infrastructure projects may also vary widely. Therefore, having integrated specifications for CO_2 transport and storage infrastructure is crucial.

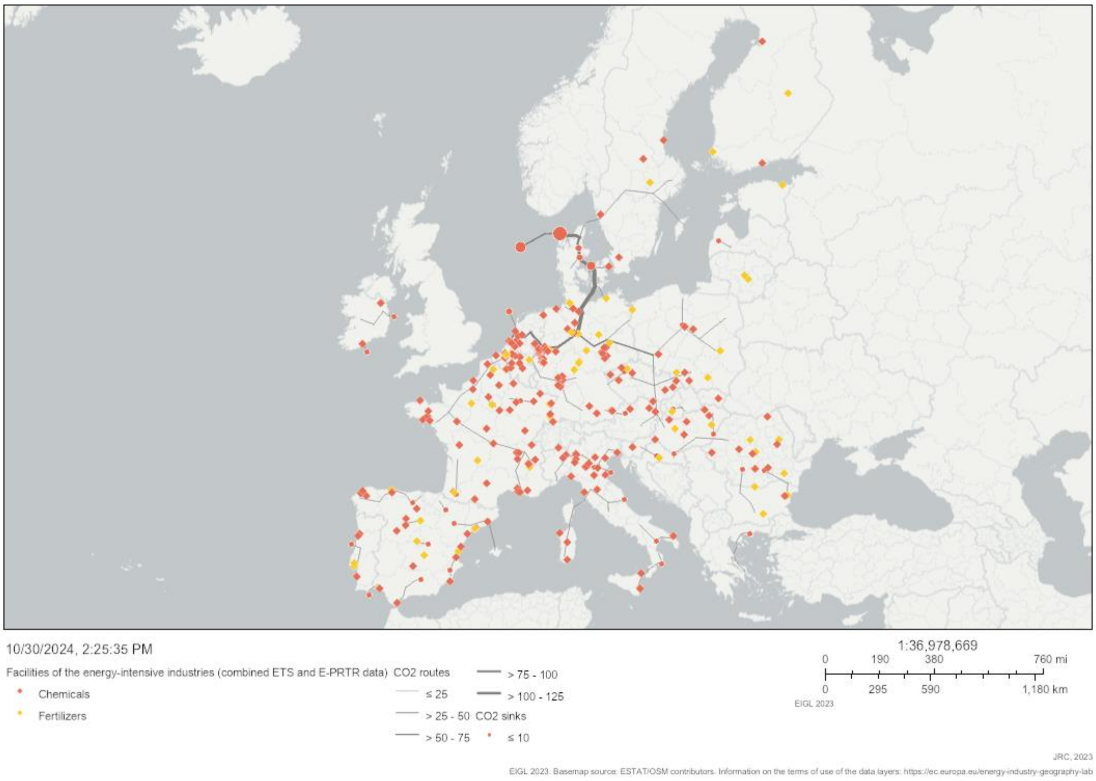
To assess **accessibility for the chemical industry to CCS infrastructure**, data from the European Commission's *Energy and Industry Geography Lab* is used as a reference. The CO_2 infrastructure analysed and featured in Figure 1 is the result of the JRC scenario A1[7] based on the total capture capacity of announced CCS projects within the EU before 2035, and projected capture capacities for the period after 2035. The scenario does not foresee the use of storage sites extra-EU as provided for in the Net-Zero Industry Act.

Figure 1 features the mapping of industrial facilities manufacturing inorganic basic chemicals (NACE 20.13), organic basic chemicals (NACE 20.14), and fertilisers and nitrogen compounds (NACE 20.15), as well as the CO_2 infrastructure expected to be developed by 2040. The Annex (page 6) features the CO_2 infrastructure that is planned to connect the industrial facilities divided by NACE code. These figures show the limited CO_2 infrastructure and sinks projected to come into operation by 2040, and the number of industrial facilities with the most capturing potential that are not connected to such network. Regional differences also emerge

[7] European Commission, Joint Research Center (JRC), Tumara, D., Uihlein, A. and Hidalgo Gonzalez, I., *Shaping the future CO_2 transport network for Europe*, Publications Office of the European Union, Luxembourg, 2024; https://data.europa.eu/doi/10.2760/582433, JRC136709.

highlighting vast areas within the EU with inadequate or absent transport infrastructure and sinks. This makes it considerably more costly to transport CO_2 for storage from these regions and hinders projects' feasibility.

Figure 1 – Industrial facilities and projected CO_2 infrastructure in 2040[8]



The current and projected situation highlights the urgent need for an **adequate EU infrastructure network for the transportation and trade of large CO_2 volumes**. An efficient CO_2 network is inherently cross-border and encompasses all different means of transportation, including pipelines, barges, and trains.

A Business Case for CCS

Linked to the CO_2 concentration and the availability of infrastructure, the economic viability of CCS technologies is being challenged as they lead to potentially higher production costs and more expensive products, impacting the competitiveness of the industry. The market development of CCS, even for high CO_2 concentration streams, remains impeded by:

- **Absence of a viable business model**. Sustainable CCS deployment needs long-term planning, monitoring, management schemes and financial provisions. Such provisions should be available for both CAPEX and OPEX as CO_2 capture technologies, transport and storage facilities not only are capital intensive but also require considerable volumes of affordable renewable or low-carbon energy which are currently not available.

---

[8] Source: Energy and Industry Geography Lab – Mapping Europe's Energy Future, JRC and European Commission. Figures are expressed in **Mtpa** (Million tons per annum).
It should be noted that while policies and scientific reports refer to CCS potential in Mtpa, they fall short in providing information on the effective total storage capacities of identified sinks. Such piece of information is crucial to assess the actual carbon storage potential.

    - The creation of a market for net zero and low-carbon footprint products is a precondition for a sustainable business case. In parallel, the role of funding measures to support technology development, cost reduction and unlock the full potential of CCS is key.

- **Lack of necessary transport and storage infrastructure network available in the short term**. For industries with long investment cycles, like the chemicals industry, investment decisions must be taken now to ensure our industry can help achieve the EU climate targets.
    - CCS infrastructure and storage deployment needs to be accelerated and serve also smaller emitters, which have unavoidable emissions but no alternative abatement solutions, by linking them to larger industrial hubs.

- **Legislative barriers**. The insufficient number of cross-border agreements hinders projects development as it does not allow CO_2 to flow from emission points to designated storage sites. Gaps in CO_2 purity levels standards and specifications impede the creation of an interoperable value chain, where industry and network operators do not share the same parameters which blocks projects or leads to unexpected higher costs for industry. Finally, addressing the lack of unbundling rules regarding storage and transport services would create a competitive CCS market with fair access rules and a transparent tariff system.
    - A regulatory framework allowing for a systematic and well-coordinated CCS development process avoiding regulatory conflicts with other pieces of legislation is crucial.

- **Low public acceptance and political support**. Gaining public acceptance for CCS is one of the key aspects for the successful roll-out of CCS projects, as there is strong Not in My Back Yard (NIMBY) approach.
    - The implementation of the CCS Directive provides for environmentally safe geological storage of CO_2.
    - Support for pilot projects and increase the wide public awareness can help developing social acceptance by showcasing the advantages of the technology in abating emissions.

The Way Forward: a Technology Positive Approach

Creating a technology-positive framework in the EU entails allowing all technologies that contribute to emissions reductions. Among those, CCS is a necessary technology to address unavoidable emissions stemming from processes that are inherently part of the chemical industry and to contribute to the EU's climate targets.

Therefore, there is a need to urgently deploy carbon capture and storage capacity and infrastructure. It is key for the European chemical industry to benefit from a technology-positive and supportive environment, to successfully transition while regaining competitiveness in Europe.

See Cefic's policy recommendations in Cefic paper on Industrial Carbon Management.

Annex: Industrial facilities by NACE code and CO_2 infrastructure expected to come online by 2040[9]

Figure 2 – Industrial facilities for the manufacture of industrial gases (NACE 20.11) and CO_2 infrastructure in 2040

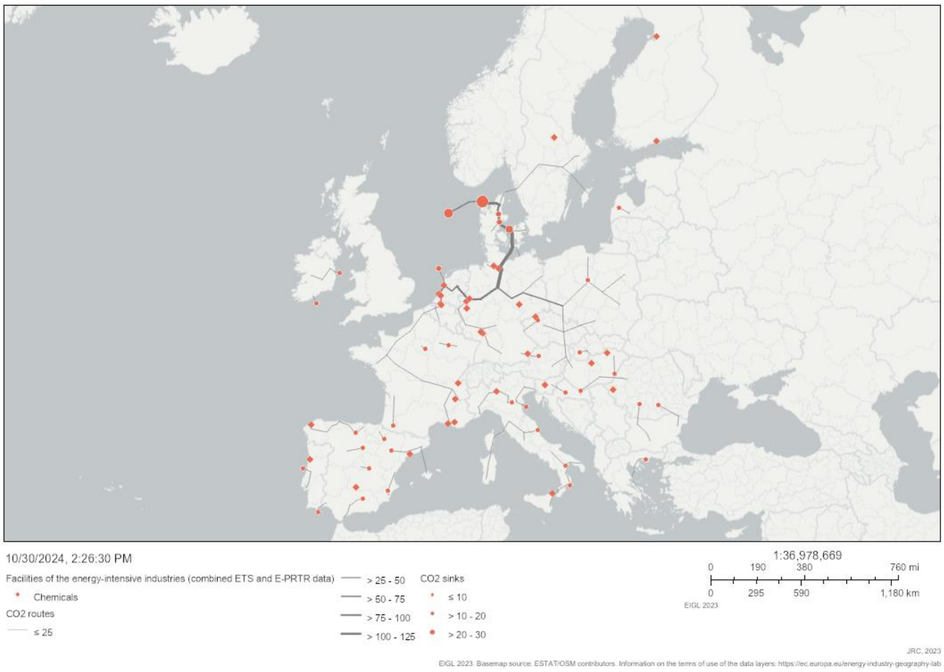
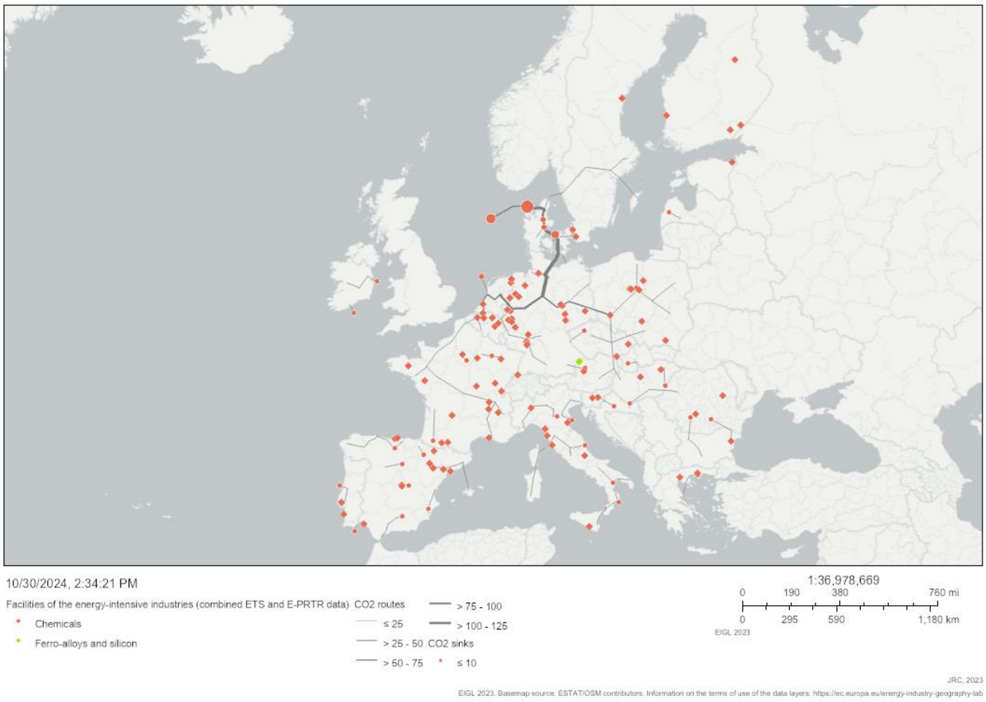


Figure 3 – Industrial facilities for the manufacture of inorganic basic chemicals facilities (NACE 20.13) and CO_2 infrastructure in 2040



[9] Source: Energy and Industry Geography Lab – Mapping Europe's Energy Future, JRC and European Commission. **Figures are expressed in Mtpa (Million tons per annum).**

Figure 4 – Industrial facilities for the manufacture of organic basic chemicals facilities (NACE 20.14) and CO_2 infrastructure in 2040

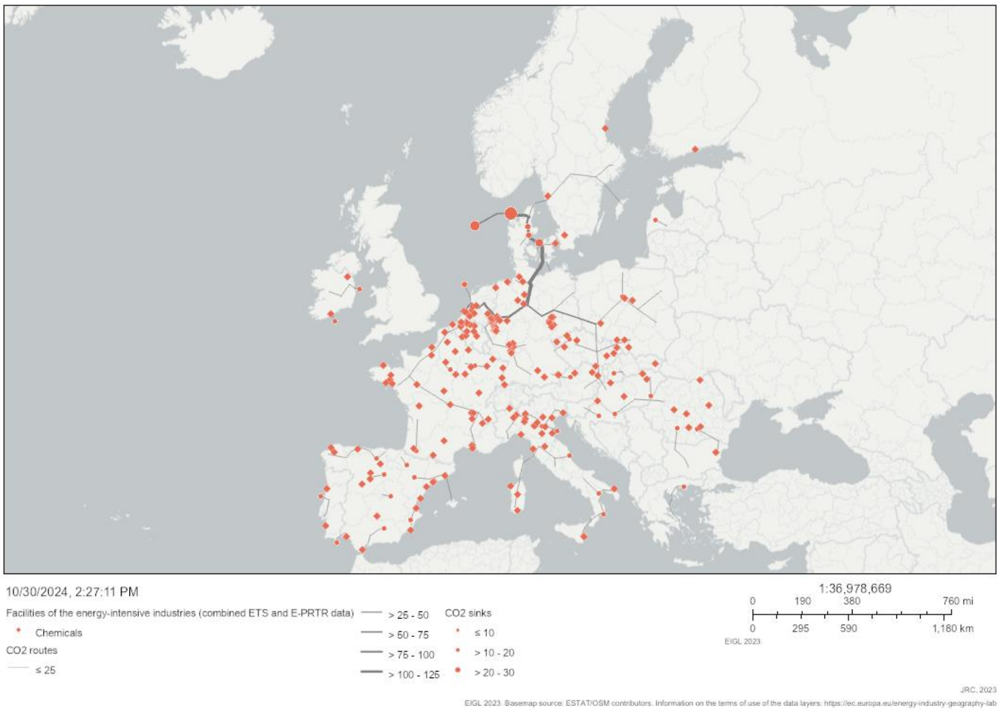
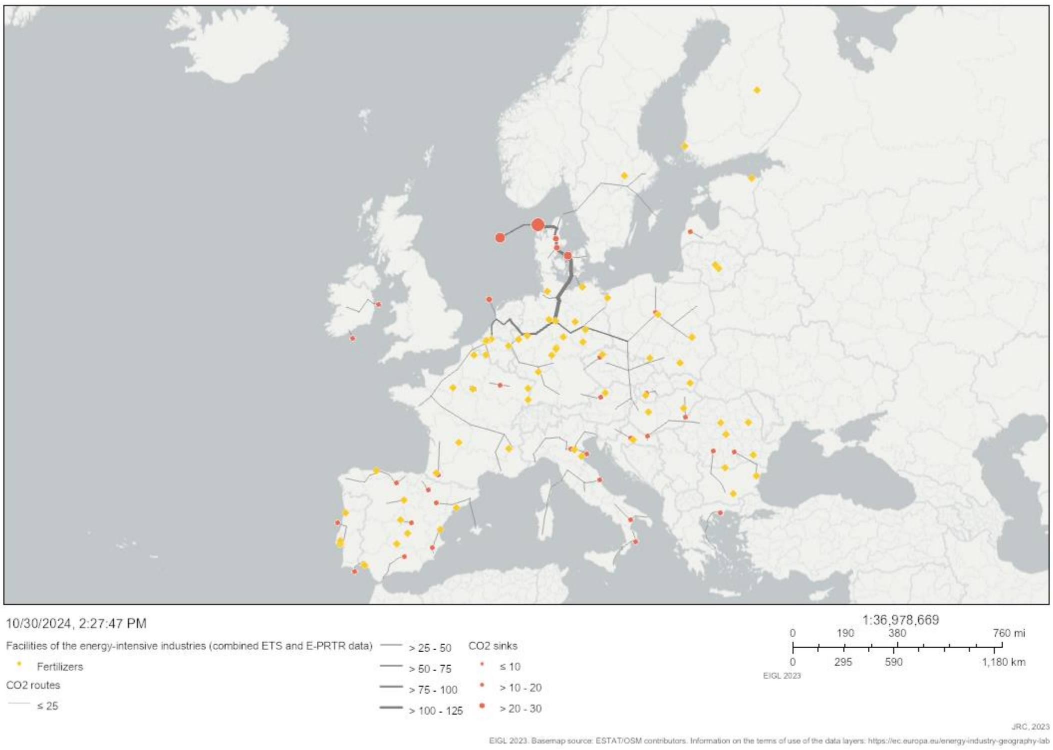


Figure 5 – Industrial facilities for the manufacture of fertilizers and nitrogen compounds (NACE 20.15) and CO_2 infrastructure in 2040



****

For more information please contact:

Elena Leonardi, Energy and Climate Manager
ele@cefic.be

About Cefic

Cefic, the European Chemical Industry Council, is the forum of large, medium and small chemical companies across Europe, accounting for 1.2 million jobs and 14% of world chemicals production.
On behalf of its members, Cefic's experts share industry insights and trends, and offer views and input to the EU agenda. Cefic also provides members with services, like guidance and trainings on regulatory and technical matters, while also contributing to the advancement of scientific knowledge.