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Legal challenges of CO_2 shipping and the unique characteristics of CO_2 offtake contracts

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Paper logo

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Authors' note

This paper, along with the associated presentation at Gastech 2023, is rooted in the original research conducted by the author, Cea Mittler. This work was previously published by the Centre for Maritime Law at the National University of Singapore (NUS CML) and The Oil, Gas & Energy Law Journal (OGEL).[1] For a more comprehensive exploration of the topics discussed herein, please refer to the aforementioned publications.

Abstract

International shipping of carbon dioxide (CO_2) is emerging as a critical element in the expansion of the carbon capture and storage (CCS) market. A successful commercial adoption of CO_2 transportation within the CCS value chain hinges on a comprehensive regulatory framework and well-defined contractual arrangements. This entails clear international and national guidelines governing CO_2 capture, transport, and storage, paired with transparent contracts addressing CO_2 liability, pricing, and risk management. These measures provide industry stakeholders with the certainty and clarity needed to spur CCS market growth and support the transition to a low-carbon economy.

By facilitating cross-border CO_2 transport, countries can access storage sites in regions best suited for safe containment, even if such sites are unavailable locally. This not only enables countries without viable storage solutions to participate in the CCS market but also allows nations with suitable storage sites to contribute their resources. However, the evolving legal landscape governing CO_2 transport, shaped by factors such as national and international regulations, contractual arrangements, and industry standards, lacks a unified international framework. This poses a significant challenge, particularly concerning potential emission leakages during transport, undermining the core objectives of CCS. It is not enough to merely plug gaps – proper liability allocation for any released CO_2 is necessary to ensure the efficacy of CCS as a climate change mitigation tool.

[1] Cea Mittler, 'The Carbon Voyage – Emissions Liability in Transporting CO_2 by Sea for CCS' (July 1, 2023). NUS Law Working Paper No. 2023/018, NUS Centre for Maritime Law Working Paper 23/05 <http://dx.doi.org/10.2139/ssrn.4492441> and Cea Mittler "Navigating Uncertainties - Exploring the Challenges of CO_2 Emissions Liability in Transporting CO_2 by Sea for CCS" OGEL 3 (2023) <www.ogel.org/article.asp?key=4094>.

The increasing momentum in rethinking the regulatory and liability framework for CO_2 shipping within the CCS value chain is encouraging. There is a growing number of pilot projects, established intergovernmental agreements, and rising demand for 'carbon carriers'. A prime example is the Norwegian Longship Project and the intergovernmental agreement between Denmark, Flanders, and Belgium for CO_2 transportation and storage in the North Sea. These initiatives underline the growing support for seaborn transport of CO_2 as part of the CCS value chain, highlighting the potential for international collaboration and serving as a model for similar global efforts.

To achieve widespread commercial adoption of CO_2 transportation, it is imperative that a concerted effort is made by all stakeholders, including governments, policymakers, industry leaders, and environmental advocates. Collectively, they must work towards establishing a comprehensive and favorable regulatory framework that not only incentivizes growth and innovation in the CCS sector but also ensures fair competition and adheres to stringent environmental and safety standards.

This paper delves into the legal intricacies of creating a CO_2 transport and storage market, highlighting unique aspects of CO_2 offtake contracts. It explores the emerging liability framework for CO_2 shipping, the challenges in developing an appropriate liability regime, and the need for well-designed contracts and a robust legal framework. The paper contributes to the discourse on mitigating risks in CO_2 shipping and advancing CCS technologies as a vital tool in combating climate change.

This paper addresses CCS as it pertains to fossil-based carbon, excluding considerations related to the implementation of CCS to bioenergy systems (BECCS).

1. CO_2 Shipping in the Context of CCS

1.1 Turning the tide

The need to fight climate change emphasizes the role of technologies that remove carbon dioxide (CO_2) emissions, including carbon capture and storage (CCS). CCS is a three-step process: first, CO_2 is separated and purified from fuels and industrial processes; second, it's compressed and transported via pipelines, trucks, or ships to a storage site; finally, it's injected deep into geological reservoirs for indefinite storage.

To meet the International Energy Agency's zero-emission target by 2050, CO_2 capture needs to rise to 1.6 gigatonnes (Gt) by 2030 and 7.6 Gt by 2050. Currently, operational CCS facilities only capture and store 43.3 megatonnes (Mt) of CO_2 annually, less than 0.1% of total global greenhouse gas (GHG) emissions. There is plenty of global CO_2 storage capacity, estimated between 8,000 Gt to 55,000 Gt. Innovative carbon utilization could use up to 5 Gt of CO_2 annually, but high costs hinder their adoption. This underscores the need for efficient CO_2 transport and storage.

As global CO_2 emissions rise, CO_2 shipping becomes increasingly important, offering a flexible way to link CO_2 sources with storage sites. CO_2 shipping can handle large amounts and distances over 350 km, making it crucial for transporting significant CO_2 volumes over short distances. The world's offshore storage capacity is estimated between 2,000 Gt and 13,000 Gt. Regions like the North Sea and Japan, with nearby emitters and distant storage sites, stand to benefit from seaborne carrier transport's flexibility.

The Longship Project, the first of its kind in the world to fully deploy CCS with ship transport, highlights Norway's pioneering efforts in establishing an industrial CCS chain that complies within global and European legal parameters. This project, marked by intricate legal agreements, highlights the complexities of addressing CO_2 emissions liability in CCS. It showcases the importance of precise contracts, effective measurement systems, and state-level negotiations for successful and profitable CO_2 shipping. This effort underlines the need for a clear legal framework balancing liability and cost, while achieving carbon reduction. Insights from the Longship Project will guide future EU and global efforts.

1.2 The CO_2 shipping value chain

1.2.1 Components and associated risks

The CO_2 shipping value chain involves several steps, beginning with the conditioning of captured CO_2, which includes processes like dehydration and liquefaction. Following this, the conditioned CO_2 is stored before being loaded onto ships, transported, offloaded, and finally injected into storage sites. The most techno-economically viable approach for CO_2 transportation is in a compressed liquid form near the triple point. When the CO_2 arrives from the capture installation, it can be liquefied as either a pressurized or non-pressurized gas. The liquefied CO_2 is then stored in tanks until ready for ship loading. Afterward, the ship transports the CO_2 to its storage destination or port terminal. At the terminal, the CO_2 is unloaded into intermediate storage tanks and conditioned for pipeline transmission to the final storage site.

Two methods exist for unloading CO_2 into offshore storage: direct injection from the ship, which necessitates on-board conditioning and transfer to an offshore storage site's injection well; or transfer in liquid form to an offshore platform for storage and subsequent injection into the storage site.

The extensive experience gained from handling Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG) is invaluable for devising risk mitigation strategies in CO_2 transport. Potential risks to address during transportation include leakage from venting during maintenance and repair, boil-off gas generation, corrosion, temperature change effects, dry ice formation due to low-pressure CO_2 transport, liquid CO_2 sloshing from ship wave interaction, impurities, and accidental CO_2 loss.

It is to be noted, regulatory mechanisms often drive the evolution of insurance requirements. Quantifying insurance risks for CO_2 leakage and its characteristics is difficult due to the complexity of CO_2 transport processes, its unique risks as a GHG, long-term liability concerns, and the changing regulatory landscape. Nevertheless, there is a hypothesis that the mature LNG market could provide a viable model or framework for CO_2 transport. If this hypothesis holds true, it could suggest that the insurance costs associated with CO_2 transport would not exceed those typically incurred for LNG transport.

2. Development of an International Value Chain

2.1 Necessitating transboundary transport of CO_2

2.1.1 Need for bilateral agreements

The implementation of CCS technologies is influenced by various factors, including resource availability, technical conditions, and regional disparities in infrastructure and geological storage access. Countries without adequate CO_2 storage capabilities must seek storage solutions in other regions, necessitating the harmonization of legal frameworks for cross-border CO_2 transport and storage. Additionally, access to existing CO_2 transportation and storage infrastructure can bolster investor and operator interest in establishing new capture facilities. In light of this, it becomes imperative to establish bilateral agreements between countries hosting capture facilities and potential storage countries.

As mandated by the London Protocol, these agreements must encompass explicit consent for the activity and delineate responsibilities. CO_2 leaks during transport at the governmental level is determined by the point at which accountability shifts from one country to another, as set out in a bilateral agreement between the relevant states under the London Protocol. As illustrated by the Longship Project in relation to any future third-party volumes, a bilateral agreement, is a prerequisite for entering into a commercial contract with Northern Lights, ensuring that legal contracts between operators effectively address the financial implications of potential leakages during transport.

2.1.2 The London Protocol - Closing the infrastructure gap?

In addition to the United Nations Convention on the Law of the Sea (UNCLOS) , which mandates that states enforce laws and regulations to prevent, reduce, and control marine pollution resulting from dumping (UNCLOS, art 210), the primary international treaties protecting the marine environment from waste dumping are the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and its 1996 Protocol (London Protocol). Currently, 87 states have acceded to the London Convention, while 53 have done so for the Protocol.

Initially, the London Convention did not address storage of waste in the seabed. In 2006, the London Protocol was amended to legally permit CCS through the 'CCS amendments to Annex I', allowing CO_2 waste streams to be injected into sub-seabed geological formations for permanent storage. However, the amendment did not address art 6, which restricts the transboundary movement of waste, including CO_2, designated for dumping or incineration. The contracting parties viewed art 6 as an obstacle to the transport component of international CCS initiatives, highlighting the need for a comprehensive revision of international treaties.

To address the incomplete ratification of the CCS amendments to Annex I, the parties to the London Protocol proposed the 'export amendment' in 2009. This amendment grants an exemption to the CO_2 export prohibition if the involved countries establish an 'agreement or arrangement'. However, this amendment requires two-thirds acceptance by the parties to the London Protocol before taking effect. As of 2019, only six out of 53 contracting parties had accepted the amendment. In 2019, the contracting parties to the London Protocol adopted a resolution allowing provisional application of the 2009 export amendment, removing the main international legal barrier to CCS and enabling cross-border CO_2 transport for offshore storage, provided a bilateral agreement is in place. This implies that parties interested in utilizing the amendment to art 6 have the right to do so. However, for those parties not inclined to export or import CO_2 for permanent geological storage, the amendment has no legal significance.

Step-by-step:

1. Should a country desire to enable the export of CO_2 for injection and permanent storage beneath the seabed, it is incumbent upon that country to submit a Unilateral Declaration pertaining to the provisional application of the 2009 Amendment to art 6 of the London Protocol. This submission should be directed to the International Maritime Organization (IMO).
2. In the case of transborder transport of CO_2, it is requisite that both participating countries separately submit their respective Unilateral Declarations.
3. Subsequent to the depositing of the aforementioned declarations, the two countries involved in the CO_2 transport must engage in negotiations with the purpose of formalizing a bilateral agreement.
4. Within the bilateral agreement, there should be a clear confirmation and delineation of permitting responsibilities shared between the two participating countries. Such responsibilities should be aligned with the mandates set forth in the London Protocol, as well as any other applicable international legal instruments, in order to provide a stable regulatory framework governing the transborder CO_2 transport.
5. The bilateral agreement should address and stipulate the terms and conditions for various aspects of the CO_2 transport, including but not limited to cost-sharing arrangements, monitoring protocols, reporting requirements, and liability considerations. Furthermore, the agreement should incorporate the specific permitting regimes referenced in step 4.
6. Upon the successful establishment and formalization of the bilateral agreement, it is necessary for both participating countries to duly notify the IMO of the existence and details of the agreement.
7. It is noteworthy that countries may submit Unilateral Declarations regarding the provisional application of the 2009 Amendment to art 6 of the London Protocol irrespective of whether they have formally ratified the amendment of art 6.

2.1.3 Towards global adoption?

This development has been characterised as a 'major breakthrough' in advancing offshore CCS. A similar sentiment was echoed in September 2022 when the Danish-Belgian CCS arrangement was signed, facilitating the transport of CO_2 for permanent geological storage under the London Protocol.

However, the limited ratification level suggests potential constraints of the London Protocol in governing cross-border CO_2 transport. Despite efforts, the lack of a comprehensive global resolution remains a challenge for broader adoption of a framework enabling shipping to close the pressing CCS infrastructure gap. To achieve broader applicability, the 2009 amendment would need to be recognized as a set of generally accepted rules, standards, and guidelines under art 208(5) of the UNCLOS. Furthermore, streamlining the administrative process for these agreements could be facilitated by sharing experiences and standardizing treaty templates.

Although not ideal, the adopted resolution presents a practical approach that effectively addresses cross-border CO_2 transport for CCS purposes, facilitating CCS and progressing towards the ambitious CO_2 reduction targets set by the Paris Agreement.

2.1.4 Whose CO_2?

Anticipated future growth in CCS may involve using one vessel to serve multiple capture facilities, which raises questions about handling mixed CO_2 streams and assigning responsibility for emissions during sea transport. In cases where multiple countries partake in CO_2 transport, the contracting State must issue permits for CO_2 loading within its territory. This obligation also applies to vessels registered under its flag even when they load CO_2 in non-contracting party territories for export elsewhere.

3. International Liability Regime

3.1 The HNS Convention and 2010 Protocol

The liability regime for damage caused by CO_2 is established by the 1996 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention), along with its 2010 Protocol (HNS Protocol), which is not yet in force due to slow ratification.

The 2010 HNS Convention covers damages caused by hazardous and noxious substances (HNS), including CO_2, transported by sea. Its liability regime is based on the Civil Liability and Fund Conventions model for oil pollution damage. 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 ICG Code. 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. When the 2010 HNS Protocol comes into force, CO_2 carriers will fall within its scope. In cases where the 1976 LLMC Convention and its 1996 Protocol apply to CO_2 carriers, the 2010 HNS Protocol will supersede them.

3.2 CO_2's Unique Status

3.2.1 A case for separate classification?

The 2010 HNS Convention introduces strict and limited liability for the shipowner for any damage caused by HNS, limited to incidents that occur while the cargo is on board the ship. Compensation is based on a two-tier system, with the first tier covered by compulsory insurance taken out by shipowners and a second tier paid from the international HNS Fund. The HNS Fund is financed by contributions from receivers of contributing cargo. In the context of the CCS projects, bulk CO_2 is anticipated to be classified as a contributing cargo to the general account. This is critical for shaping policies in the evolving CCS sector and raises a key question: Is it appropriate to label CO_2 as contributing cargo at this early stage of CCS growth?

1. CCS is in its nascent stage, stakeholders differ from conventional CO_2 traders; and

2. CO_2's inherent attributes distinguish it from other substances within the general account. As a non-flammable substance with a low propensity for environmental contamination, CO_2 occupies a unique position. CO_2's unique characteristics, including its non-flammable nature and minimal environmental risk, set it apart from other substances in the general account. Its anticipated use of existing gas transport infrastructure further emphasizes its distinct position.

Furthermore, this regime restricts the shipowner's right to seek compensation for damages from other entities involved in the operation of the ship, such as charterers, managers, or operators. This limitation constitutes a potential disadvantage, as it precludes the pursuit of legal recourse against parties who may have greater financial means than the shipowner.

3.2.2 Suitability in relation to CO_2 leakages?

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, considering CO_2's role in combating climate change through CCS, a separate account may be more suitable than the generic HNS regime. 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 raising questions about the Convention's suitability.CO_2 has unique characteristics that differentiate it from typical HNSs covered under the Convention. In the context of CCS, it serves environmental protection purposes and has properties of both gas and liquid when stored. Given the specific requirements and risks associated with CCS, there may be a need for a more precise regulatory framework tailored to CCS rather than fitting it into the existing HNS regime. In addition, the 2010 HNS Protocol, pending sufficient ratifications for its enforcement, may not cover all CCS-related jurisdictions. Its current structure may be unsuited to the evolving CCS industry, prompting a re-examination for safe CO_2 transport. Nonetheless, it could inform the development of a tailored CCS framework.

Incorporating a market-mechanism, such as an emission trading system, into the CCS value chain can help address the liability gap in the HNS regime. This integration quantifies CO_2 emissions liability, encourages emission reduction via a market-based approach, and incentivizes investment in CCS technology and improved CO_2 shipping practices. Furthermore, it considers the environmental costs of CO_2 leakage, fosters safe and efficient CO_2 transport, and promotes CCS industry growth.

4. An EU Perspective: Responsibility for CO_2 Leakage during Transport

4.1 The importance of fit for purpose regulation

For commercially viable CO_2 shipping to emerge, it is imperative to establish agreements that address cost and risk-sharing for CO_2 losses during maritime transport. In crafting these contracts, it is vital to pinpoint the juncture at which liability for CO_2 losses transfers from the capture facility to the transport and storage operator. Concurrent with the planning of the

Longship Project, the Norwegian government has sought to elucidate the appropriate interpretation of relevant EU legislation. This effort yields valuable insights into the formation of industry practices and sets a precedent for constructing the inaugural industrial CCS chain within the existing European legal framework.

4.2 The regulatory framework

4.2.1 EU ETS and CO_2 ship transport

The integration of ETS is crucial for controlling GHG emissions and meeting international climate obligations. Grasping the interplay between CCS projects and ETS application is essential for shaping successful climate policies and regulations. Who bears the liability for CO_2 emissions during capture, transport and storage under the current and suggested revision of the EU ETS regulations.

Until recent amendments, the regulatory framework under Directive 2003/87/EC (ETS Directive) contained an apparent discrepancy in the treatment of CO_2 transport by pipeline opposed to ship transport within the context of CCS. While the ETS Directive explicitly covered CO_2 transport via pipelines for geological storage, CO_2 transport by shipping was notably absent from the scope of these regulations.

This omission raised a legal conundrum in the context of the CCS sector, as it means that CO_2 emissions from ship transport are not subject to the same surrender of allowances requirement as emissions from pipeline transport. This inconsistency deviates from the underlying principles of the CCS Directive. The CCS Directive does not recognize CO_2 shipping as part of the transport network, but rather focuses on pipelines. Furthermore, the Regulation (EU) 2018/2066 (MRR Regulation) sets 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 fossil CO_2 which is not emitted from the installation but transferred out of the installation to a transport network for long-term geological storage. Here CO_2 transport means the transport of CO_2 by pipelines for geological storage in a storage. This wording has not been amended.

This regulatory gap was addressed by Norway in its request for clarification to the EU Commission in 2019 to ensure a consistent and comprehensive approach to CCS regulation thereby ensuring that all CCS transport modes are subject to the same regulatory requirements. The interpretation from this correspondence was, that the capture installations in as part of the Longship Project should be permitted to deduct from their emissions any CO_2 intended for the offshore storage. The Commission should be informed of the measures implemented, including specific monitoring plans developed for each capture installation in collaboration with the responsible public authorities. These plans should account for any CO_2 lost during transport. Nonetheless, the capturing installations remain accountable for any CO_2 released into the atmosphere and must surrender the corresponding amount of allowances, with losses measured at the point of delivery. Put in other words, the right to subtract CO_2 emissions is deferred until the captured CO_2 is delivered from a truck or ship to the pipeline transport network regulated under the ETS Directive. This delay means that the capture operator retains liability for any CO_2 losses that occur during transport until the CO_2 is successfully transferred to the storage operator at the receiving terminal. Essentially, the capture operator is responsible for the CO_2 and any associated emissions until the point at which the CO_2 is handed over to the storage operator (point of delivery).

What if the transport is conducted by a third party and not the capturing operator? In accordance with the above scenario, the capture operator remains legally responsible for any CO_2 emissions and losses that occur during transport, even when the transport to the receiving terminal is undertaken by a separate legal entity. This obligation persists despite the capture operator's lack of direct oversight over the transportation process. Consequently, these emissions cannot be subtracted from the total emission account of the capture operator, thereby incurring liability for CO_2 emissions beyond its immediate control.

As done in the Longship Project, this imbalance was addressed by contractual solutions. According to the state aid agreement between the government (Norway) and Northern Lights, the risk for CO_2 is transferred on delivery from the capture installation operator to Northern Lights (storage operator). Delivery takes place at the 'shipping point' which means the point of delivery of CO_2 at the connection flanges for loading hose/arm at the vessel's manifolds for liquid and gaseous CO_2. 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 delivery at the shipping point and during transport, the government or Northern Lights will pay quota allowances for and cover other costs related to any emitted CO_2.

Under this regulatory interpretation, the onus for leakage during CO_2 transport falls on the operator of capture facility. In practice this means that the capture facility operator, who is likely to subcontract the transport of CO_2, is nevertheless liable for leakage during transit, despite not having direct control over the transportation process. As previously highlighted, an agreement could compel the storage operator to indemnify the capture operator for any financial repercussions arising from CO_2 losses during transportation.

4.2.2 Amendment: Who bears the liability & the right to subtract emissions?

As per the most recent amendment to the ETS Directive, dated 5 June 2023, maritime transport activities are now encompassed within the ambit of Annex I, which delineates the categories of activities subject to the Directive. In the specific context of CCS, the language has evolved from exclusively referencing GHG transport by pipeline to now encompassing "Transport of greenhouse gases for geological storage in a storage site … with the exclusion of those emissions covered by another activity under this Directive." This adaptation can be traced back to the Commission's amendment proposal dated 14 July 2021, which advocated for the extension of Annex I to include all CO_2 transportation modalities, such as ship and truck, to ensure equitable treatment. Furthermore, in order to preclude double accounting, emissions from transportation that are already accounted for under a different activity pursuant to the Directive should be ascribed to that particular activity. Consequently, this regulatory interpretation implies that the party legally accountable for emissions during transport is the ship operator, rather than the operator of the capturing installation. However, certain ambiguity remains with regards to this interpretation. Moreover, to effectively manage carbon capture in a manner that both reduces net emissions and ensures accurate accounting of all emissions without double counting, while also fostering economic incentives, the Commission should conduct an assessment by July 2026 determining whether all GHG emissions covered under the ETS Directive are appropriately accounted for, and whether any instances of double counting have been successfully prevented. Nonetheless, the amendments to the EU ETS do not seem to rectify the ambiguity surrounding when CO_2 emission allowances may be subtracted by the capture facility operator. This is because Article 49 of the MRR Regulation still stipulates that allowances for CO_2 that has not been emitted can only be subtracted when the CO_2 has been transferred out of the installation to a transport network (as per definition only encompassing pipelines). This matter has not been addressed in the amended MRV Regulation (EU) 2015/757 on the monitoring, reporting and verification of GHG emissions from maritime transport, which focuses on commercial maritime transport activities. It has been suggested that mitigating measures for boil-off gas generation through onboard-liquefication could be a means to minimize leakage.

5. Offtake Agreements

5.1 A key element

Building investor trust and interest in any commercial project is reliant upon a strong commercial foundation, which serves as a cornerstone for the project's success. A robust commercial foundation is particularly crucial for CCS projects, which often require a significant upfront investment and entail complex contractual and risk allocation considerations.

One of the key elements of a solid commercial foundation is the project's ability to generate a steady cash flow. For CCS projects, securing offtake commitments from emitters is essential to guaranteeing this cash flow and, ultimately, obtaining a final investment decision (FID) from investors. However, the CCS market is highly competitive, and emitters — the counterparties to these offtake agreements — come in various forms and sizes, with differing financial resources and risk tolerance levels.

5.2 Connecting commercial and risk considerations of CCS projects

As observed in the preceding discussion, projects typically involve both private and public players. While larger private companies may be able to absorb losses in the early stages of a project, smaller companies may lack the resources to do so. Negotiating balanced offtake agreements becomes crucial, as the risk allocation must be suited to the risk tolerance of each party. Agreements that allocate too much risk to a counterparty with limited capacity to bear it could ultimately backfire and hinder the project's progress.

Furthermore, the risk landscape in the offtake space is multifaceted, with some components of the agreement chain being insurable while others are not. It is vital to consider the ripple effects of risk allocation on equipment manufacturers, service providers, and their respective insurance possibilities and balance sheets. As the CCS industry continues to evolve, it is essential to strike a balance in negotiations that does not follow the traditional power dynamics of conventional negotiations.

For emitters, the decision to invest in capture equipment is often the most capital-intensive one they will make. As such, it is imperative that they ensure their offtakers possess strong balance sheets and can provide operational assurance. This assurance becomes even more crucial when considering the inherent technical risks associated with CCS projects. Technical risk assessments play a vital role in de-risking CCS projects and garnering stakeholder support, contributing to a project's overall commercial viability.

In conclusion, establishing a solid commercial foundation is crucial for attracting investor interest and securing FID for CCS projects. Balancing risk allocation in offtake agreements, conducting technical risk assessments, and ensuring the financial stability of all parties involved are key factors that contribute to a CCS project's success. Furthermore, in relation to the preceding discussion on the transfer of CO_2 liability between the operator of the capture facility and the ship operator, it is important to consider the risk and liability implications of offtake agreements in CCS projects. When negotiating these agreements, the allocation of risks related to CO_2 transport should be carefully addressed. Contractual arrangements, such as those used in the Longship Project, can be instrumental in distributing CO_2 emission-related risks among the involved parties, including the capture facility operator, the ship operator, and other stakeholders. In this context, the financial stability of all parties, as well as their risk tolerance levels, should be taken into account to achieve balanced and effective risk allocation.

6. Concluding Remarks

Addressing the growing need to reduce GHG emissions, CCS technologies have emerged as pivotal tools in the battle against climate change. The successful deployment of CCS, however, requires the efficient and secure transportation of captured CO_2, particularly across international borders. In this context, the potential risks associated with CO_2 transport, including leaks and unintended releases, must be meticulously managed to avoid exacerbating the very climate impacts the technology aims to mitigate.

CCS is distinct from traditional waste disposal in that it seeks to protect the environment by reducing anthropogenic CO_2 emissions. The practical implementation of the London Protocol, however, may face certain challenges in regulating cross-border CO_2 transport. While the 2009 amendment to the Protocol addresses the legality of CO_2 transport, further measures or adaptations may be necessary for a comprehensive and effective regulatory framework. The lack of widespread ratification could hinder the development of large-scale CCS and the expansion of CO_2 shipping, requiring bilateral agreements or arrangements for international projects.

The 2010 HNS Convention provides a legal framework for the burgeoning CCS industry, but there are calls for CO_2 to have its own distinct account due to its unique characteristics and role in climate change mitigation. The current HNS regime may not be adequately suited to the CCS industry, and a potential revision could include integrating an ETS to encourage safe CO_2 transport and support the growth of the CCS sector.

The incorporation of market-based mechanisms into the liability framework may offer valuable tools for quantifying and managing CO_2 emissions. Although uncertainties remain concerning the inclusion of CO_2 shipping in the EU ETS, contractual arrangements, as demonstrated in the Longship Project, can help distribute CO_2 emission-related risks and address the challenges associated with the current legal framework. Moreover, the development of comprehensive insurance products, addressing both immediate and long-term liabilities, is essential for effectively managing CCS projects and fostering the continued expansion of the CCS industry.

The CCS landscape is experiencing a significant transition, characterized by increasing attention and investment from both governments and private entities, but tempered by past setbacks and ongoing skepticism. As the demand for CCS projects escalates in the struggle against climate change, international cooperation and consensus-building will be crucial in realizing its full potential. Beyond traditional CCS, technologies such BECCS and Direct Air Capture (DAC) represent promising negative emission solutions for atmospheric CO_2 removal. The push towards net-zero targets has spurred the emergence of start-ups developing innovative CCS technologies, suggesting a future where CCS is no longer solely the domain of large fossil-fuel corporations. Breakthroughs like CO_2-consuming microbes and technologies capable of converting CO_2 into stone within two years exemplify potential disruptors to conventional CCS systems, underscoring the importance of ongoing research and development in the field.

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