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THE CARBON VOYAGE – EMISSIONS LIABILITY IN TRANSPORTING CO_2 BY SEA FOR CCS

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ABSTRACT

The urgent need to address global warming and reduce greenhouse gas emissions has positioned carbon capture technologies as crucial climate change mitigation tools. Safe and efficient CO_2 transportation, especially transboundary shipping, is critical in this context, raising numerous legal and regulatory concerns. This paper examines the existing international legal framework, highlights the limitations of the London Protocol and the HNS Convention, and emphasises the importance of international cooperation and consensus-building in addressing legal barriers to CO_2 transport by sea. The paper also explores the potential integration of a market-based mechanism, the ETS, into the liability framework to incentivise safe CO_2 transport and support CCS industry growth. Additionally, it stresses the significance of developing robust insurance products and fostering collaboration among industry stakeholders, regulators, and policymakers. Finally, the paper provides insights into contractual considerations for allocating CO_2 emissions risk, drawing on the leading example of the Norwegian Longship Project, the world's first full-scale CCS deployment that incorporates ship transport of CO_2 within its CCS chain. This paper contributes to the continuing dialogue on mitigating risks in CO_2 transport by sea through a comprehensive examination and targeted suggestions. It advocates for the responsible development and deployment of CCS technologies in the global fight against climate change.

Keywords: Carbon Capture and Storage (CCS), CO_2 transport by sea, liability framework, CO_2 emissions risk, Emissions Trading System (ETS), climate change

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1 Introduction

1.1 Capturing a moment

Leading authorities contend that achieving a net-zero carbon economy by 2050 necessitates the deployment of carbon capture and storage (CCS) technology, [1] as behavioural modifications in isolation may prove inadequate.[2] Due to the scale of the problem – the global increase in greenhouse gas (GHG) emissions – and the nature of the solutions involved in the captured and transportation of carbon dioxide (CO_2), transboundary CO_2 shipping is gaining more momentum with new pilot projects, intergovernmental CO_2 shipping agreements and orders of new carbon ships. The flexibility of shipping in matching sources with sinks makes it a promising avenue for achieving significant decarbonisation in hard-to-abate sectors. According to estimates, CO_2 transport may, by mid-century, necessitate the deployment of around 600 vessels and generate up to 10,000 employment opportunities.[3]

However, deploying CO_2 transport requires a clear but flexible legal framework addressing liability and risk allocation, particularly regarding CO_2 emissions. In addition, the public perception and acceptance of CCS rely on implementing secure and environmentally sound

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1 CCS is commonly conceptualised as a three-step process: firstly, separating and purifying CO_2 from fuels, feedstocks, and industrial processes; secondly, compressing and transporting CO_2 via pipelines, trucks or ships to the designated storage site; and finally, injecting the CO_2 deep into geological reservoirs, where it will be stored indefinitely. See R Stuart Haszeldine et al, 'Negative Emissions Technologies and Carbon Capture and Storage to Achieve the Paris Agreement Commitments' (2018) 376 Philosophical Transactions of the Royal Society 7 <https://royalsocietypublishing.org/doi/10.1098/rsta.2016.0447> accessed 16 May 2023; Sam Holloway et al, 'Chapter 5 Carbon Dioxide Transport, Injection and Geological Storage', *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) <https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_5_Ch5_CCS.pdf> accessed 16 May 2023.

2 Intergovernmental Panel on Climate Change, 'Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change' (IPCC 2014) <https://www.ipcc.ch/assessment-report/ar5/> accessed 30 April 2023; In contrast, Kirchsteiger argues, that CCS is a method that aims to combat global warming by managing, rather than minimizing, the production of harmful emissions, with the objective of limiting their effects rather than preventing the risk entirely. Hence, preventing the release of emissions into the atmosphere by means of long-term geological storage cannot be seen as the same as reducing emissions directly at the source. Christian Kirchsteiger, 'Carbon capture and storage-desirability from a risk management point of view' (2008) 46(7) Safety Science 1149, 1153.

3 Zero Emissions Platform, 'Role of CCUS in a below 2 degrees scenario' (ZEP 2018) 22 <https://zeroemissionsplatform.eu/wp-content/uploads/ZEP-Role-of-CCUS-in-below-2c-report.pdf> accessed 30 April 2023.

practices throughout the transportation and storage of CO_2.[4] This paper analyses the emerging international liability regime for transboundary CO_2 transport, focusing on challenges and opportunities in de-risking CO_2 shipping. It evaluates the emerging global legal regime and provides insights into contractual considerations for allocating CO_2 emissions risk under the leading example of the Norwegian Longship Project, the world's first full-scale CCS deployment incorporating ship transport within its CCS chain.[5]

1.2 More CO_2 than we can handle?

Operational CCS facilities capture and store 43.3 megatonnes (mt) of CO_2 annually, representing less than 0.1 per cent of total global GHG emissions.[6] The International Energy Agency (IEA) projected in 2010 that CCS could contribute to a 19 per cent reduction in emissions by 2050.[7] To align with this, captured CO_2 must increase to 1.6 gigatonnes (gt) of CO_2 by 2030 and 7.6 $gtCO_2$ by 2050.[8] Innovative carbon utilisation pathways could use 5 $gtCO_2$ annually, but economic costs limit their realisation.[9] Thus, market demand may not sufficiently reduce GHG emissions, highlighting the importance of CO_2 transport and storage for mitigation efforts.

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4 Martha M Roggenkamp, 'Transportation of Carbon Dioxide in the European Union: Some Legal Issues' in Ian Havercroft et al (eds), *Carbon Capture and Storage: Emerging Legal and Regulatory Issues* (Hart Publishing 2018) 245, 248.

5 Northern Lights, 'About the Longship Project' <https://norlights.com/about-the-longship-project/> accessed 30 April 2023.

6 International Energy Agency, 'CCUS Facilities in Operation by Application, 1980-2021' (IEA 2022) <https://www.iea.org/data-and-statistics/charts/ccus-facilities-in-operation-by-application-1980-2021> accessed 30 April 2023; Samantha McCulloch, 'Carbon Capture in 2021: Off and Running or Another False Start?' (24 November 2021) <https://www.iea.org/commentaries/carbon-capture-in-2021-off-and-running-or-another-false-start> accessed 30 April 2023.

7 International Energy Agency, 'Energy Technology Perspectives 2010 – Scenarios & Strategies to 2050' (IEA 2010) <https://www.iea.org/reports/energy-technology-perspectives-2010> accessed 30 April 2023.

8 International Energy Agency, 'Net Zero by 2050 – a Roadmap for the Global Energy Sector' (IEA 2021) <https://www.iea.org/reports/net-zero-by-2050> accessed 30 April 2023. However, the IEA Sustainable Development Scenario, intended to achieve net-zero global CO_2 emissions from the energy sector by 2070, would require that in 2070 10.4 $gtCO_2$ is captured from across the energy sector. International Energy Agency, 'CCUS in Clean Energy Transitions' (IEA 2020) <https://www.iea.org/reports/ccus-in-clean-energy-transitions/ccus-in-the-transition-to-net-zero-emissions> accessed 30 April 2023.

9 Currently, captured CO_2 can be used in industrial processes, including the production of synthetic fuels, plastic, construction materials, as well as usage in the food and beverage industry and in agriculture. These account for an estimated 230 $mtCO_2$ annually. In addition, a major use of captured CO_2 is enhanced oil and gas recovery (EOR or EGR), by which captured CO_2 is injected into the respective oil or gas reservoirs to increase production rates. International Energy Agency, 'Energy Technology Perspectives 2020' (IEA 2020) <https://www.iea.org/reports/energy-technology-perspectives-2020> accessed 30 April 2023.

The world possesses substantial CO_2 storage capacity, with estimates ranging from 8,000 to 55,000 gt.[10] Most CO_2 storage capacity is onshore, particularly in deep saline formations and depleted oil and gas fields. Countries such as Australia, Brazil, Canada, China, and the United States have ample onshore capacity, suggesting they may favour a pipeline-based approach over ship transport in their CCS strategies. In contrast, the global offshore storage capacity ranges from 2,000 to 13,000 gt. Regions such as the North Sea in Europe and Japan, where emitters are located near the coast and storage sites are dislocated, may benefit from the network flexibility provided by carrier transport.[11] Ship transport of CO_2 becomes preferable when the transport distance exceeds 350 km, offering advantages in quantity, shorter project durations, and flexibility in source and sink locations.[12] As a result, CO_2 shipping can play a crucial role in scenarios where short distances and large quantities are considered.[13]

2 Developing a legal framework for the cross-border transfer of CO_2

2.1 The London Convention and its Protocol

2.1.1 Trapped by treaties? Challenges and implications for CCS and CO_2

Article 210 of the United Nations Convention on the Law of the Sea (UNCLOS) mandates states to enforce laws and regulations to prevent, reduce, and control marine pollution resulting from dumping.[14] Complementing UNCLOS, the 1972 Convention on the Prevention of Marine

[10] Raimund Malischek and Samantha McCulloch, 'The World Has Vast Capacity to Store CO_2: Net Zero Means We'll Need It – Analysis' (IEA 2021) <https://www.iea.org/commentaries/the-world-has-vast-capacity-to-store-co2-net-zero-means-we-ll-need-it> accessed 30 April 2023. Approximately 70% of industrial and power-related emissions in the United States, Europe, and China are located within 100 km of potential storage sites.

[11] Hisham Al Baroudi et al, 'A Review of Large-Scale CO_2 Shipping and Marine Emissions Management for Carbon Capture, Utilisation and Storage' (2021) 287 Applied Energy 7. It should be noted that not all potential CO_2 storage capacity will be viable due to factors such as land use constraints and public acceptance. Technical factors like the quality of the cap rock must also be considered during site selection. Moreover, distinct environmental challenges arise for each mode of transport, necessitating particular liability arrangements. For a thorough comparison on liability regime between ship and pipeline transport, see Viktor Weber and Michael N Tsimplis, 'The UK Liability Framework for the Transport of CO_2 for Offshore Carbon Capture and Storage Operations' (2017) 32 Int'l J of Marine & Coastal Law 138.

[12] Sandrine Decarre et al, 'CO_2 maritime transportation' (2010) 4(5) Int'l J of Greenhouse Gas Control 857, 863.

[13] Byeong-Yong Yoo et al, 'Development of CO_2 terminal and CO_2 carrier for future commercialized CCS market' (2013) 12 Int'l J of Greenhouse Gas Control 323, 331.

[14] United Nations Convention on the Law of the Sea (UNCLOS) 1982, <https://www.un.org/depts/los/convention_agreements/texts/unclos/closindx.htm> accessed 2 June 2023.

Pollution by Dumping of Wastes and Other Matter (London Convention)[15] and its 1996 Protocol (London Protocol),[16] serve as the primary international treaties safeguarding the marine environment from waste dumping. The London Convention and the London Protocol have been acceded to by 87 and 53 states, respectively.[17] These central legal instruments notably did not encompass CCS or the transboundary movement of CO_2. This omission is attributable to the fact that when drafted, the comprehension and technological advancement in the field of CCS and the potential implications of transboundary CO_2 transport were less advanced and understood than they currently are.[18] In this context, determining whether CO_2 is considered waste becomes crucial. The London Convention's applicability to diverse CO_2 streams invites considerable ambiguity; nevertheless, this is clarified within the framework of the London Protocol.

The London Convention prohibits dumping waste or other materials specified in Annex I, generally referred to as the 'black list'.[19] The rationale behind this is the recognised detrimental impact these substances can have on aquatic life, even at low concentrations.[20] The substances identified in Annex II, known as the 'grey list', require meticulous handling if their volume crosses significant amounts. Under specific conditions, a permit might be granted for their disposal.[21] Finally, Annex III presents a set of essential stipulations that need careful consideration during the permit approval process. These stipulations form the framework for determining whether the disposal of certain materials is permissible. Annex I does not explicitly mention CO_2 in any of the prohibitive listings, nor does it appear in Annex II.

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[15] Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, <https://www.imo.org/en/OurWork/Environment/Pages/London-Convention-Protocol.aspx> accessed 2 June 2023.

[16] 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1996, ibid.

[17] Status of the HNS Convention and 2010 Protocol <https://www.hnsconvention.org/status/> accessed 30 April 2023.

[18] Nigel Bankes, 'Carbon Capture and Storage and the Law of the Sea' in Elise Johansen et al (eds), *The Law of the Sea and Climate Change – Solutions and Constraints* (CUP 2020) 160, 173.

[19] London Convention, art IV(1)(a).

[20] Ray Purdy and Richard Macrory, 'Geological Carbon Sequestration: Critical Legal Issues' (Tyndall Centre for Climate Change Research, Working Paper 45 2004) 21 <https://www.academia.edu/45211696/Geological_carbon_sequestration_critical_legal_issues> accessed 16 May 2023.

[21] London Convention, art IV(1)(b).

When determining whether CO_2 is classified as waste or other matter, its potential categorisation as 'industrial waste' should be considered.[22] As a matter of policy, it can be concluded that if the captured CO_2 can be proven to originate from manufacturing or processing operations, it would fall under this category and consequently be disallowed under the Convention. However, if it is determined not to be an industrial waste, it would not be subject to the prohibitions of Annex I. In this case, its regulation would fall under the permit procedure defined in other parts of the Convention.[23] The stance within the Protocol is somewhat more direct.

2.1.2 CCS amendments to Annex I

The original text of the London Protocol did not explicitly identify CO_2 as an allowable waste stream disallowing the geological storage of CO_2 in subsea formations.[24] To rectify this, the London Protocol was amended in 2006, explicitly permitting CCS through the 'CCS amendments to Annex I'.[25] This created a legal basis in international law for regulating the injection of CO_2 waste streams into sub-seabed geological formations for permanent storage.

Nonetheless, the amendment to the Protocol failed to address art 6, which restricts the transboundary movement of waste designated for dumping or incineration. Despite the intention of the amendment, the existing restrictions within the Protocol could inadvertently stifle the growth and development of crucial CCS projects on an international scale, particularly concerning the transportation and disposal of captured CO_2. This underscores the need for a more comprehensive approach to revising international treaties to facilitate climate-critical initiatives better.

2.1.3 Addressing the export prohibition

Due to the inadequate ratification of the CCS amendments to Annex I, the parties to the London Protocol proposed the 'export amendment' in 2009 that offers an exemption to the

[22] A term introduced to the Annex I list starting from 1 January 1996.

[23] Purdy and Macrory (n 20) 21-22.

[24] Bankes (n 18) 174. The language of the Protocol did not specifically prohibit the utilisation of CO_2 as part of an EOR. Furthermore, it did not preclude the injection of CO_2 in the context of offshore natural gas processing operations.

[25] IMO Res. LP.1(1) (2006) on the amendment to include CO_2 sequestration in sub-seabed geological formations in Annex 1 to the London Protocol.

prohibition of exporting CO_2 streams. This exemption is granted provided the involved countries have established an 'agreement or arrangement', with specific details outlined under the amended art 6(2) and art 6(3).[26] The 2009 amendment has not yet entered into force as it necessitates a two-thirds acceptance by the London Protocol parties.[27] As of 2019, only six out of the 53 contracting parties, including Norway, the UK, the Netherlands, Iran, Finland, and Estonia, had accepted the amendment.

To address this issue, the contracting parties to the London Protocol adopted a resolution in 2019, which allowed for the provisional application of the 2009 export amendment to art 6.[28] This resolution effectively removed the primary international legal barrier to CCS, enabling the transport of CO_2 for offshore storage across international borders. This development has been characterised as a 'major breakthrough' in advancing offshore CCS.[29] In September 2022, a similar sentiment was echoed when the Danish-Belgian CCS arrangement was signed, facilitating the transport of CO_2 for permanent geological storage under the London Protocol.[30]

Following the provisional application of the 2009 amendment to art 6 of the London Protocol, it is now possible for two or more states to agree to export CO_2 for geological storage under the amended art 6(2). To this end, states must submit a formal declaration of a provisional application under art 6(3) to the Secretary-General of the International Maritime Organization (IMO), which serves as the Secretariat for the London Convention and the

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[26] The term 'agreement' refers to a legally binding commitment between states, such as a memorandum of agreement or treaty, while 'arrangement' implies a non-binding understanding between states, such as a memorandum of understanding. International Energy Agency Greenhouse Gas Research and Development Program (IEAGHG, 'Exporting CO_2 for Offshore Storage – the London Protocol's Export Amendment and Associated Guidelines and Guidance, 2021-TR02' (2021) 5 <https://www.club-co2.fr/files/2021/04/IEAGHG-2021-TR02-Exporting-CO2-for-Offshore-Storage-The-London-Protocol-s-Export-Amendment-and-Associated-Guidelines-and-Guidance.pdf> accessed 30 April 2023.

[27] London Protocol, art 21.

[28] IMO Res. LP.5(14) (2011) on the provisional application of the 2009 amendment to Article 6 of the London Protocol.

[29] Dirk Uwer and Daniel Zimmer, *Carbon Capture and Storage: The Legal Landscape of Climate Change Mitigation Technology* (Globe Law and Business Ltd 2020) 47.

[30] Naida Hakirevic Prevljak, 'Danish-Belgian CCS Agreement Paves Way for Creating "Actual Market" for Maritime Transport of CO_2' (Offshore Energy 3 October 2022) <https://www.offshore-energy.biz/danish-belgian-ccs-agreement-paves-way-for-creating-actual-market-for-maritime-transport-of-co2/#:~:text=The%20agreement%20on%20CO2%20transport> accessed 30 April 2023: 'Besides the framework on carbon capture, utilization, and storage (CCUS) cooperation, the parties have also concluded an arrangement on how cross-border CO_2 transportation can take place under the London Protocol, which is said to have long been an unanswered question in the development of the international value chain.'

London Protocol and acts as the depositary organisation for the latter. Furthermore, countries must inform the IMO of any agreements and arrangements concerning the authorisation and responsibilities of the parties involved in compliance with the existing guidelines.

2.1.4 Solution reached — effective but not appropriate?

Weber argues that although no fundamental legal obstacles hinder the transport of CO_2 by sea, the current international and European legal frameworks are inadequately prepared to accommodate this mode of transport.[31] Weber posits that the ultimately adopted resolution, which allows cross-border CO_2 transport for CCS purposes, is effective but not entirely appropriate. A more fitting solution would have involved an interpretative resolution, as opposed to an amending resolution, clarifying the non-applicability of art 6 to CO_2 transport during CCS operations.[32]

Weber's stand is based on several factors. Thus, the London Protocol was not designed with CCS in mind and exporting CO_2 for CCS purposes was not pertinent to art 6.[33] Moreover, the primary objective and purpose of art 6 do not involve regulating CO_2 export for CCS.[34] The proposed solution does not attempt to surmount the art 6 barrier but asserts that no such obstacle exists. Consequently, any alternative addressing this impediment is unsuitable, even if it achieves the desired outcome.[35] It is essential to clarify that an interpretative resolution only defines the interpretation of a treaty in its current form and does not modify the Protocol. Moreover, this invalidates arguments based on the idea of interdependent obligations.[36]

Additionally, CCS activities differ from conventional dumping practices, as they are conducted with the explicit goal of environmental protection through mitigation measures. Hence, the interpretative resolution should explicitly state that art 6 provisions do not apply to the export

[31] Viktor Weber, 'Are We Ready for the Ship Transport of CO_2 for CCS? Crude Solutions from International and European Law' (2021) 30 RECIEL 387, 387.
[32] Ibid, 389.
[33] Ibid, 390; Bankes (n 18) 160, 171, 173.
[34] Ibid, 391.
[35] Ibid.
[36] Ibid.

of CO_2 streams intended for CCS purposes.[37] Weber's arguments are further reinforced by the limited or restricted applicability of the London Protocol as a whole.[38]

While the resolution adopted by the contracting parties to the London Protocol, which permits the provisional application of the 2009 amendment to art 6, may not be regarded as the optimal solution by some scholars, it nevertheless presents a practical approach that effectively addresses the legality of cross-border CO_2 transport for CCS purposes. This resolution constitutes a substantial advancement in facilitating CCS and progressing towards achieving the ambitious CO_2 reduction targets established by the Paris Agreement[39]. It is important to emphasise that the preceding discussion holds greater theoretical significance than practical implications.[40]

2.2 Incentives, certainty, and collaboration

The slow ratification process correlates with the dwindling interest in CCS within the international community. This is primarily attributable to the absence of a compelling business case, prevailing public perception, and various policy and regulatory complexities, which collectively exacerbate the perceived investment risk associated with CCS.[41]

While the United Nations Framework Convention on Climate Change (UNFCCC)[42] and the 2015 Paris Agreement mandate mitigation, a misunderstanding exists around CO_2 removal from the atmosphere as a part of climate change mitigation. This misconception often occurs when CO_2 removal is compared with mitigation, commonly and incorrectly understood as reducing GHG emissions.[43] Consequently, there is a tendency to overlook the importance of planning and preparing for the potential integration of CO_2 removal into national, regional, and global governance frameworks.[44]

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37 Ibid.
38 Ibid, 391-92.
39 Paris Agreement 2016 <https://unfccc.int/process-and-meetings/the-paris-agreement> accessed 2 June 2023.
40 Weber (n 31) 392.
41 David Langlet, 'Exporting CO_2 for Sub-Seabed Storage: The Non-Effective Amendment to the London Dumping Protocol and Its Implications' (2015) 30 Int'l J of Marine & Coastal Law 395, 398.
42 United Nations Framework Convention on Climate Change. See <https://unfccc.int/> accessed 2 June 2023.
43 Matthias Honegger et al, 'Is carbon dioxide removal "mitigation of climate change"?' (2021) 30 RECIEL 327.
44 Ibid, 327.

Hence, CO_2 removal should be recognised as part of the 'mitigation' concept, as defined in the Paris Agreement and the UNFCCC. This interpretation suggests that the responsibilities specified in these agreements should not be limited to emission reduction but should also include the initiation of removal strategies.[45] Such a stance elevates the importance of CO_2 removal, advocating for its central role in comprehensive climate change mitigation efforts. It further underlines the necessity to embed CO_2 removal strategies within governance frameworks, ensuring a holistic and effective strategy for tackling climate change. A synergistic policy framework is essential to facilitate this approach, one that promotes CCS investment through incentives ensures regulatory certainty and fosters stakeholder collaboration.[46]

2.3 The day after tomorrow

Despite implementing measures to prevent art 6 of the London Protocol from hindering cross-border CO_2 transport, the absence of a global consensus remains a significant challenge for the broader adoption of a framework that closes the critical CCS infrastructure gap. The Protocol's limited ratification level indicates possible hindrances in managing transnational CO_2 transport, potentially limiting its practical application. Simply ratifying the 2009 amendment or pledging its provisional application may not be adequate.

Could the London Convention and subsequent Protocol serve as effective guidelines or international standards, given that a limited number of states have negotiated them? For the 2009 amendment to the London Protocol to achieve broader applicability, it would necessitate recognition as a set of generally accepted rules, standards, and guidelines under UNCLOS, art 208(5). Such recognition could facilitate more extensive adoption of the amendment and promote a more cohesive international stance on CO_2 transport.

The European Union (EU) has devised a strategic approach to circumvent the London Protocol's constraints. Promoting bilateral agreements under Directive 2009/31/EC (CCS

[45] Ibid, 331-332.

[46] Hope McLaughlin et al, 'Carbon Capture Utilization and Storage in Review: Sociotechnical Implications for a Carbon Reliant World' (2023) 177 Renewable and Sustainable Energy Reviews 113215.

Directive)[47] serves a dual purpose within the EU context. It offers a means to navigate the constraints imposed by the London Protocol and ensures that the delineation of responsibilities and compliance measures are effectively addressed. By advocating for these agreements, the EU cultivates a holistic approach to carbon capture initiatives, upholding international legal obligations while addressing crucial concerns related to the implementation and oversight of cross-border CCS projects. However, the present scope of the CCS Directive does not cover the transport of CO_2 by ship.

3 International liability framework for hazardous and noxious substances – the HNS Convention

3.1 Background and entry into force

The 1996 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention)[48] and its 2010 Protocol (HNS Protocol)[49] form the liability regime relevant to damage caused by CO_2.[50]

The HNS Convention[51] is based on the Civil Liability and Fund Conventions[52] model covering pollution damage caused by spills of persistent oil from tankers. Hence, the underlying intention was to design an international liability framework for hazardous and noxious substances (HNS) sharing similarities with the carriage of oil. However, by 2009, the HNS Convention had still not entered into force, and this led to the adoption of a Protocol in 2010

[47] Directive 2009/31/EC of the European Parliament and the Council of 23 April 2009 concerning the geological storage of carbon dioxide [2009] OJ L140/114 (CCS Directive).

[48] International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea 1996 <https://www.hnsconvention.org/the-convention/> accessed 2 June 2023.

[49] Protocol to the 1996 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 2010 (not yet in force).

[50] References to the legal text is made to the 'Consolidated text of the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996, and the Protocol of 2010 to the Convention' (IMO 2018) <https://www.hnsconvention.org/the-convention/> accessed 2 June 2023. Unless otherwise stated, reference to the 2010 HNS Convention is to this consolidated text.

[51] See Colin de la Rue et al, *Shipping and the Environment* (3rd edn, Informa Law from Routledge 2022) ch 7.

[52] i.e., International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1992 <https://iopcfunds.org/about-us/legal-framework/1992-fund-convention-supplementary-fund-protocol/> accessed 2 June 2023 and the International Convention on Civil Liability for Oil Pollution Damage 1992, ibid. For detailed consideration, see de la Rue, ibid, ch 2 and ch 3.

designed to address practical problems that had prevented many States from ratifying the HNS Convention.[53] The Protocol will enter into force eighteen months after the date on which it is ratified by at least twelve States, including four States, each with not less than two million units of gross tonnage, and having received during the preceding calendar year a total quantity of at least 40 million tonnes of cargo that would be contributing to the general account.[54] It is anticipated entry into force will happen sooner rather than later.[55]

The carriage of CO_2 is governed by the International Maritime Dangerous Goods Code (IMDG Code)[56] and the International Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).[57] Liquefied bulk CO_2 is included in the 2010 HNS Convention due to its reference in art 1(5)(a)(v) to Chapter 19 of the IGC Code.[58] The inclusion of CO_2 in the list of specified products by the Maritime Safety Committee (MSC) necessitates adherence to the corresponding rules and regulations for the construction and operation of ships involved in the transportation of CO_2.[59] Consequently, when the 2010 HNS Convention comes into force, CO_2 carriers will fall within its scope.[60] In cases where the 1976 Convention

[53] See Richard Shaw, 'Pollution of the Sea by Hazardous and Noxious Substances – Is a Workable International Convention on Compensation an Impossible Dream?' in Malcolm Clarke (ed), *Maritime Law Evolving: Thirty Years at Southampton* (Hart Publishing 2013) ch 3.

[54] 2010 HNS Protocol, art 21.

[55] Status of the HNS Convention and 2010 Protocol (n 19): 'Although eight States (Canada, Denmark, France, Germany, Greece, the Netherlands, Norway and Turkey) signed the 2010 HNS Protocol, subject to ratification, Canada, Denmark, Estonia, Norway, South Africa and Turkey are the first States to have consented to be bound by the Convention. There has, however, been significant progress reported by a number of other States in recent months and it is anticipated that a number of those States will ratify in the near future'. See also Michael Tsimplis, 'Marine Pollution from Shipping Activities' in Yvonne Baatz (ed), *Maritime Law* (5th edn, Informa Law from Routledge 2021) 439.

[56] International Maritime Dangerous Goods Code (IMDG Code) (IMO, 2021). The IMDG Code is mandatory under Part VII, reg 3, of the International Convention for the Safety of Life at Sea (SOLAS) 1974.

[57] International Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk 1983 (IMO, 1983) adopted by IMO Res. MSC.5(48) (1983) on the adaptation of the International Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) (IMO, 1983). The IGC Code is mandatory under Chapter VII, reg 12, of SOLAS by IMO Res. MSC.6(48) (1983) adoption of amendments to the International Convention for the Safety of Life at Sea (SOLAS) 1974.

[58] This inclusion stemmed from IMO Res. MSC.220(82) (2006), which added CO_2 to ch 19 of the IGC Code in 2006.

[59] IMO Res. MSC.220(82)(2006) on the adoption of amendments to the International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk; Roggenkamp (n 4) 258.

[60] Weber and Tsimplis (n 11) 148.

on Limitation of Liability for Maritime Claims (LLMC Convention) and its 1996 Protocol (LLMC Protocol) [61] apply to CO_2 carriers, the 2010 HNS Convention will supersede them.[62]

Conversely, prior to the enforcement of the 2010 HNS Convention, the LLMC Convention, as amended, provides a legal framework that shipowners transporting CO_2 can adhere to.[63] This legal instrument parallels the 2010 HNS Convention, setting a maximum liability per incident based on the ship's tonnage and requiring forming a financial fund via a deposit or financial guarantee.[64] However, the compensation limits within the LLMC Convention are considerably lower than those in the 2010 HNS Convention. The fund mandated by the LLMC Convention is intended for direct compensatory payments upon established liability rather than acting as a safety net. [65] A common provision between the LLMC and HNS Conventions is that shipowners cannot limit their liability in cases where they have intentionally or recklessly caused damage.

3.2 Liability beyond pollution

The 2010 HNS Convention covers damage in the territory or territorial sea of a State Party to the Convention. It also covers pollution damage in the exclusive economic zone (EEZ), or equivalent area, of a member State and damage, other than pollution damage, caused by hazardous and noxious substances carried on board ships registered in the flag of the member State outside the territorial sea of any State. According, The following types of damage are covered under art 1(6):

> (a) loss of life or personal injury on board or outside the ship carrying the HNS; (b) loss of or damage to property outside the ship; (c) loss or damage by contamination of the

[61] Convention on Limitation of Liability for Maritime Claims 1976; Protocol to the 1976 Convention on Limitation of Liability for Maritime Claims 1996 (referred to as LLMC Convention); IMO Res. LEG.5(99) (2012) on the amendment to the limitation amounts set out in Article 3 of the 1996 Protocol (entered into force 8 June 2015).

[62] 2010 HNS Convention, art 42. See also Weber and Tsimplis (n 11) 158; Weber (n 31) 392.

[63] For discussion see Weber and Tsimplis, ibid, 152-157.

[64] LLMC Protocol, arts 3 and 5.

[65] Roggenkamp (n 4) 260.

environment; (d) and the costs of preventive measures, such as clean-up operations at sea and onshore, and further loss or damage caused by them.[66]

Claims under the 2010 HNS Convention will be assessed according to criteria that the governments of HNS Fund member States will establish.

The exclusion of national recovery rights ensues when the international regime governs the damage caused. In the specific context of CO_2 carriers, the existing shipping liability regimes or national liability laws will apply only if the international instruments are not applicable. Until the enactment of the 2010 HNS Convention, any claims arising from personal injury, loss, or environmental harm caused by a CO_2 carrier will be subject to the prevailing national framework. In such circumstances, shipowners' liability to third parties will be restricted under one of the globally established limitations of liability frameworks, with the LLMC the most likely option.[67]

The scope of the 2010 HNS Convention is limited to incidents that occur while the cargo is on board the ship.[68] Consequently, any accidents that may transpire prior to loading, during the storage of CO_2 in tanks or following its discharge do not fall under the purview of the 2010 HNS Convention, even where the cargo is in the owner's possession. Therefore, the Convention's applicability depends on whether the damage occurred before or after the cargo had crossed the ship's rail or loading line.[69] There remains uncertainty as to whether the 2010 HNS Convention would apply in temporary discharge or transhipment cases.[70]

[66] The 2010 HNS Convention does not apply to oil pollution damage from tankers, as defined in the International Convention on Civil Liability for Oil Pollution Damage, nor to loss or damage as covered by the International Convention on Civil Liability for Bunker Oil Pollution Damage 2001. Loss or damage caused by radioactive materials is also excluded.

[67] Michael Tsimplis and Kyriaki Noussia, 'The Use of Ships within a CCUS System: Regulation and Liability' (2022) 181 Resources, Conservation and Recycling 6.

[68] HNS Convention, art 1(9).

[69] Tsimplis (n 55) 443.

[70] Ibid.

3.3 Strict liability for the shipowner

The 2010 HNS Convention introduces strict and limited liability for the registered[71] shipowner.[72] This means that the shipowner is liable for the damage in case of an accident, even if the fault rests with certain third parties.[73] In cases where there is a causal link between the HNS present on a ship and the resulting damage, the mere occurrence of the damage is sufficient to establish the shipowner's liability.[74] This strict liability is subject to certain exceptions under art 7 for which the onus of proof falls on the shipowner.[75] The liability is limited according to the gross tonnage[76] of the vessel and the type of cargo rather than on the amount of HNS actually carried as per the calculation method provided in art 9.[77] Regarding carrier size, Northern Lights announced in late 2022 that the project had signed contracts with JV DA and Kawasaki Kisen Kaisha Ltd (K Line) to operate the first 7,500 m^3 liquefied CO_2 carriers.[78]

Compensation is based on a two-tier system, with the first tier covered by compulsory insurance taken out by shipowners. Where this insurance does not cover an incident or is insufficient to satisfy the claim, a second tier of compensation is paid from the international HNS Fund. Subject to the 2010 HNS Convention not affecting any rights that the shipowner may have to seek compensation from a third party who may be responsible for the damage caused, no claim for compensation for damage under the 2010 HNS Convention or otherwise may be made against inter alia any charterer, manager or operator of the ship.[79] This is a potential disadvantage, as it prohibits pursuing legal proceedings against other parties

[71] Ibid, art 1(3).
[72] Ibid, art 7(1).
[73] Ibid, arts 7(1), 7(5) and 7(6).
[74] Ibid, art 7(1) damage must be caused 'in connection with the carriage'.
[75] Ibid, art 7(2) and 7(3).
[76] A gross ton is a unit for the measurement of a ship's volume. See the International Convention on Tonnage Measurement of Ships 1969.
[77] Art 9(1)(a): 'Where the damage has been caused by bulk HNS: (i) 10 million Special Drawing Rights (SDR) for a ship not exceeding 2,000 units of tonnage; and (ii) for a ship with a tonnage in excess thereof, the following amount in addition to that mentioned in [10 million SDR] (i): for each unit of tonnage from 2,001 to 50,000 units of tonnage, 1,500 SDR; for each unit of tonnage in excess of 50,000 units of tonnage, 360 SDR; provided, however, that this aggregate amount shall not in any event exceed 100 million SDR'.
[78] Northern Lights, 'Northern Lights awards ship management contract to "K" Line' (19 December 2022) <https://norlights.com/news/northern-lights-awards-ship-management-contract-to-k-line/> accessed 16 May 2023.
[79] HNS Convention, art 7(5)(c).

involved in the ship's operation, even if such parties possess a greater financial capacity than the shipowner.[80]

3.4 The HNS Fund

The HNS Fund, established under art 13, aims to compensate for damages and losses resulting from the transport of HNS by sea. Financed by contributions from receivers of contributing cargo,[81] the Fund offers compensation to those affected by incidents involving such cargo. In the context of the CCS projects, CO_2 is regarded as contributing cargo.[82] In cases where the shipowner or their insurer cannot fully compensate for the damages, the HNS Fund will pay 'top-up'[83] compensation to cover the remaining costs. This means the HNS Fund provides additional compensation to ensure the claimant receives full compensation for their losses. However, the HNS Fund only pays compensation for damages that exceed the shipowner's liability and has specific criteria for what types of damages are eligible for compensation.[84] The maximum amount payable by the HNS Fund for any single incident is 250 million SDR, including the sum paid by the shipowner or its insurer.

3.5 CO_2, same but different?

With the 2010 HNS Convention, bulk CO_2 is anticipated to be classified as a contributing cargo to the general account, emphasising the need to consider related CO_2 transport risks for CCS.[85] This insight is vital for informed decisions and policy development in the evolving CCS industry. It raises a crucial question: is it justified to classify CO_2 as contributing cargo, especially during the early stages of the CCS industry?

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80 Weber and Tsimplis (n 11) 148.

81 HNS Convention, art 1(10): 'Contributing cargo means any bulk HNS which is carried by sea as cargo to a port or terminal in the territory of a State Party and discharged in that State. Cargo in transit which is transferred directly, or through a port or terminal, from one ship to another, either wholly or in part, in the course of carriage from the port or terminal of original loading to the port or terminal of final destination shall be considered as contributing cargo only in respect of receipt at the final destination.'

82 Weber (n 31) 392; ft 78 still applicable, meaning that the HNS Finder database categorizes CO_2 as packed, non-contributing cargo <https://www.hnsconvention.org/hns-finder/> accessed 19 May 2023.

83 2010 HNS Convention, Explanatory Note annexed to the consolidated version, para 32.

84 2010 HNS Convention, art 14(5)(a).

85 Weber (n 31) 393.

The core of the HNS Fund is built upon contributions made by importers or traders of various HNSs.[86] Consequently, the Convention outlines establishing a general account subdivided into different sectors, such as bulk solids and other HNSs.[87] The Convention also provides for creating separate accounts, including those for oil, liquefied natural gas (LNG), and liquefied petroleum gas (LPG). [88] The reasoning behind these distinct accounts can be traced to the reluctance of importers handling less hazardous cargoes to participate in a unified HNS Fund. Their concerns revolved around the possibility of inadvertently subsidising accident-prone and less safe segments of the industry.[89]

Two critical factors must be examined when considering CO_2 under the general account.[90] Firstly, it is vital to acknowledge that commercial CCS remains in its formative stage. Consequently, the stakeholders engaged in current pilot projects differ from conventional importers or traders of CO_2. In contrast to typical commodities, CO_2 in the CCS value chain will neither be traded on the market nor used as raw material for manufacturing goods. Secondly, the inherent properties of CO_2 provide a strong argument for its own distinct account. As a non-flammable substance with minimal expected environmental pollution risks, CO_2 sets itself apart from other substances under the general account. Additionally, CO_2 transport for CCS purposes is poised to leverage the well-established gas transport industry,[91] further highlighting its unique position.

3.6 Suitability for governing CO_2 emission leakage

The 2010 HNS Convention's suitability as an instrument to govern CO_2 emission leakage in the context of CCS warrants a critical examination.

The 2010 HNS Convention provides the legislative stability necessary for developing and deploying a global CCS market, wherein CO_2 is transported by ships. This stability is reinforced by its clarity to third parties and the ability it grants contracting parties to assess risks and required insurance. However, there is a persuasive argument that CO_2 should be eligible for

[86] HNS Convention, arts 16-20 and Annex II.
[87] Ibid, art 16(1).
[88] Ibid, art 16(2)(a)-(c).
[89] Tsimplis (n 55) 439.
[90] Weber (n 31) 393.
[91] Al Baroudi (n 11) 5.

its own separate account rather than being subsumed under the generic HNS regime, particularly if it is to play a significant role in combating climate change through CCS technology.

The nature of CO_2, serving environmental protection purposes, in the context of CCS differs from the typical HNSs covered under the 2010 HNS Convention. This underscores the distinctive role of CO_2 in CCS and raises questions about the Convention's suitability. The unique characteristics of CO_2, with properties of both a gas and a liquid when stored, might necessitate specific consideration. Given the particular requirements and risks associated with CCS, there might be a need for a more precise regulatory framework tailored to the needs and risks of CCS rather than trying to fit it into an existing framework designed for a different purpose. Lastly, the issue of coverage and applicability. The 2010 HNS Convention has not yet entered into force due to the lack of sufficient ratifications, and even if it enters into force, it may not be applicable in all jurisdictions involved in CCS activities. As a result, the current HNS regime may not be adequately tailored for the evolving CCS industry, necessitating a re-evaluation to ensure safe CO_2 transport in the context of CCS. However, it could serve as a starting point or model for developing a more specific framework for CCS.

Linking emissions trading and CCS for effective incentives? Integrating market-based mechanisms, such as the European Union Emissions Trading System (EU ETS), into the CCS value chain holds potential.[92] Addressing the liability gap by incorporating an ETS into the HNS regime could help quantify CO_2 emissions liability and promote emission reduction through a market-based approach. This incentivises investments, propels CCS technology development, and emphasises enhancing CO_2 shipping practices.[93] Moreover, it accounts for the environmental costs of CO_2 leakage within the liability framework, encourages safe and efficient CO_2 transport, and fosters CCS industry growth.[94]

[92] Al Baroudi (n 11) 18.

[93] Stephanie La Hoz Theuer and Andrés Olarte, 'Trading Systems and Carbon Capture and Storage: Mapping Possible Interactions, Technical Considerations, and Existing Provisions' (ICAP 2023) 1 <https://icapcarbonaction.com/system/files/document/La%20Hoz%20Theuer%20%26%20Olarte%20%282023%29.%20ETSs%20and%20CCS_ICAP.pdf> accessed 30 April 2023.

[94] International Energy Agency, 'Implementing Effective Emissions Trading Systems: Lessons from International Experiences' (IEA 2020) <https://iea.blob.core.windows.net/assets/2551e81a-a401-43a4-bebd-a52e5a8fc853/Implementing_Effective_Emissions_Trading_Systems.pdf> accessed 30 April 2023.

4 Liability exposure and insurance considerations

4.1 Elements of the value chain and risks

The components of the CO_2 shipping value chain encompass the conditioning of captured CO_2, which involves processes such as dehydration and liquefaction. This is followed by storage, then loading, and ultimately concludes with offloading and injection.[95] The most techno-economically viable option for transporting CO_2 is in a liquid, compressed format close to the triple point.[96] When CO_2 arrives from the capture installation, it is liquefied either as a pressurised or non-pressurised gas. Subsequently, the liquefied CO_2 is stored in tanks until it is ready to be loaded onto a ship. After loading, the ship proceeds to its storage location or port terminal. In the latter, it is first unloaded into intermediate storage tanks and then conditioned for pipeline transmission to the final storage. There are two options for unloading CO_2 into offshore storage. The first is direct injection from the ship, which requires conditioning the fluid on board and transmitting it to the injection well of an offshore storage site. The second option is to transfer the CO_2 in liquid form to an offshore platform, where it is stored before being injected into the storage site. [97]

The wealth of knowledge from handling LNG and LPG is recognised as significant in shaping effective risk mitigation strategies in CO_2 transport.[98] Potential risks and challenges to consider and manage during the transport phase include leakage caused by venting during maintenance and repair, boil-off gas generation, corrosion, effects caused by temperature change, dry ice formation due to shipping low-pressure CO_2, sloshing of liquid CO_2 by ship wave interaction, impurities as well as accidental loss of CO_2.[99]

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[95] For a thorough description of the components of the CO_2 shipping chain, including conditioning, see Al Baroudi (n 11) 18-25.

[96] Ibid, 20 and Table 17.

[97] Ibid, 24-25.

[98] Ibid, 5.

[99] For further details, see Global CCS Institute, 'Knowledge Sharing Report. CO_2 Liquid Logistics Shipping Concept (LLSC): Safety, Health and Environment (SHE) Report' (Global CCS Institute 2011) <https://www.globalccsinstitute.com/resources/publications-reports-research/knowledge-sharing-report-co2-liquid-logistics-shipping-concept-llsc-safety-health-and-environment-she-report/> accessed 30 April 2023; Al Baroudi (n 11) 11-14 and 25-29.

4.2 Harnessing insurance as a risk mitigation tool

Given the risks and uncertainties inherent in CCS activities, insurance has significant potential to serve as an effective risk-mitigating mechanism.[100] While some marine insurance policies for shipping CO_2 are available, upscaling the industry with large-scale transhipments of CO_2 poses novel challenges. Quantifying the risk of leakage and risks posed by CO_2 characteristics is challenging for insurance. This is because of the complex and dynamic nature of CO_2 transport processes, the unique risks associated with CO_2 as a GHG, the long-term liability considerations, and the evolving regulatory landscape. These factors make it difficult for insurers to accurately assess and underwrite the risks, leading to uncertainties in pricing premiums, setting coverage limits, and determining policy terms and conditions. Consequently, insurers might restrict coverage, increase exclusions, or require higher premiums, making insurance hard to obtain.[101] Other risks, such as regulatory and credit risks, directors' and officers' liability, and emerging risks associated with future technology deployment, could add complexity.[102]

The features of the insurance market – its capacity, terms, and conditions – are intrinsically linked to the prevailing regulatory framework, which, in the context of large-scale CCS activities, remains to be fully developed and thoroughly tested. Regulatory mechanisms typically guide the trajectory of insurance requirement evolution. Hence, the absence of a unified legal or regulatory framework that explicitly defines the extent of liability introduces an element of controversy and uncertainty.[103] However, there is a hypothesis that the mature LNG market could serve as a plausible model or framework for CO_2 transport. If this proves accurate, it could imply that the associated insurance costs for CO_2 transport would not surpass those typically incurred for LNG.[104]

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[100] Swati Gola and Kyriaki Noussia, 'From CO_2 Sources to Sinks: Regulatory Challenges for Trans-Boundary Trade, Shipment and Storage' (2022) 179 Resources, Conservation and Recycling 6.

[101] Ibid.

[102] Ibid. See also P Maguire, 'Conquering Insurance Obstacles for Carbon Sequestration Technologies' (2009) <https://www.powermag.com/conquering-insurance-obstacles-for-carbon-sequestration-technologies/> accessed 30 April 2023.

[103] Gola and Noussia (n 100) 6.

[104] Tsimplis and Noussia (n 67) 7.

With the progressive evolution of the industry, a proliferation of opportunities for insurers is anticipated.[105] The diversification of insurance products and the introduction of novel entrants into the market serve as potential mechanisms to counteract the current lack of insurance options that effectively contend with long-term liability issues.[106] The formulation and implementation of pilot offerings allow insurers to cultivate a comprehensive and nuanced understanding of the risk landscape. This knowledge acquisition process is instrumental in establishing a solid foundation for a profitable and resilient business model.[107]

In a noteworthy endeavour to curtail carbon emissions in the shipping industry and establish policy standards, the Global Centre for Maritime Decarbonisation (GCMD) has formed a strategic partnership with Gard, an established player in the international maritime insurance domain. The partnership strongly emphasises addressing the risks associated with CCS technology, specifically regarding GCMD's pioneering onboard carbon capture project (REMARCCABLE).[108] Such strategic partnerships highlight the synergies that can be leveraged to navigate and manage these risks while advancing decarbonisation goals. Similarly, insurers like Zurich are increasing the pool of products suitable for CCS activities.[109]

State intervention is vital for developing insurance products to address long-term liability concerns.[110] The Longship Project serves as a recent exemplification, where state aid agreements have been instrumental in providing commercial incentives.[111] Furthermore, the Grant Agreement between Norway and Northern Lights for the transport of CO_2 specifies

[105] Ibid.
[106] Gola and Noussia (n 100) 7.
[107] Ibid.
[108] Global Centre for Maritime Decarbonisation (GCMD), 'Project REMARCCABLE' <https://www.gcformd.org/project-remarccable> accessed 30 April 2023; Global Centre for Maritime Decarbonisation (GCMD), Global Centre for Maritime Decarbonisation & Gard partner to de-risk the uptake of decarbonisation' (24 November 2022) <https://www.gcformd.org/post/global-centre-for-maritime-decarbonisation-gard-partner-to-de-risk-the-uptake-of-decarbonisation> accessed 30 April 2023.
[109] Zurich is presently leading a task force that aims to create an insurance product to mitigate physical and legal risks linked to CCS. Frank Streidl and Kayne Sheppard, 'Sustainability in Energy Insurance' (15 December 2020) <https://www.zurich.co.uk/news-and-insight/sustainability-in-energy-insurance> accessed 30 April 2023.
[110] Gola and Noussia (n 100) 7.
[111] CCS Norway, 'Tailored State Aid Agreements are Necessary' (1 March 2023) <https://ccsnorway.com/state-aid-agreements-were-necessary/> accessed 30 April 2023.

liability insurance requisites intended to cover all operations within the value chain.[112] The integral role of state support, thus, extends beyond fostering the growth of the CCS industry; it is also pivotal in mitigating the risks integral to this evolving industry.

5 Transport of CO_2, ETS and allocation of liability

5.1 Allocating liability for CO_2 emissions in ship transport

For the development of commercially viable CO_2 shipping to transpire, it is crucial to secure agreements on cost and risk-sharing for CO_2 losses during ship transport. In formulating these contractual arrangements, an essential factor to consider is determining the liability transfer point for CO_2 losses between the capture facility, the transport and the storage operator. Prior to and in parallel with the planning of the Longship Project, the Norwegian government has been working on clarifying how the relevant EU legislation should be interpreted. This interpretation provides valuable insight into the development of industry practices, setting a precedent for how the first industrial CCS chain is being constructed within the current European legal framework.

5.2 The EU ETS and the right to subtract CO_2 emissions

The implementation of ETS can play a pivotal role in managing GHG emissions and fulfilling international climate commitments. Understanding the dynamics between CCS operations and ETS implementation is vital to crafting effective climate policy and regulation.

The EU ETS, enacted by Directive 2003/87/EC (ETS Directive),[113] is implemented in the European Economic Area (EEA)[114] and requires industrial facilities within its scope to

[112] Avtale om tilskudd til etablering og drift av transport og lagring av CO_2 ('Tilskuddsavtale') mellom staten v/ Olje- og energidepartementet og Northern Lights JV DA cl 48 <https://www.regjeringen.no/no/tema/energi/co2-handtering/f/id2950113/> accessed 30 April 2023 (Grant Agreement).

[113] Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC [2003] OJ L275/ 32 (ETS Directive).

[114] Theuer and Olarte (n 93) 36: 'The storage of CO_2 emissions beyond the jurisdiction of the EEA is not prohibited, but it is not eligible for the allowance surrendering exemption granted by the EU ETS, thereby creating limited incentives for carbon storage activities outside the EEA.'

surrender allowances for their annual CO_2 emissions.[115] Annex 1 of the Directive lists activities covered, including capturing GHG emissions from installations for transport and geological storage. According to art 12(3)(a), allowances need not be surrendered for emissions verified as captured, transported, and permanently stored under the CCS Directive. In other words, emissions captured, transported, and stored will be considered as not emitted.[116]

The Monitoring and Reporting Regulation (EU) 2018/2066 (MR Regulation)[117] supplements the ETS Directive by setting out the rules for measuring and disclosing information about emissions from activities that the ETS Directive covers. According to art 49, the operator must subtract from the installation's emissions any amount of CO_2 which is not emitted from the installation but transferred out of the installation to a transport network for long-term geological storage.[118] 'CO_2 transport' means the transport of CO_2 by pipelines for geological storage in a storage site permitted under the CCS Directive.[119] Similarly, the CCS Directive defines a 'transport network' as a '… network of pipelines […] for the transport of CO_2 to the storage site'.[120]

The distinction in treatment between CO_2 transportation via shipping and pipelines deviates from the underlying principles of the CCS Directive.[121] The foundation of restricting transport scope to pipelines lies in Annex I of the ETS Directive, which categorises pipeline transport as an ETS activity and mandates the operator to surrender allowances for the CO_2 emissions generated. An important question is whether CO_2 emissions from ship transport in the context of CCS can be subtracted.

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[115] ETS Directive, art 12(3). Annex 1 lists the activities falling within its scope. EU's legislative bodies have reached a preliminary agreement to implement the EU ETS for shipping from 2024, subject to final adoption expected in 2023.

[116] Roggenkamp (n 4) 251.

[117] Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 601/2012 of 21 June 2012 [2018] OJ L334/1 (MR Regulation).

[118] MR Regulation, art 49(a)(ii).

[119] Ibid, art 3(52).

[120] CCS Directive, art 3(22).

[121] Roggenkamp (n 4) 259: '… this is not in the spirit of the CCS Directive.'

5.3 A push for change

The Norwegian government sought clarification from the European Commission on whether CO_2 transported by ship for permanent storage could be included in the EU ETS, specifically in the context of the Longship Project.[122] Norway asserted that the capture installation should subtract corresponding CO_2 emissions once CO_2 is transferred from a vessel or truck to transport infrastructure or storage.[123] Liability for leakage during transport should be assigned to the capture installation operator, irrespective of whether the transport to the receiving terminal is managed by an entity other than the capture installation operator.[124] The European Commission Directorate General Climate Action (DG CLIMA) concurred with Norway's stance in its response.[125]

The Commission asserted that the installation responsible for capturing the CO_2 should be allowed to subtract any CO_2 intended for offshore storage from its emissions inventory once the transport to the storage site has been completed.[126] The Commission also highlighted the need for monitoring plans tailored to each capture installation, considering any CO_2 lost during transport. The measurement of CO_2 losses during transport would be undertaken at the point of delivery to the transport network or storage site.[127]

Following the response from DG CLIMA, it appears that the capture installation bears full responsibility for CO_2 emissions occurring during ship transport. Contrarily, the proposed amendment to the ETS Directive, particularly recital 41, envisions extending Annex I coverage

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[122] Norwegian Government, 'The Norwegian CCS demonstration project — request for legal clarifications related to the ETS directive and the MR-regulation'. Letter from Norwegian Ministry of Climate and Environment to DG CLIMA, 7 July 2019 <https://bora.uib.no/bora-xmlui/bitstream/handle/1956/21783/Vedlegg-til-masteroppgave--22CCS-in-the-EU-ETS-request-for-legal-clarification-22-i-originaltekst.pdf?sequence=2&isAllowed=y> accessed 30 April 2023.

[123] Ibid, 5 and 6.

[124] Ibid, 6.

[125] The Commission asserted that the installation responsible for capturing the CO_2 should be allowed to subtract any CO_2 intended for offshore storage from its emissions inventory once the transport to the storage site has been completed. Adriana Reyes-Lúa et al, 'CO_2 Ship Transport: Benefits for Early Movers and Aspects to Consider – 4th Report of the Thematic Working Group On: CO_2 Transport, Storage, and Networks' (EU CCUS PROJECTS NETWORK 2021) 19 <https://www.ccusnetwork.eu/sites/default/files/TG3_Briefing-CO2-ship-transport-Benefits-for-early-movers-and-aspects-to-consider.pdf> accessed 30 April 2023.

[126] Ibid.

[127] SF Gassnova, 'Regulatory Lessons Learned from Longship – the Public Sector's Involvement in Europe's First Industrial CCS Chain' (CCS Norway 2022) 36 <https://ccsnorway.com/publication/regulatory-lessons-learned/> accessed 30 April 2023.

to all modes of transport, thereby ensuring equitable treatment regardless of whether or not the EU ETS covers the means of transport. The practical implication of the amendment could mean that, to avoid double counting, the onus for CO_2 emissions during ship transport might be allocated differently.[128] As a result, it is imperative to accurately delineate responsibilities within the contractual relationship between the capture installation and the shipowner or operator under the EU ETS. To achieve a balanced assignment of these responsibilities, emphasis should be placed on precise fiscal metering during both on- and offloading phases within the contractual agreement.

5.4 Contractual arrangements and considerations

5.4.1 Transfer of responsibility for CO_2

The transport by sea of CO_2 not subject to the EU ETS under the current regime was circumvented in the Longship Project through state aid agreements between the industrial partners and the Norwegian government. According to the state aid agreement between the government and Northern Lights, the risk for CO_2 is transferred on delivery from the capture installation operator to Northern Lights.[129] Delivery takes place at the 'Shipping Point'.[130] Consequently, the operator of the capture installation holds the risk of the operation of the installation, including any emissions of CO_2 before delivery at the Shipping Point. After

[128] European Commission, Proposal for a Directive of the European Parliament and of the council amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757 (Brussels, 14 July 2021) COM(2021) 551 final. Recital 41: 'As carbon dioxide is also expected to be transported by means other than pipelines, such as by ship and by truck, the current coverage in Annex I to Directive 2003/87/EC for transport of greenhouse gases for the purpose of storage should be extended to all means of transport for reasons of equal treatment and irrespective of whether the means of transport are covered by the EU ETS. Where the emissions from the transport are also covered by another activity under Directive 2003/87/EC, the emissions should be accounted for under that other activity to prevent double counting.' See also Reyes-Lúa (n 125) 19-20.

[129] Grant Agreement (n 112), cl 22.3 and cl 47.1.

[130] Agreement on the support for capture of CO_2 between The Government of Norway by the Ministry of Petroleum and Energy and Norcem AS, 27 January 2021 <https://www.regjeringen.no/no/tema/energi/co2-handtering/f/id2950113/> accessed 30 April 2023. Cl 3, 'Shipping Point', means the point of delivery of CO_2 from the Recipient to the Transport and Storage Operator (at the connection flanges for loading hose/arm at the vessel's manifolds for liquid and gaseous CO_2).

delivery at the Shipping Point, the government or Northern Lights will pay quota allowances and cover other costs related to any emitted CO_2.[131]

The Longship Project comprises the transport of CO_2 by ships at sea from the EU ETS and non-EU ETS sectors.[132] This adds levels of complexity in terms of finding a fit-for-purpose solution. In practice, the capture installation, subject to the EU ETS (Norcem), will be able to subtract allowances when the CO_2 has entered the receiving terminal and upon receipt of a certificate issued by Northern Lights for CO_2 delivered.[133] However, Norcem will not have the right to subtract allowances for leaked CO_2 during transport. The fact that the capture operator cannot subtract from its emissions any CO_2 leakage occurring during transport will result in the capture operator being held liable for emissions over which they have no direct control. This issue was raised by Norcem during the state negotiations, stating that it could not accept the risk related to any financial losses stemming from CO_2 leakage during ship transport where it was not the operator.[134] As a result, Northern Lights and the government agreed to assume responsibility for costs associated with CO_2 leakage during ship transport under a cost-sharing arrangement.

In contrast to Norcem, Celsio is not subject to the EU ETS. After transport, when the CO_2 from Celsio enters the Northern Lights storage network, it is regulated under the EU ETS. Northern Lights and the government will cover potential costs related to leakage during ship transport, as with Norcem.[135]

5.4.2 Third-party volumes

The storage site will maintain surplus capacity to accommodate additional CO_2 volumes. This ensures that the tariffs accrued from new clients will constitute a major source of revenue for

[131] Ibid, cl 27.1. Further provisions relating to the transport of CO_2 are provided in appendices to the agreements, which are exempt from public disclosure due to duty of confidentiality.

[132] Gassnova (n 127) 36. A percentage of CO_2 emissions in both captures part of the Longship Project installations originates from the combustion of both fossil and biogenic sources. In its letter to Norway, the European Commission indicated that it does not support the interpretation that captured CO_2 from biological sources could be subtracted. This was based on art 49(1) of the MR Regulation, which states that the emissions of CO_2 shall be from fossil carbon.

[133] Ibid.

[134] Ibid.

[135] Ibid, 38.

Northern Lights.[136] Third parties will be granted access to storage and transport services under objective and non-discriminatory terms, contingent upon the relevant intergovernmental agreements.[137] An intergovernmental agreement must be established before entering any contract with Northern Lights.

The responsibility for CO_2 delivered to Northern Lights' ships from new customers will follow the same framework as the responsibility for CO_2 from Norcem and Celsio. Given that ship transport of CO_2 in the context of CCS is outside the EU ETS's purview, the capture operator retains responsibility for CO_2 leakage during sea transport, regardless of the vessel operator. As previously highlighted, legal contracts between operators can govern the financial consequences of potential leakages during transport.

In addition to commercial considerations, the responsibility for CO_2 leaks during transport on government levels should be clarified. The point at which accountability for such incidents transfers from one country to another is outlined in a bilateral agreement between the relevant states under the London Protocol. This bilateral agreement is a prerequisite for entering into a commercial contract with Northern Lights. It ensures that legal contracts between operators effectively govern the financial consequences of potential leakages during transport.

5.4.3 CO_2 measurement in the transport chain

A measurement regime for CO_2 in the CCS chain is needed for transferring the responsibility for the CO_2 between parties.[138] The accuracy of CO_2 measurements throughout the CCS value chain, including during ship on- and offloading, is vital for ensuring precise emission monitoring and reporting, which, in turn, is critical for facilitating equitable financial transactions throughout the CCS chain and ensuring accurate subtraction of emissions under the EU ETS.[139] As there are still uncertainties surrounding the technical performance of fiscal meters for CO_2, the cost implications associated with metering may lead to a potential conflict between the necessity of fulfilling legal obligations versus the objective of cost-

[136] Grant Agreement (n 112), cl 25.
[137] Ibid, cl 25.1.
[138] Gassnova (n 127) 33.
[139] Reyes-Lúa (n 125) 20.

effectiveness.[140] In order to mitigate this challenge, it may be necessary to explore alternative contractual arrangements to address this issue in the future. In addition, the transport agreement should also reflect any emissions stemming from the ship's propulsion system (operational emissions) during its voyage.[141] Undoubtedly, the operator of the capturing installation is unable to assess or control these, and proposing liability could be deemed unreasonable. Furthermore, it has been suggested that provisions related to onboard re-liquefaction could be considered to mitigate boil-off gas generation that occurs during the loading, transport and offloading activities.[142]

According to art 49 of the MR Regulation, reporting captured CO_2 at the capture site necessitates measurement systems with lower than 2.5 per cent uncertainties. However, there are instances where meeting the 2.5 per cent requirement is either technologically or financially unfeasible. In such situations, the regulations allow for a relaxation to 5 per cent uncertainty. This condition is subject to meeting the minimum 5 per cent requirement and in the absence of other viable measurement methods that exhibit uncertainty lower than 1.5 per cent under realistic operational conditions.[143]

The absence of traceable calibration of fiscal meters for CO_2 under transport conditions creates uncertainty about whether the meters satisfy the stringent EU ETS requirements during CCS operations. It remains ambiguous whether the measurement regulations at the capture site apply to emission control during shipping, despite the anticipated similarity in uncertainty requirements. Consequently, deploying less expensive measurement techniques, such as radar level gauging[144] rather than fiscal metering, may emerge as a viable alternative

[140] Ibid, 21.

[141] Weber highlights, that these operational emissions where not addressed by the Norwegian government nor by the Commission in their respective correspondence: Weber (n 31) 394. As of 2024, subject to shipping being included under the EU ETS, these operational emissions would presumably fall under the shipowner's obligation.

[142] Reyes-Lúa at al (n 125) 15. Al Baroudi (n 11) 26, section 9.2 where the estimated boil-off gas rates for CO_2 carriers are discussed.

[143] MR Regulation, art 49.

[144] Radar level gauging is a non-invasive technique that utilises radar technology to measure the level of liquid cargo in a ship's tanks. This method involves high-frequency radar waves that reflect off the liquid cargo's surface and return to the gauge. The reflected signal is then transformed into a distance measurement between the surface of the liquid and the top of the tank, which is then utilised to compute the volume and weight of the liquid cargo within the tank. This method is widely adopted in the shipping industry, particularly for large commercial vessels that transport oil, chemicals, or liquefied gases, due to its ability to provide accurate and reliable measurements without needing physical contact with the cargo.

for CO_2 shipping.[145] In the latest amendments to the ETS Directive, the Commission highlighted that it should adopt delegated acts to amend the methods for monitoring inter alia CO_2 emissions with the inclusion of shipping into the ETS.[146]

The Longship Project assesses the quality and quantity of CO_2 at multiple points. Yet, the total volume of CO_2 inventory on the ship is established during the transfer of CO_2 from the capture site to the ship and before the CO_2 is transferred from the ship to the receiving terminal.[147] The principle of measuring quantity is analogous to the system utilised for trading other liquefied gases like LPG.[148] Capture sites are to measure the density of liquid CO_2, which aids in determining the mass of liquid CO_2 loaded.[149] Capture sites will receive compensation based on the volume of CO_2 received by the ship and adjusted to -26°C.[150] The Custody Transfer Measurement System (CTMS) measures the change in CO_2 liquid level in the ship's tanks, which is then adjusted for factors such as CO_2 composition, pressure, temperature, trim, and list. The accuracy is estimated to be significantly below 2.5 per cent, in line with the MR Regulation.

5.4.4 Whose CO_2 emissions?

In the Longship Project, each capture facility is assigned a dedicated vessel, streamlining responsibility assignment and mitigating risks related to mixed cargo from various CO_2 streams. However, future expansion of CCS may require using a single vessel for multiple capture facilities, raising concerns about mixed CO_2 streams and the allocation of responsibility for emissions during sea transport.

Considering potential scenarios where multiple countries are involved in CO_2 transport, it is incumbent upon the contracting State to issue a permit for loading a CO_2 stream onto a vessel

[145] Reyes-Lúa (n 125) 20.

[146] Amendments adopted by the European Parliament on 22 June 2022 on the proposal for a directive of the European Parliament and of the Council amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and Regulation (EU) 2015/757' (COM(2021)0551 – C9-0318/2021 – 2021/0211(COD)), amendment 487, recital 67.

[147] Gassnova (n 127) 40.

[148] Ibid.

[149] Ibid.

[150] Ibid.

within its territory. This responsibility also extends to vessels registered under its flag and loading CO_2 in non-contracting party territories for export to another country.[151]

5.5 Balancing innovation and standardisation

While relying on market mechanisms and agreements between parties to find the most effective and efficient solution may be possible, this approach can create complexities between the national rules and relevant international instruments. As shown in the Longship Project, this market-oriented approach emphasises flexibility and innovation, allowing for adaptability in response to changing circumstances. At this stage, a uniform system could impede such flexibility, potentially hindering innovation and the ability to address the unique challenges and contexts faced by different parties involved. However, in the long run, a lack of uniformity could result in inconsistencies and difficulties in coordinating global efforts and providing a level playing field. In contrast, a uniform system arguably ensures compatibility and consistency between the various components of the CCS framework, fostering a cohesive and integrated response to a global issue.

Ultimately, the choice between relying on a market-driven approach or implementing a uniform system involves a delicate balance between the desired flexibility regarding innovation and growth and the need for standardisation within a future international CCS regime. The greatest challenge facing CCS is not technology but the uncertainty of where policy and regulation are going and that 'adaptive, flexible, and performance-based' regulatory approaches will be required.[152]

6 Conclusions

The pressing need to curtail GHG emissions has thrust CCS technologies into the limelight as crucial climate change mitigation solutions. As the demand for CO_2 sequestration grows, the safe and efficient transportation of CO_2 becomes a critical aspect of CCS operations. The transboundary shipping of CO_2 raises numerous legal and regulatory issues, necessitating the development of a comprehensive liability regime to address associated risks. The potential

[151] IEAGHG (n 26) 5.

[152] Norman Shilling, 'Carbon Capture and Storage—An Equipment Manufacturer's Perspective' in Havercroft (n 4) 25, 33.

hazards of CO_2 transport, such as leaks and unintended releases, may inadvertently exacerbate climate change by allowing CO_2 to re-enter the atmosphere.

CCS deviates from conventional dumping activities by serving as an environmental protection measure aimed at mitigating the impact of anthropogenic CO_2 emissions on climate. The practical implementation of the London Protocol might face certain constraints; ratification of the 2009 amendment or submission of a declaration for its provisional application might not sufficiently address the intricacies of governing cross-border CO_2 transport. The Protocol's real-world effectiveness may confront additional challenges or require further measures for a comprehensive application. The regulatory framework review demonstrated that the lack of ratification might impede the development of the full-scale CCS and the scaling-up of CO_2 transport by sea. Hence, international CCS projects may encounter difficulties due to the need for bilateral agreements or arrangements. This highlights the importance of continued cooperation and consensus-building in addressing legal barriers to CO_2 transport. Despite some critique of the appropriateness of the adopted resolution for the amendment of art 6 of the London Protocol, it has resolved the legality issue of cross-border CO_2 transport and allowed for progress in the CCS field.

While the 2010 HNS Convention offers legislative stability for the emerging CCS industry, there are arguments for CO_2 to have its own separate account due to its unique nature and role in climate change mitigation. The current HNS regime may not be sufficiently tailored to the CCS industry, and a re-evaluation of the regime could involve integrating an ETS to incentivise safe CO_2 transport and support CCS industry growth.

Examining the incorporation of market-based mechanisms into the liability framework could provide means of quantifying and managing CO_2 emissions. There are uncertainties surrounding the inclusion of CO_2 shipping in the EU ETS; however, as demonstrated by the Longship Project, contractual arrangements can help distribute CO_2 emission-related risks. Moreover, developing robust insurance products that consider a comprehensive risk assessment framework for both immediate and long-term liabilities is vital for effectively managing CCS projects and fostering the continued growth of the CCS industry.

The state of CCS is in a significant transitional period, marked by heightened interest and investment from governments and private companies but also tempered by past disappointments and ongoing scepticism.[153] As the need for CCS projects intensifies in the fight against climate change, fostering international cooperation and consensus-building will be pivotal in unlocking its potential. In addition to conventional CCS, Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Capture (DAC) represent future negative emission technologies aimed at atmospheric CO_2 removal.[154] The need to meet net-zero goals has led to a rise in start-ups developing CCS technologies, hinting at a future where CCS extends beyond large fossil-fuel corporations. Breakthroughs such as CO_2-consuming microbes and technologies capable of transforming CO_2 into stone within two years are prime examples of potential disruptors to traditional CCS systems.[155] These innovative findings underscore the crucial role of ongoing research and development in CCS.

[153] See Akshat Rathi, 'Big Money Rushes into Carbon Capture. Can It Deliver This Time?' (16 May 2023) <https://www.bloomberg.com/news/articles/2023-05-16/big-money-rushes-into-carbon-capture-can-it-deliver-this-time?cmpid=BBD051623_GREENDAILY&utm_medium=email&utm_source=newsletter&utm_term=230516&utm_campaign=greendaily> accessed 16 May 2023. Under President Joe Biden, the US government has pushed forward regulations and incentives including tax credits and infrastructure funding to boost CCS technologies. If the proposals materialise, the US could host nearly half of the world's CCS capacity by 2030. The United Arab Emirates (UAE), hosting the COP28 summit, also signalled a major role for CCS. Large private companies such as JPMorgan Chase, Alphabet Inc, Meta Platforms Inc, and Microsoft have also shown interest in carbon-removal technologies.

[154] BECCS combines bioenergy generation with CO_2 sequestration, leveraging biomass as an energy source and concurrently sequestering the resulting emissions. DAC, in contrast, captures CO_2 directly from ambient air via specialized processes, facilitating subsequent compression, transportation, and underground storage. These technologies offer potential avenues for climate change mitigation, yet entail challenges such as cost, energy consumption, and resource demands.

[155] Damian Carrington, 'Volcanic Microbe Eats CO_2 "Astonishingly Quickly", Say Scientists' *The Guardian* (19 April 2023) <https://www.theguardian.com/environment/2023/apr/19/volcanic-microbe-eats-co2-astonishingly-quickly-say-scientists#:~:text=A%20microbe%20discovered%20in%20a,greenhouse%20gas%20from%20the%20atmosphere.> accessed 30 April 2023; Carbfix, <https://www.carbfix.com/> accessed 30 April 2023.