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Potential Regulatory Frameworks for Cross-Border CO_2 Transport between the EU and UK

1. Introduction

Historically, the low technological readiness and high costs of carbon capture relative to energy efficiency and other renewable energies meant that it was not favoured as a decarbonisation mechanism, particularly in Europe. Additionally, because carbon removal technologies have been primarily developed or deployed by firms involved in fossil fuel extraction or usage, concerns have been raised by environmental groups that real emission reductions cannot be obtained through carbon capture. In recent years, several developments have combined to change both the political and industrial landscape for carbon capture. These include the technical success of carbon capture technology in specific applications, the implementation of carbon pricing and/or emissions trading systems to create a business case for carbon capture and an increasing realisation that net-zero scenarios for industrial economies cannot be met without a significant deployment of Carbon Capture and Storage (CCS) and Carbon Capture and Utilisation (CCU) technologies.

For heavy industry in Western Europe and the UK, particularly those with hard-to-abate emissions like the cement, steel and petrochemical sectors, the deployment of CCS/CCU is viewed as imperative if they are to maintain their viability beyond 2050. While carbon capture is dependent on the industry and the specific technology to be applied, the transportation and storage of CO_2 is dependent on geology, geography and regulatory frameworks. In many cases, countries with high capture capacity (for example France and Germany) have limited offshore geological storage and significant domestic opposition to onshore geological storage. On the other hand, several countries with high offshore storage capacity (for example Norway, the United Kingdom and Denmark) are not likely to come close to filling up their storage sites with domestic capture alone. This contrasts with the United States or Canada where planned CCS hubs have been designed to have capture, transport and storage within single jurisdictions and in a relatively sequenced chain[1].

While CCS on its own – in contrast with CCU - does not have a standalone business case for CO_2 producers, regulatory ‘carrots and sticks’, whether in the form of emissions trading systems (ETS) like that of the EU or tax credits like those provided through the Inflation Reduction Act (IRA) in the US, have been implemented to create a case for change. Standing in way of these mutually beneficial outcomes for European countries are regulations, including the London Protocol, which prohibits the cross-border transfer of CO_2. An amendment has been in place since 2009 to exempt CO_2 that is

[1] Ihejirika, Nnaziri. 2023. *Scaling CCUS in Canada: An Assessment of Fiscal and Regulatory Frameworks.* https://www.oxfordenergy.org/publications/scaling-ccus-in-canada-an-assessment-of-fiscal-and-regulatory-frameworks/

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geologically stored, but it is yet to be ratified by the required two-thirds majority[2]. In the meantime, the provisional application of the 2009 Amendment to Article 6, which requires bilateral agreements, has been leveraged in the short term to kickstart projects for capture, transport and storage.

This article outlines the history and current state development of CCS in Europe. Upon that basis, potential regulatory frameworks that can enable a competitive cross-border CO_2 transport and storage network between Western Europe and the UK will be explored and proposed.

2. Background

Greenhouse gas (GHG) emissions management has been a cornerstone of European policy for several decades, with the world's first ETS launched by the EU in 2005. Covering 45% of the EU's GHG emissions, the ETS operates on a cap-and-trade basis, whereby installations covered by the system are required to meet increasingly lower emissions limits each year or purchase allowances (from installations below their limit) to do so. The system's scope as well as its success in helping reduce power sector and industrial emissions by 37% since 2005 has influenced the creation of schemes in other jurisdictions, including Canada and the US[3]. Despite these reductions, there is an acknowledgement that to achieve the emissions level required to meet legally binding net-zero commitments, carbon capture utilisation and storage (CCUS) must be part of the decarbonisation mix, particularly for hard-to-abate sectors like cement, steel and petrochemicals.

From a regulatory perspective, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, otherwise known as the 'London Protocol', was amended in 2006 to allow the storage of CO_2 in subsea geological formations, however the export of CO_2 between countries was specifically prohibited due to the classification of stored CO_2 as a waste stream[4]. Given that several countries have high capture capacity but low storage capacity or domestic reluctance to support onshore CO_2 storage (e.g., Germany), an amendment to the protocol was proposed in 2009 to allow international transport of CO_2. This amendment is yet to be ratified by the required number of signatories as of the writing of this paper. In the absence of ratification, countries have been allowed to establish bilateral agreements in support of CO_2 transport and storage. This still results in the treatment of CO_2 as waste, rather than cargo, impacting requirements for product handling[5]. On the other hand, these bilateral agreements have helped create momentum and some investment certainty for developers of CO_2 transport and storage projects.

Although CCUS costs remain relatively high, the lack of alternatives for heavy industry and the imperative to get going have led to increased support from politicians. In Germany, for example, the Green Party has come out in favour of deploying CCS, acknowledging that there is not enough time for alternatives to be developed[6]. In advance of official policy, and leveraging bilateral agreements possible under the London Protocol, several European firms signed agreements for captured CO_2 to be stored at the Northern Lights CCS hub in Norway[7]. Moreover, demand for storage does not appear to be a concern: for instance, the Porthos CCS hub in the Netherlands, although storing CO_2 captured only from the immediate Rotterdam port area, has already sold out its 2.5 $MtCO_2$/year capacity[8].

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[2] International Maritime Organization. 2019. Carbon Capture and Sequestration. https://www.imo.org/en/OurWork/Environment/Pages/CCS-Default.aspx.

[3] International Carbon Action Partnership. 2024. *About Emissions Trading Systems.* https://icapcarbonaction.com/en/about-emissions-trading-systems.

[4] (International Maritime Organization 2019)

[5] Lampert, Edwin. 2023. *The London Protocol is key to unlocking international CO2 shipping.* https://www.rivieramm.com/news-content-hub/news-content-hub/the-london-protocol-is-key-to-unlocking-international-co2-shipping-77700.

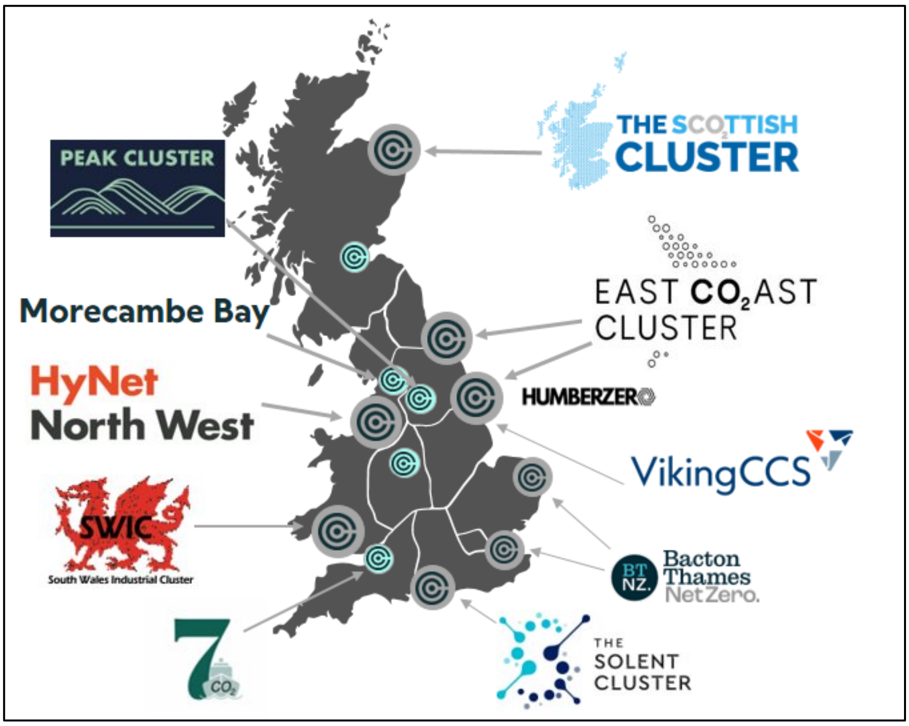
[6] Kurmayer, Nikolaus. 2023. *German Greens make way for European carbon management plan.* https://www.euractiv.com/section/energy-environment/news/german-greens-make-way-for-european-carbon-management-plan/.

[7] Northern Lights JV. 2023. *Northern Lights enters into cross-border transport and storage agreement with Orsted.* https://norlights.com/news/northern-lights-enters-into-cross-border-transport-and-storage-agreement-with-orsted/.

[8] Port of Rotterdam. 2023. *First CO2 storage project in the Netherlands is launched.* https://www.portofrotterdam.com/en/news-and-press-releases/first-co2-storage-project-in-the-netherlands-is-launched

In December 2023, the UK Government announced its 'CCUS Vision' that involves the creation of a competitive market by 2035 as part of its net-zero commitment, while adding £5 billion annually to the UK economy, by 2050. Leveraging on public investment of £20 billion dedicated towards CCS developments over a 20-year period, the government hopes to enable storage, transport and storage of up to 50 $MtCO_2$/year by 2035 and 180 $MtCO_2$/year by 2050. These CCUS hubs (Figure 1) are strategically located in industrial clusters of the UK and can feasibly absorb all the UK's captured CO_2 based on the 2030 target, with additional capacity for imported CO_2. The EU followed that up with the launch of its Industrial Carbon Management Strategy in February 2024[9]. The Strategy includes a commitment for the EU to achieve climate neutrality by 2050, enabled by the capture of up to 450 $MtCO_2$/year[10]. While the UK vision focuses on CCS infrastructure and economic impacts, the EU strategy appears to focus on creating a harmonised market for carbon removal in general that connects capture sites with storage operators and integrates with other sectors, particularly gas, electricity and hydrogen.

Figure 1: Current CCUS cluster proposals in the UK



Source: CCS Association (CCSA)

By 2030, it is estimated that 700 projects could be in operation or advanced stages of development globally, capturing up to 435 $MtCO_2$ annually[11]. While not a feature of North American CCS networks, CO_2 shipping has also developed at pace over the past several years with the first pair of ships in support of the Northern Lights projects scheduled to be commissioned later in 2024, and several others due to set sail by 2026[12]. It would appear then that the basis for an accelerated deployment of CCS networks in the EU and the UK has been established. Before exploring the compatibility of the EU-UK

[9] European Commission. 2024. *Development of EU ETS (2005-2020).* https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/development-eu-ets-2005-2020_en.
[10] Borchardt, Klaus-Dieter. 2024. *Carbon Capture Usage and Storage the new driver of the EU Decarbonization Plan?* https://www.oxfordenergy.org/publications/carbon-capture-usage-and-storage-the-new-driver-of-the-eu-decarbonization-plan/
[11] International Energy Agency. 2024. *Carbon Capture, Utilisation and Storage.* https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage.
[12] Webb, Peter and Phillips, Ian. 2024. *What do we need to know to make CO2 shipping for CCS a reality?* https://www.oxfordenergy.org/publications/what-do-we-need-to-know-to-make-co2-shipping-for-ccs-a-reality/

vision statements, potential alignment and regulatory frameworks that can enable closer integration, it is first worth examining the CO_2 demand and supply markets in Europe further.

3. Demand Dynamics: Carbon Capture in the EU and the UK

Outside of the Norwegian Sleipner and Snøhvit CCS projects, which capture and store a combined 1.8 $MtCO_2$/year, there are no operational CCS facilities in Europe[13]. In all, there are up to 119 projects in various stages of commercial development with several planned to be completed before 2030. The early operational challenges experienced by both Sleipner and Snøhvit in terms of CO_2 migration and geological acceptance respectively, demonstrate that a lot is still unknown about long-duration CO_2 storage[14]. Both projects have safely stored 22 $MtCO_2$, but this highlights the need for realistic CCS targets and committed funding to enable learning and scaling over a shorter cycle. The ETS Innovation Fund will be heavily leveraged to fund CCS projects, but there are calls for a stronger incentive framework to drive meaningful progress[15].

Like their peers in North America, CCS projects in Europe have developed at a modest pace even though CCS costs have decreased and are expected to decrease further through scale. This is largely due to uncertainties related to the regulatory environment, fiscal incentives and availability of the infrastructure required to support the full value chain. ETSs in both the EU and the UK have seen price highs breach the equivalent of €100/tCO_2, which makes CCS adoption cost-competitive for specific sectors like ammonia and refining located close to transport and storage networks[16]. However, for the hardest to abate sectors costs remain higher and this does not include the initial outlay of capital required to achieve final investment decision (FID). This is likely to change significantly in the near term, aided by net-zero incentives that are particularly favourable to early movers who can deploy projects before 2030.

The funding provided by the UK Government, along with the EU (US$1.5 billion) and its member countries Netherlands (US$ 7.3 billion) and Denmark (US$ 1.2 billion) has also sent positive signals to CO_2 producers[17]. Leveraging pricing models developed by the Clean Air Task Force, Figures 2a and 2b show the marginal abatement cost curve for facilities capturing the nearly 700 $MtCO_2$/year targeted by the UK, EU and Norway. In the long term, assuming new pipelines and the most optimistic cost learning patterns, the volumes required by 2050 can be captured for less than €85/tCO_2. Under the most conservative cost estimates, and assuming no new pipelines, all in costs stay above €100/tCO_2 for almost all facilities but do not exceed €137/tCO_2 for any.

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[13] Global CCS Institute. 2023. *CCS In Europe Regional Overview*. https://www.globalccsinstitute.com/wp-content/uploads/2023/12/CCS-in-Europe-Report_updated-15-12-23.pdf

[14] Hauber, Grant. 2023. *Norway's Sleipner and Snøhvit CCS: Industry models or cautionary tales*. https://ieefa.org/resources/norways-sleipner-and-snohvit-ccs-industry-models-or-cautionary-tales

[15] Borchardt, Klaus-Dieter. 2024

[16] https://www.statista.com/statistics/1322275/carbon-prices-united-kingdom-emission-trading-scheme/

[17] International Energy Agency. 2024. *Carbon Capture, Utilisation and Storage*. https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage.

Figure 2a: Long term CCS Costs Under the Pipeline, Low-Cost Scenario

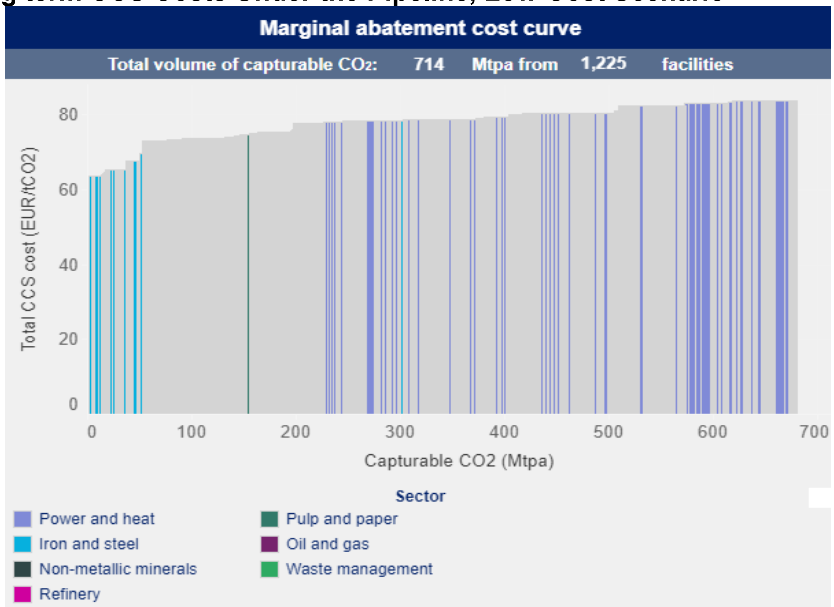
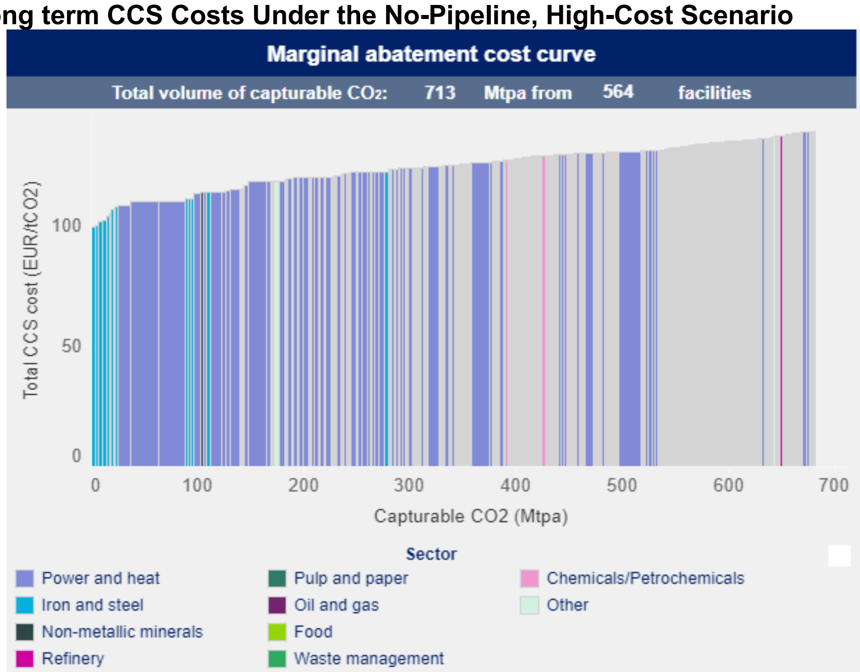


Figure 2b: Long term CCS Costs Under the No-Pipeline, High-Cost Scenario



Source: Clean Air Task Force

The combination of announced incentives is the driver behind the increase in project announcements, but it is imperative that early movers are carefully selected if CCS is to scale effectively. Experts have suggested that carbon capture is relatively proven – or at least technologically viable - for ammonia, refining, steam generation, cement and waste-to-heat systems, but relatively more challenging for power generation[18]. Additionally, to maintain momentum, the respective ETS' in Europe need to

[18] Author interview with Ralf Dickel, Senior Visiting Research Fellow *Oxford Institute for Energy Studies*. April 2024

maintain pricing levels that make them cost competitive with the full cycle cost of CCS. The rate of announced FIDs will also need to accelerate to enable scaling of the entire value chain, particularly transport and storage.

4. Supply Dynamics: Carbon Transport and Storage in the EU and the UK

Pipelines are the preferred mode of transport for most industrial processes, and in an idealised model where the capture point and storage location are in proximity, it would be the only option. The technical viability of CO_2 pipelines is not in doubt, with an estimated 9000km of CO_2 pipelines in operation globally, many spanning hundreds of kilometers in length[19]. It is also possible to repurpose existing natural gas pipelines to handle partial or full CO_2 streams, and this could be a more economic approach to tie in capture points that feed into existing natural gas networks. In Europe, pipelines are expected to play a significant role in moving captured CO_2 from inland Europe to the coasts (North Sea in particular) where CCS hub networks provide optionality for temporary or permanent storage. Several projects are underway to build this network of pipelines, or repurpose existing ones, specifically in Poland, France, Germany, Belgium and the Netherlands where they can take advantage of capture points along the route to ensure the lines are full, maximising toll revenues for pipeline operators. A major European midstream logistics firm, Fluxys, is planning a combination of gas pipeline repurposing and the construction of new subsea pipelines linking the Netherlands with Norway and the North Sea for total CO_2 storage of up to 40 $MtCO_2$/year[20,21].

Opposition to the build out of new pipelines means that existing natural gas lines are likely to be repurposed, however there is a potential for competition because this pipeline infrastructure interests developers of renewable natural gas and hydrogen projects as well. Since storage sites are expected to be offshore, shipping is a viable transportation mode for CO_2. Shipping provides additional flexibility for shippers, especially in decoupled value chains where the CO_2 producer is not the owner or primary user of a particular storage site. Several projects, including Northern Lights, Aramis (Netherlands) and D'Artagnan (France) include CO_2 shipping as core features, while Total's Bifrost project in Denmark is slated to be served by ship only[22]. The shipping of CO_2 has drawn parallels to liquified petroleum gas (LPG) transport, since CO_2 transported in the low-pressure (LP) configuration is theoretically in same physical state as semi-refrigerated LPG[23]. Like LPG, upstream and downstream terminals can also act as process hold points to ensure optimal physical conditions for shipping (-55ºC, 116 psi for the LP configuration) and for injection into the reservoir as a supercritical liquid (>31ºC, >1059 psi)[24]. The existence of LPG networks today provides an opportunity for direct leverage of equipment, and certainly the skills required to handle CO_2-specific ships, with shipping capacity approaching 40 $MtCO_2$/year by 2030[25].

If moderate progress is being made in the development of CO_2 transport logistics, then the pace of CO_2 storage is accelerated. Enabled by CCS policies in the UK, Norway and the EU, and favourable geological conditions around the North Sea in particular, several storage hubs have been identified for development. CO_2 is preferably stored in deep saline reservoirs or depleted hydrocarbon fields, where physical conditions allow the supercritical fluid to remain in-situ. In Europe, a clear preference appears

19 International Energy Agency. 2024. *CO2 Transport and Storage*. https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage/co2-transport-and-storage.

20 Fluxys. 2024. *Fluxys and Equinor launch solution for large-scale decarbonisation in North-Western Europe*. https://www.fluxys.com/en/projects/co2-hub-in-zeebrugge

21 Fluxys is also considering plans for CO_2 transport via pipeline between Zeebrugge in Belgium and the Bacton area in the UK, under Italian firm ENI's 'Bacton Thames Net Zero' project.

22 Global CCS Institute. 2023. *CCS In Europe Regional Overview*. https://www.globalccsinstitute.com/wp-content/uploads/2023/12/CCS-in-Europe-Report_updated-15-12-23.pdf

23 Webb, Peter and Phillips, Ian. 2024. *What do we need to know to make CO2 shipping for CCS a reality?* https://www.oxfordenergy.org/publications/what-do-we-need-to-know-to-make-co2-shipping-for-ccs-a-reality/

24 National Energy Technology Laboratory. 2024. *What is Carbon Capture and Storage?* https://netl.doe.gov/carbon-management/carbon-storage/faqs/carbon-storage-faqs.

25 Webb and Phillips. 2024

to be for depleted gas fields and saline reservoirs in the North Sea. This preference is largely driven by convenience, given the existing networks of pipelines, storage terminals and large industry in the immediate area. However, there is also a large degree of opposition to inland geological storage of CO_2, with Germany banning it outright and several other countries not sanctioning onshore projects[26]. Even if onshore storage is not permitted, the available capacity in the North Sea would allow the UK, EU and Norway to meet their cumulative 2050 storage targets for an average of 282 years (Table 1).

Table 1: North Sea Hub CO_2 Storage[27]

North Sea Hub	Total Storage ($MtCO_2$)	Injection Rate ($MtCO_2$/year)	Storage (Years)
Norway	80000	50	1600
United Kingdom	78000	180	433
European Union	34300	450	76

The significant investment level announced by the UK and Norwegian Governments for their flagship CCS hubs is likely to enable continued development of the projects. Given the depth of subsea drilling and midstream expertise in both countries, and the capacity of their North Sea clusters alone to handle the vast majority of captured CO_2 from Europe, investors are increasingly confident about their viability. Northern Lights, the Norwegian flagship project, is scheduled to receive its first CO_2 shipment from Denmark in 2025[28]. ENI, which leads the HyNet hub consortium in Northwest England that is expected to capture, transport and store up to 10 $MtCO_2$/year by early 2030s, is confident that it has enough local demand to enable project sanction. Italian firm ENI has also submitted a project proposal to develop a new CCS Cluster with the Bacton Thames Net Zero project, leveraging its Hewett lease, a depleted gas field, as a CO_2 storage site for up to 300 $MtCO_2$[29]. With this level of activity, it seems inevitable that the North Sea will become the hub of European CCS transport and storage. At the same time, with no current agreements in place between the EU and the UK for transport and storage, there is a missed opportunity to fully leverage the excess capacity and the logistics networks to deliver cost effective options. For example, the cost of shipping CO_2 from the EU to the UK is expected to be up to four times cheaper than shipping to Norway[30].

5. Cross-Border Mechanisms & Barriers to CO_2 Movement

It is clear, then, that the transport and storage value chains are largely proven or at least technically feasible. Given their proximity to both capture points, relatively short transport distances and abundant storage capacity, it is logical to expect something akin to a CO_2 free trade zone in the North Sea. Post-Brexit, the EU and the UK ratified the Trade and Cooperation Agreement (TCA) to facilitate the movement of goods and services between both regions. The TCA is designed to remove tariffs and quotas on goods that satisfy point of origin requirements and pose no threat to the health, safety, environment or security of either party[31]. However, since CO_2 is considered a waste stream, rather than a good or product, it is not currently covered by the TCA and would not meet the requirements for free trade. Specifically, the London Protocol and the ETSs of both regions are barriers to the seamless

[26] Federal Ministry for Economic Affairs and Climate Action. 2024. *Climate Change Mitigation.* https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2024/02/20240226-minister-habeck-intends-to-make-it-possible-to-use-ccs.html.

[27] Author calculations based on data from the Norwegian, UK and EU governments.

[28] Author interview with Toby Lockwood, Technology and Markets Director for Carbon Capture at Clean Air Task Force (CATF), April 2024

[29] Interview between Hasan Muslemani, Head of Carbon Management Programme at OIES and Francesca Nociti, Head of CCUS Services and Stakeholder Engagement at ENI, April 2024

[30] Estimate by ENI

[31] Government of the United Kingdom. 2021. *UK/EU and EAEC: Trade and Cooperation Agreement .* https://www.gov.uk/government/publications/ukeu-and-eaec-trade-and-cooperation-agreement-ts-no82021.

movement of CO_2 between the EU and the UK. The requirements associated with these regulations and systems are highlighted below as a basis for identifying how they can be leveraged to arrive at mutually beneficial outcomes.

5.1 London Protocol

The cross-border movement of CO_2 is governed by Article 6 of the London Protocol and is binding on all signing parties. This segment of the protocol, although originally intended to prevent the transport of waste from contracting parties of the protocol to non-contracting parties, prohibits the export of CO_2 intended for storage at sea[32]. Some questions have been asked about why CO_2 is considered waste rather than simply a commodity with global warming potential, considering that it is a commodity that is effectively traded[33]. In addition, CO_2 has a perceived value given that its removal from a firm's operating life cycle may be an enabler of the firm's social licence to operate. However, other experts have argued that the waste term is economically correct when CO_2 is permanently stored in geological formations, as the fiscal value of any credit or trade associated with it is based on the stream staying in the formation and not leaking out[34]. An amendment to Article 6, which would permit the export and receipt of CO_2 was proposed in 2009 but has not been approved by the required two-thirds of signatories to the Protocol. To maintain momentum for CCUS projects, a resolution was passed allowing contracted parties to enter into bilateral agreements, with Norway, Belgium, the Netherlands, Denmark and Sweden entering into multiple bilateral agreements with each other[35].

5.2 Emissions Trading & Carbon Markets

The UK-ETS was introduced in 2021, post-Brexit and largely replicates the EU-ETS. There are some differences in how revenues from the ETS are utilised by the government and how much broader the scheme should be in terms of coverage, with the EU looking at buildings and transportation[36]. The UK Government has also taken steps to increase the number of carbon allowances available to support certain industrial sectors, showing a higher degree of market involvement than the EU Commission[37]. The market sentiment envisioned by the diverging approaches is reflected in the pricing of both markets over time (Figure 3). However, the largest roadblock to CO_2 transport and storage, particularly to offshore storage sites by ship, is that neither ETS was designed with the shipment of CO_2 in mind[38]. While producers are allowed to deduct CO_2 transported and stored within the EU from their ETS liabilities, in theory CO_2 shipped to non-EU countries like the UK would not be eligible for such deductions. The same barrier is in place for CO_2 producers in the UK looking to transport to non-UK storage locations. Since the capturing entity – not the transport or storage site – owns the emission, there is minimal incentive for producers to ship CO_2 outside their jurisdiction, even if the logistics and economics suggest they should. Additionally, while shipping firms are responsible for emissions associated with the transport of CO_2 while in their custody, CO_2 producers remain accountable for fugitive emissions while it is being transported. In the absence of a cross-border framework, this can create 'grey zones' in CO_2 accounting, and pose a threat to the integrity of the CCS supply chain. However, both ETSs have similar safety standards and safeguards, as their legal basis pre-dates Brexit.

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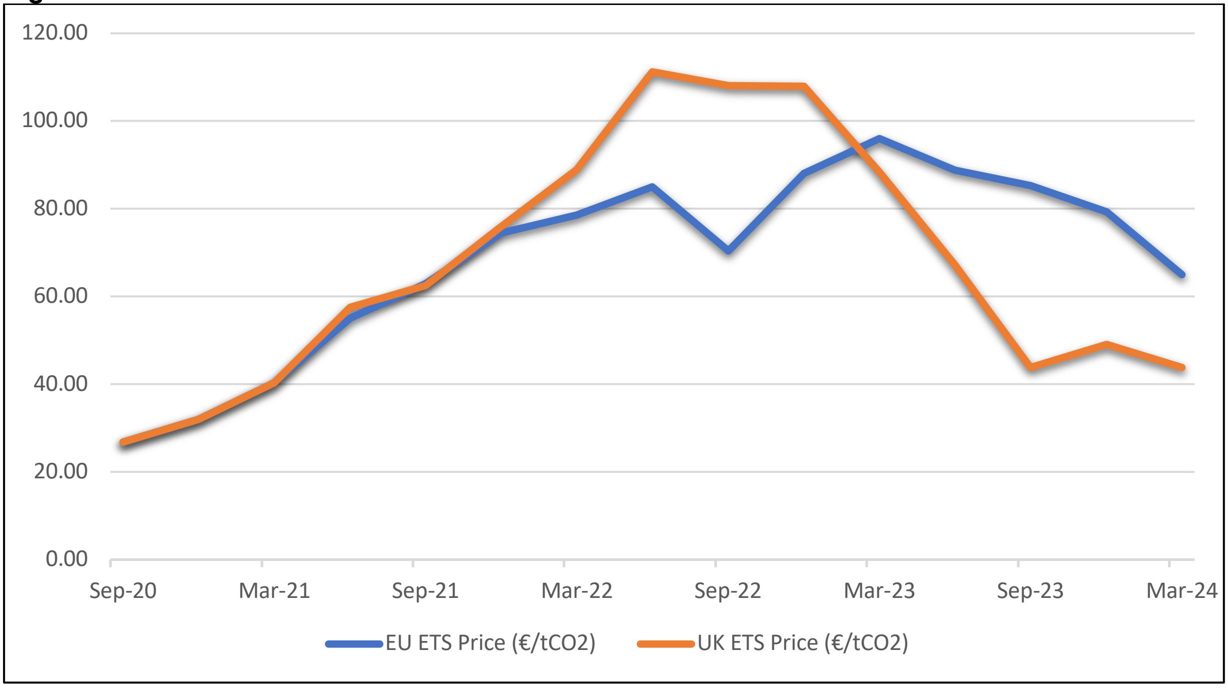
[32] (International Maritime Organization 2019)
[33] Author interview with Ralf Dickel, April 2024.
[34] Author interview with Toby Lockwood, April 2024.
[35] Government of Norway. 2024. *Five Northern European countries conclude international arrangements on transport and storage of carbon across borders.* Link
[36] Low, James, and Sam Lowe. 2023. *UK and EU Emissions Trading Schemes - drifting in different directions?* https://ukandeu.ac.uk/uk-and-eu-emissions-trading-schemes-drifting-in-different-directions/.
[37] Hague, Daniel. 2024. *Why the UK's carbon price drop in 2023?* https://steergroup.com/insights/news/why-did-uks-carbon-price-drop-2023
[38] Davies et. al, 2024. *Regulatory Barriers to a European Market for CO2 Transport by Ship.* Link

Figure 3: ETS Price: UK vs EU



Sources – Statista, Carbon Price Tracker

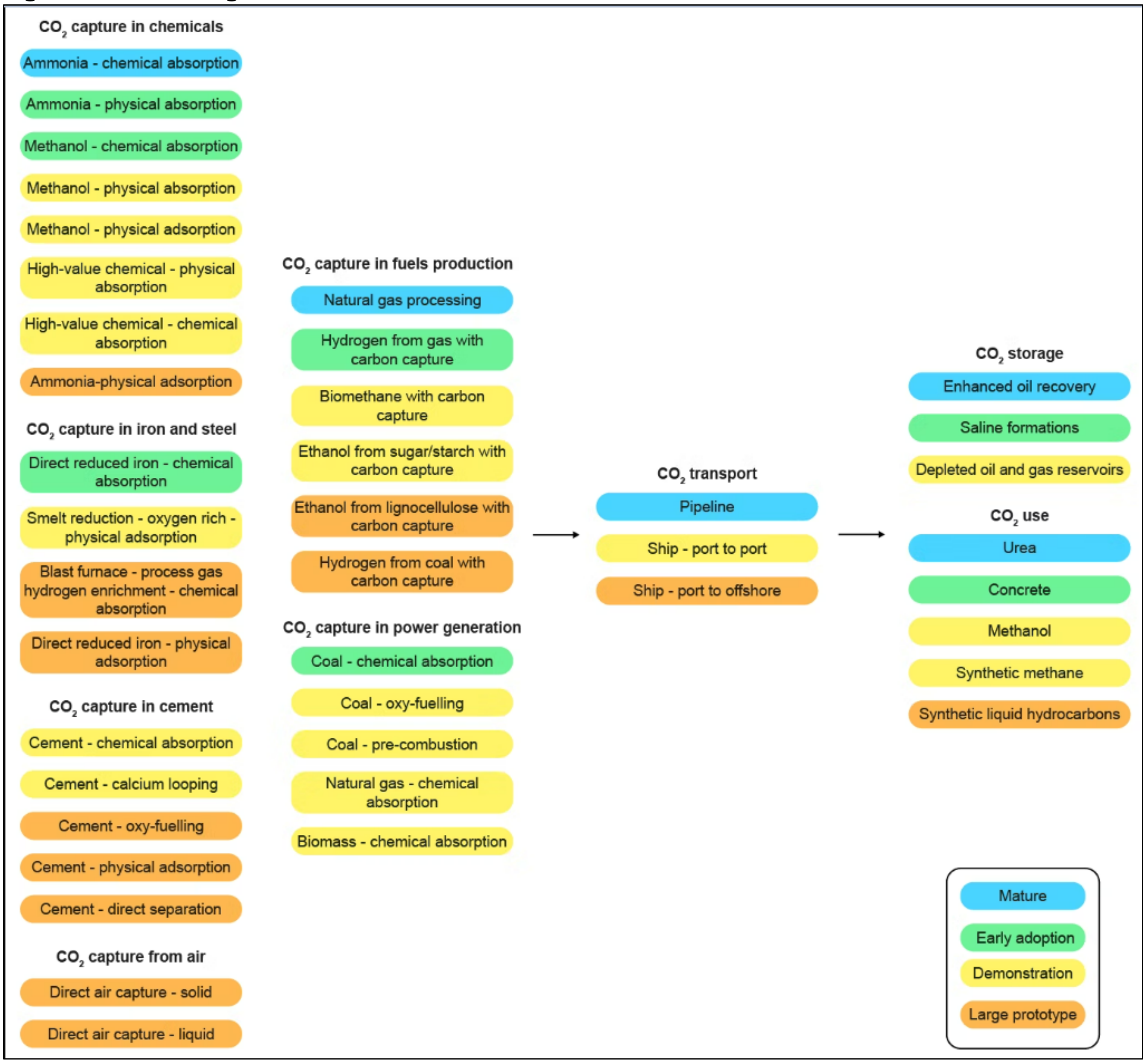
6. Feasibility of a Cross-Border CCS Network

The viability of the CCS value chain has been demonstrated through the scaling of enabling technologies and the repurposing of infrastructure that is already leveraged in other sectors, primarily oil and gas. In addition, governments in Europe – the EU, the UK and Norway – have announced the development of ambitious CCS projects. Despite this, there is still some doubt about the ability of CCS to lead to meaningful emissions reductions. These are largely linked to the interconnectedness of CO_2 infrastructure, regulations and markets and how perfectly all these need to align for CCS to play its imagined role. It is perhaps interesting to note that these perceived gaps only highlight the need for a coordinated CCS network, not just to minimise costs through scale but to enhance value by optimising the investment required for development and sustainment. These dimensions are summarised below.

6.1 Infrastructure

The technologies that underpin CCS are largely proven. CO_2 transport by pipeline is a reality in many parts of the world, particularly in North America. The ability to leverage natural gas pipelines is also an advantage given the plethora of those lines in Europe, even if there is likely to be competition for that capacity from hydrogen and other renewable fuels in the future. CO_2 storage has also been demonstrated to be successful at scale, both for EOR and permanent storage, despite documented challenges with the Sleipner and Snøhvit projects. CO_2 capture is the biggest challenge in the value chain, because the technologies to be deployed in the hardest to abate sectors are the least mature (Figure 4). Increased and reliable access to shipping and storage, with the optionality to optimise logistics for reduced cost will be of benefit to CO_2 producers. Creating a 'borderless' network in the North Sea increases this possibility and benefits the entire ecosystem while avoiding the cost of building excess capacity that is not required.

Figure 4: Technological Readiness of the CCUS Value Chain



Source: IEA

6.2 Regulations

As noted earlier, the key regulations governing the movement of CO_2 in Europe are London Protocol and the respective ETS mechanisms in the EU and the UK. These regulations are similar, with both jurisdictions having aligned targets on emissions reduction and similar safety standards, given that the legal basis for both pre-date Brexit. Additionally, the capacity the EU requires to store its emissions can be met by already announced projects in Norway and the UK, without the need for additional investment by CO_2 producers in the EU. This would require a bilateral agreement between the UK and countries within the EU, like Norway has done, allowing the storage of CO_2 produced in one jurisdiction in the other. In addition to diversifying storage options, thus increasing CO_2 accounting assurance, this exchange would build consistency between transport and storage firms by requiring them to comply with similar regulations and technical specifications. The political angle is the main roadblock here, with concerns in the UK about UK projects and firms potentially being subject to EU laws for emissions originating in the UK. Another option would be for parties to the London Protocol to agree that CO_2 is not covered by Article 6, if the integrity of the system encasing it is maintained, with penalties for CO_2 leakage during transport and storage.

6.3 Markets

The cost of CCS is often flagged as a reason not to invest in the technology, particularly since there is no 'return on investment' for capturing point-source emissions. The approach taken by European jurisdictions is to incentivise CO_2 producers to install CCS to avoid emission penalties, and to incentivise CO_2 transport and storage firms by creating an economic model that is viable. To ensure this model achieves its aims, it is important that the cost of CCS remains lower than that of an emission allowance. While the EU-ETS price would support that in certain applications, the UK price currently does not, presenting a dilemma for UK producers who may choose to emit rather than install CCS, further delaying the country's net-zero goals. Linking the two ETSs would avoid that, given the likelihood of government intervention and a larger pool of players to drive a more representative price. Like regulations, there is a political risk, however this is more than offset by the need for the government to justify its significant investment in the CCS storage hubs, and for those networks to return value to their developers and participants.

6.4 Monitoring & Control

Any coordinated effort between the EU and the UK will require regular monitoring to ensure that desired outcomes are being achieved, and that the agreements remain mutually beneficial. The methodology used to determine the 'owner' of the emitted CO_2 as well as any CO_2 emitted during transport and storage will be of most importance to network participants. For example, if a firm produces CO_2 in France and wants to store it in the UK's North Sea shelf, the CO_2 is unlikely to count towards reducing the firm's obligations under the EU-ETS today even if a bilateral agreement exists between the UK and the EU. This may drive projects focused on bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC), rather than CCS, since they would not have the same reduction obligations under the ETS. On the other hand, a revision of the EU-ETS to recognise the UK (and vice-versa) could cause the jurisdiction receiving CO_2 to look for additional compensation since they are taking all the liability without the attendant decrease in country emissions. Any agreement would need to establish these boundaries and be directive about how liabilities like carbon leakage will be handled, to ensure the integrity of CO_2 accounting, along with the applicable legal systems to manage disputes. Even the current bilateral agreements in place between European countries do not offer a lot of insight into these, as they are mostly statements of intent with little detail or specificity.

7. Conclusion

CCS has been identified as the most-ready technology for hard-to-decarbonise sectors like cement, steel, chemicals and refining. Development has accelerated over the last few years in Europe, with several projects spanning capture, transport and storage slated to receive FID by 2025 and be online by 2030. This pace has been backed by ambitious targets of European governments – EU, UK and Norway – which not only plan to either build or subsidise these networks but have also enshrined the requirement for CCS in their ambitious plans to be net-zero economies by 2050. Altogether, the continent plans to capture close to 700 $MtCO_2$ annually by 2050, up from 1.9 $MtCO_2$ in 2023. The significant investment required to deliver this commitment is backed by industry, with several firms experienced in developing offshore oil and gas fields, being lined up to manage the return of CO_2 to those subsea formations and saline aquifers. While not fully scaled, the technologies required to enable this value chain are already in place.

Given its geological conditions, the North Sea has emerged as the main hub of CCS activity in Europe, hosting most of the storage sites under development. However, CO_2 producers are limited in their ability to leverage the entire network under regulations currently in place. Together, the London Protocol and the respective ETS markets are hurdles that must be addressed for cross-border CO_2 transport to be feasible. For the London Protocol, this would require either a bilateral agreement between interested EU countries and the UK along the lines of the post-Brexit TCA, or collaboration on a proposal for the

London Protocol to specifically exclude CO_2 from coverage by Article 6 although this may be less likely to succeed.

Although the TCA does not address carbon transport, it can provide a context under which interested parties can establish negotiations. Article 392 (Carbon Pricing) of the TCA requires an effective system of carbon pricing, cooperation on pricing and the removal of barriers on the trade of goods that are relevant to climate change. For the ETS market, this would require a linking between the EU and UK systems, even if they remain separate. Such linking would allow for mutual recognition of emitted CO_2, allowing producers in the UK to retain ownership of allowances for CO_2 stored in the EU and vice-versa. Legally, this should pose no challenge, as the ETSs share common regulations and safety standards. These regulations would also need to be backed by strict monitoring guidelines to minimise the likelihood of carbon leakage, both physically and for accounting purposes. While these challenges seem straightforward, there are political realities that have prevented them from being implemented. Overcoming these requires a realisation from the EU that there is little economic value in developing storage sites at significant cost if sites in the UK present a better economic proposition, ensuring the Commission is not dependent on Norway alone. For the UK, it offers an opportunity to share transport and storage costs with CO_2 producers in EU, without adding liability to the latter.

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