The use of ships within a CCUS system: regulation and liability

The use of ships within a CCUS system: Regulation and liability.

M. Tsimplis[a*] and K. Noussia[b]

[a] School of Law, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong (SAR), China.

[b] School of Law, University of Reading, Foxhill House, Shinfield Road, Whiteknights, Reading RG6 6EP, Berkshire, UK

Abstract

The transport of CO_2 by ships for storage or utilisation is a component of CCS/CCUS systems which has been considered based on existing ship designs and on the assumption that the internationally agreed standards are always applicable and always constrain the ship and storage designs that can be used. This paper demonstrates that, for systems developed with one or two jurisdictions, novel ship and storage designs can be considered irrespective of the international regulatory system. Significant discretion also exists within the international regulatory system for novel designs. Thus, the consideration of cost and efficiency of CCUS systems need not be constrained to existing ship designs. In addition, the established limitation of liability regime, which protects shipowners, charterers, managers, and operators of ships, provides an upper limit for the financial exposure for losses during transport by ships, an aspect which is not well defined when pipelines are used.

1 Introduction

The increase in atmospheric greenhouse gas concentrations caused by, primarily, the use of fossil fuels has created serious risks for humanity. Reducing the atmospheric emissions of greenhouse gases can moderate some of the risks posed by climate change and enable policies for adaptation to be effective. Within this context and because the cost and availability of renewables is significant higher than that of using fossil fuels, capturing and storing the produced carbon dioxide in order to avoid its emission to the atmosphere has been proposed as an interim solution. Carbon capture and storage/sequestration (CCS) reduces atmospheric GHG emissions thus prolonging the use of fossil fuels. Provided that the cost is cheaper than that of renewables and that the stored

*Corresponding author: m.tsimplis@cityu.edu.hk. Kyriaki Noussia worked on the insurance issues involved and M. Tsimplis on the other parts of the paper.

emissions are sealed from the atmosphere for centuries, CCS is an option that has been considered for more than two decades. To reduce the cost further the utilisation of the captured CO_2 has been considered making the waste management operation of CCS to a financially less burdensome operation of Carbon Capture Utilisation and Storage (CCUS). The most viable utilisation procedure is currently the use of the CO_2 to enhance the recovery of oil and gas (CCUS-EOR) from existing oil and gas fields being in the last stage of their operation [1].

The storage of CO_2 in depleted oil fields requires the transport of captured CO_2 from the point of capture to the storage place, which can be on land or at sea. It is technically possible to utilise all available modes of transport, including pipelines, ships, railways, and trucks as components of a CCS or CCUS system. Pipelines are currently considered the better onshore option while ships and pipelines offer cost effective options for offshore storage [2]. Pipelines have higher capital costs and lower operating costs than ships[2], however the financially optimal transport method depends on the volume of CO_2 to be transported and the distance of the storage place from the point of capture [3]. In situations where there are multiple points of capture and the storage formation is offshore, or where island states without storage capacity are concerned, ships can be the better option.

Each transport system involves the risk of an accident imposing liability on the operators. The relevant risk between pipelines and ships can be assessed by considering the analysis of oil pollution accidents from pipelines and ships [4]. Thus, a complete assessment of the financial efficiency of each type of transport must include the liability arising from such accidents. In this respect, although ships have been involved to more incidents and to larger oil spills, so one would expect that the situation with the carriage of CO_2 would be analogous, from the point of view of their operators, ships have an advantage in that shipowners are protected by a legal framework of limitation of liability rights.

The comparison between pipelines and ships within various conceptualisations of CCUS systems has been based on existing ship designs. However, because existing CO_2 carriers have small capacity, the development of larger CO_2 carriers is considered necessary. In addition, the development of “dual purpose” ships carrying LNG-gas in one direction and CO_2 for storage on the return journey is also under consideration [5]. This option has evident environmental advantages in that what would have been a voyage on ballast for an LNG carrier would be used for the carriage of CO_2. Thus, for CCUS-EOR systems both voyages would be profitable.

Existing CO_2 carriers are constructed and regulated under the International Maritime Organisation (IMO) regulatory and liability system. The IMO is a UN body established by international treaty, where globally applicable safety and environmental standards are negotiated [6]. The IMO system develops regulatory standards based on consensus between states. To achieve consensus negotiations may take significant time and their implementation can be delayed. The advantage of developing globally applicable regulations means that compliant ships can trade internationally based on certification provided by the flag state. For existing CO_2 carriers, the international regulatory part is included under the mandatory International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). Ships built in compliance with the IGC Code are permitted to trade globally provided they remain properly certified and compliant.

Where the CCUS planning requires larger CO_2 carriers than those presently available, or dual-purpose ships, developing designs compliant with the IGC Code is only one of the options available, especially where the CCS/CCUS-EOR system is planned to operate exclusively in the jurisdictional areas of one state, or where only two states are involved. In such circumstances international law permits alterative regulatory arrangements for the operation of these ships. Developing larger CO_2 carriers or dual-purpose ships outside the IGC Code framework would be faster and the modification of applicable standards would be easier than under the IGC Code. However, ships non-compliant with the IMO instruments will not enjoy the global trading capabilities of the IGC Code compliant ships.

This paper considers the regulatory and liability options for the use of CO_2 carriers where (a) the CCS/CCUS-EOR system requires maximum flexibility, thus full compliance with the IGC Code is required; where the CCS/CCUS-EOR system is located in one state, that is the shipment of CO_2 and the discharge from the ship is located within the jurisdictional zones of one state; and (c) where the loading and discharge ports are located in two states.

These options have not been considered in the literature simply because there is an underlying assumption that only IGC Code compliant ships provide legally acceptable options. This paper explains why this assumption is incorrect and ship designers can consider designs beyond the IGC Code standards. It is argued that considering these alternative regulatory arrangements could provide faster development of new designs of CO_2 carriers adopt custom made liability regimes favouring CCUS-EOR systems and can reduce uncertainty with respect to legal liability. These alternative options may be able to reduce the cost and the liability exposure for national or bilateral CCS/CCUS-EOR systems.

The legal options for the development of CO_2 carriers are based on the rights states enjoy under international law. Thus, an outline of the international legal arrangements for the governance of ships is presented in the next section.

2 Legal responsibility for the operation of ships under international law.

The current legal framework for the governance of shipping is contained in the LOSC which, partly, codifies pre-existing customary international law. The governance of shipping balances the interest of coastal states which wish to have some control on the ships passing close to their coasts and through the coastal state's waters against the navigational interests of trading states which aim for the widest freedom of navigation possible for their ships. In general, the rights of the coastal state with respect to the control of foreign ships reduce and the rights of the flag states for navigational freedom increase ass the distance from the coastline increases.

The coastal state's rights are at their strongest when a foreign ship is voluntarily in its port or within its internal waters. The coastal state can impose conditions for entry for ships visiting its ports or can deny entry or even close its ports [7].

In the territorial sea, i.e., the zone which extends up to 12 nm from the coast, the coastal state has sovereignty (LOSC Art.2) and can impose laws and regulations on foreign ships except those exercising the right of innocent passage [8]. The navigational right of innocent passage is granted to all other states under LOSC Article 17. A foreign ship in under innocent passage, when it is passing through the territorial sea of the coastal state in a way which does not prejudice the peace, good order and security of the coastal state. With respect to ships on innocent passage the powers of the coastal state are limited in two important, for this discussion, ways. First, the laws imposed on ships on innocent passage cannot, under LOSC Art. 21, result into imposing conditions on the foreign ship for the construction, design equipment and manning (CDEM) which exceed the internationally agreed standards. Thus, the coastal state is not at liberty to demand CDEM standards which differ from those internationally agreed. In addition, the coastal state cannot stop or detain a ship while the ship is on innocent passage and any enforcement with respect to a violation of a coastal state's law has to wait until the foreign ship enters a port of the coastal state or, in some cases, a port of a third state or has to be effected towards the owner.

Beyond the territorial sea and up to 200nm from the coastline the legal regime of the Exclusive Economic Zone (EEZ) provides for exclusive rights of the coastal state with respect to living and non-living resources, marine research, and protection of the marine environment. However, under Art. 58 of LOSC other states have freedom of navigation for their ships within the EEZ. The freedom of navigation in the EEZ has to be exercised with due regard to the rights granted to the coastal state. Furthermore, the coastal state is granted express rights to regulate ships sailing through the EEZ with respect to pollution under LOSC Art. 211(5). This is achieved by imposing laws on foreign ships passing through the EEZ. However, the laws that the coastal state can impose have to conform with the internationally agreed standards. The coastal state also enjoys enforcement powers for the violation of such laws against foreign ship passing through the EEZ (LOSC Art.220). With respect to safety regulations and other, than pollution laws, the EEZ is equivalent to the legal regime of the high seas which is explained below.

On the high seas all states enjoy a number of freedoms including the freedom of navigation. Thus, every state has the right to sail ships flying its flag (LOSC, Art. 90) and no state has the right to enforce its laws or interfere with a foreign ship on the high seas except where the foreign ship is involved in piracy, slave trading, drag trafficking or unauthorised broadcasting. Thus, the regulation of ships on the high seas is a matter under the exclusive powers of the flag state which is also responsible for exercising control over its ships and for setting appropriate safety construction and operation standards [7][8][9]. Such standards should be in conformity to generally accepted "international regulations, procedures and practices".

3 International shipping regulations for CO_2 carriers

The role of international shipping standards is, as it has been explained, important in the discussion of the navigational rights of ships and the duties of the coastal and flag states. These standards operate in all three legal zones which have been discussed here. In the territorial sea, the internationally agreed regulations limit the power of the coastal state to develop laws concerned with the CDEM standards with respect to ships on innocent passage. In the EEZ, and in respect of pollution from ships, they limit the powers of the coastal state in developing pollution laws for foreign ships sailing through their EEZ. Finally, under LOSC Art. 94, they impose on the flag states an obligation to conform with them when discharging their duty to ensure the safety of their ships.

The scope of these obligations needs to be clarified. With respect to the CO_2 carriers, in particular, the question is whether the IGC Code is such an international regulation, procedure, or practice. of adoption by states required to make such internationally agreed standards compulsory.

3.1 The IGC Code

The IGC Code has been developed for the purpose of ensuring the safe transportation of liquefied gasses in bulk [10]. It has been made mandatory for states contracting to the SOLAS Convention since 1986 [11]. However, the mandatory character of the legal instrument does not all parts of the Code are mandatory. In particular, section 1.1.2 makes the provisions of one other section and three appendices recommendatory or informative. It follows then that when LOSC Art. 94 requires conformity with international standards, even if the IGC Code is considered as such an international standard it is unarguable that conformity with its recommendatory or informative parts is demanded.

Because the IGC Code is part of SOLAS, there are a number of consequences. First, it is arguable that the IGC Code is included in the generally accepted international regulations which a flag state is required to conform to under Art. 94. This is because SOLAS has been ratified by 162 states which cover more than 98% of the world tonnage and its two main Protocols of 1981 and 2000 have been ratified by 122 and 123 states respectively covering more than 97% of the global tonnage. Because the IGC Code prescribes design and construction criteria for the containments of liquefied gas such criteria would arguably fall within the CDEM standards to the extent that they are not included in the IGC parts which are of a recommendatory or informative character.

Under the IGC Code CO_2 carriers are classed as a type 3G ship which is defined as requiring moderate preventive measures to preclude the escape of the cargo (Chapter 2 s.2.1.2). LNG carriers are considered as 2G ships involved with cargoes which “require significant preventive measures to preclude their escape”. Thus, with respect to the development of dual-purpose ships, the risk classification of the ship would differ. The IGC Code requires in such a case that the more stringent rules apply (s. 2.1.4).

A second consequence arising from the implementation of the IGC Code as part of SOLAS, is that its application is subject to the general SOLAS arrangements. Regulation 1 states that SOLAS applies only to international voyages, unless expressly provided otherwise. Part VII, which makes the IGC Code mandatory, does not modify the general rule of SOLAS application. As a result, the IGC Code does not apply at all to CO_2 carriers or dual-purpose ships which are not engaged in international voyages. The design, construction, and operation of such ships within the jurisdictional areas of a coastal state concerns only that coastal state. Thus, for coastal states which have storage capacity, the design and type of ships used is a matter for the maritime administration of that state alone.

Furthermore, SOLAS Regulation 4(a) empowers the administration of the flag state to exempt ships which normally do not engage in international voyages from SOLAS requirements when such a ship undertakes an international voyage and provided that the arrangements are, in the view of the administration safe. The exemption cannot be used, of course, as the basis of regular transporting of CO_2, but indicates that the mandatory application of IGC Code does not, as a matter of fact, mean that all CO_2 or dual-purpose carriers have to be comply with each and every prescriptive aspect of the IGC Code in all international voyages.

Thus, ships which depart from the detailed rules included under the IGC Code can still be considered as formally compliant with the IGC Code, provided that their departure from the detailed construction rules can be authorised by the flag state.

The discretion available to the flag state administration is further supported by two provisions of SOLAS, i.e., Regulations 4(a) and 5. Regulation 4(a) authorises the flag to exempt a ship which has features of a novel kind where the application of SOLAS "might seriously impede research into the development of such features". This broad exemption from the mandatory character of SOLAS concerns Part II-1 (Construction, Subdivision and stability, machinery, and electrical installations), Part II-2 (Fire protection, fire detection and fire extinction), Part III (Life-saving appliances and arrangements) and Part IV (Radio communications). This power does not expressly refer to Part VII which demands compliance with the IGC Code. Two points can be made here. First, the IGC Code itself includes provisions enabling the use of novel designs. Thus, under Part F, the possibility of using limit state design for novel cargo containment concepts exists. Also s. 4.16.3 provides testing standards for novel structural designs which are detailed in Appendix 5. Thus, it appears that where the construction of a larger or dual-purpose CO2 carrier is concerned, the flag state has the power to exempt the particular ship or novel design to the extent this is concerned with the parts referenced in Regulation 4(a) and also the power to accept designs for the storage facilities onboard the ship which follow the IGC Code. The flag state has the duty to only do this where the arrangements for the novel design are such that the overall operation is as safe as the prescribed technical standards. Persuading the flag state to follow such a path would practically need to be done through one of the classification societies as most flag states would not have the expertise and the resources to engage in detailed testing of novel designs.

Regulation 5 enables the administration of the flag state to authorise the use of equivalent "fitting, material, appliance or apparatus" if it is satisfied "by trial or otherwise" that the adopted equivalent is at least as effective as that prescribed under SOLAS. In such a case the administration has to report the equivalent arrangement, but its decision is authoritative and is not subject to any review by the IMO or by other states. The IGC Code includes the same provision for equivalents under s.1.3. Ships authorised by the flag state to use equivalents are also compliant with the IGC Code and are entitled to certification by the flag state.

4 Options for the regulation of CO_2 carriers.

It is evident then that, although the IGC Code is mandatory, its application does not affect ships operating within the jurisdiction of one state and, in addition, it provides exemptions and the possibility of experimenting with alternative designs provided that the required testing is undertaken. A ship exempted under such arrangements is, perhaps surprisingly, formally compliant with the IGC Code and with SOLAS and would be entitled to certification by the flag state. The overview of the relevant legal provisions enables the comparison of the regulatory constraints imposed on the various CCS and CCUS-EOR systems depending on where the discharge port or storage facility is located.

4.1 Ships used within CCS/CCUS-EOR located within the jurisdiction of one state.

Where an offshore CCUS system is within the jurisdiction of a coastal state, that state can specify the design, operational and safety rules for such a ship. There is no issue of compliance with SOLAS or the IGC Code because these are not applicable to such ships.

The coastal state may choose to provide express rules for the regulation of the ship, in a way similar to what the IMO does, or may choose to move away from the "command and control" regulatory regime and towards self-regulation. The national regulation of the offshore oil and gas sector provides an example of a regulatory regime which increasingly adopted self-regulation of the industry at various degrees. Self-regulation together with the relatively small number of companies involved in the offshore oil and gas sector has led, in turn, to a degree of harmonisation in the applicable standards as companies prefer to have uniform standards globally [12]. This then has further led to efforts, by the industry, of standardisation of specifications of equipment used as the lack of standardisation made the design and production of equipment inefficient [13]. The "command and control" approach focuses the regulatory process on the compliance with each regulation instead of the overall safety and outcome of the process. This can lead to failures and accidents despite the compliance with the letter of the law [14]. In addition, it imposes a significant cost on the regulator and may result into delays in implementing new and innovative technology. Self-regulation has been criticised as being able to work primarily for the largest companies involved in the most hazardous activities [14]. It does however reduce the burden of the coastal state which is only concerned with regulating the self-regulators rather than be involved with each and every new design or development and develop appropriate standards for them [12]. Where CCUS is a one state operation and particularly where CCUS-EOR is concerned there is no need to work for international regulation as all the control and the liabilities are under the jurisdiction of the coastal state. The result is the same whether the ship is a modified existing ship, a bespoke ship exclusively used for the carriage of CO_2 or a bespoke ship carrying gas or other cargo one-way and CO_2 in the return journey. While standardisation increases efficiency, it is optimum for it to occur where the technology is mature rather than constrain the development of new designs.

4.2 Ships used within CCS/CCUS systems involving two states.

For a CCUS system where two states only are involved, one as the exporting state and the other as storing state, there is a question whether the international legal arrangements constrain the development of CO_2 carriers to the standards already in place, namely SOLAS and the IGC Code. It is assumed here that the ship is registered in one of the two states.

If the ships just move between the jurisdictional zones of the two states without ever going on the high seas an argument can be made that the other states have no interest in regulating the standards for such CO_2 carriers. Even if both states involved are assumed to be contracting states to SOLAS and it is further argued that, because the ship is in an international voyage, SOLAS and IGC should apply, there is no enforcement mechanism against that ship which can be activated by a state other than the two states involved.

Where there are two states involved in such a system but the CO_2 carrier has also to sail on the high seas, it is submitted that the two states involved are free to develop the design, construction and storage standards involved. There is a difficulty in this submission arising from the operation of LOSC Art. 94(5) which requires the laws of the flag state to be in conformity with the "international regulations, procedures and practices". The exact scope of this provision has not been subject of judicial interpretation. A commentator has gone as far as to argue that even states which have not signed up to such standards are obliged to conform to them [15]. This latter position is, it is submitted, unarguable. States are the supreme actors in international law and the suggestion that they are subject to a responsibility to conform to standards other states have adopted goes against the equal status of all states in international law. This is also supported by the practice of some flag states which are not signatory to SOLAS, and therefore to the IGC Code, and ~~which they~~ do not impose compliance to such instruments on their ships. Furthermore, such an interpretation would raise the question of how extensive the agreement should be to bind the flag state.

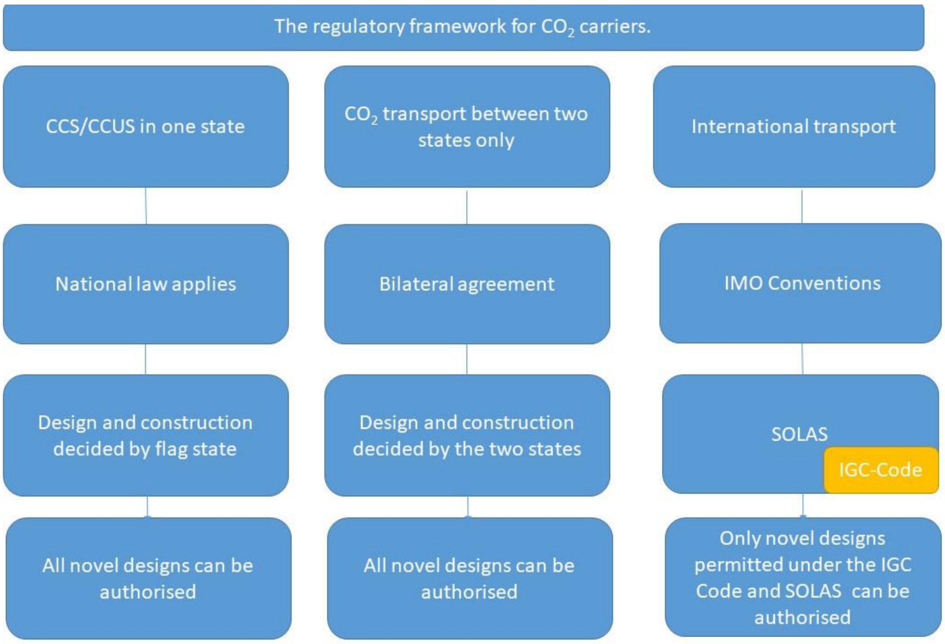
The argument based on LOSC Art. 94(5) becomes stronger if the two states involved are parties to the SOLAS Convention. In such a case, it would then be arguable that the flag state should develop laws for a CO_2 carrier which conforms to the international standards agreed by that state, for ships engaged in international voyages. However, once again a scenario where a third state can challenge the non-compliance with Art. 94(5) against the flag state or prosecute the ship is difficult to perceive. On the high seas, only the flag state has such powers and when the ship is within the jurisdictional areas of the two states involved only these two states would be practicably able to survey or enforce their laws on the ship. An alternative, more conservative approach, could require conformity to SOLAS and the IGC-Code to the extent that standards for novel designs for the cargos' storage are concerned. Thus, in such a case a bilateral agreement between the two states would suffice to enable any agreed type of ship to be utilized. Such arrangements have been used in the past to permit trading of nuclear ships.

Where the ship has to go through the territorial sea of a third state the situation becomes more complicated. If the ship is a novel design which falls within the latitude granted to the flag state under SOLAS and the IGC Code, then the coastal would have to respect the innocent passage right irrespective of whether its national law would not have permitted the development or registration of such a ship. If the ship does not meet the criteria for a novel design, then there would be a question on whether such a ship endangers the coastal state's order, safety and environment in which case the passage is not innocent.

4.3 Ships suitable for use in CCS/CCUS-EOR operations in various states.

Both of the two previous CCUS systems constrained the way ships could be used by their operators. Developing ships which may not be compliant with the IGC Code could make such ships unsuitable for operation in other states which demand compliance with the SOLAS and the IGC Code. Developing CO_2 carriers which are fully compliant with SOLAS and the IGC Code requirements would ensure global operational capability for such ships and a market to sell them on if the CCUS completes its operation by filling in the storage facility or ceases to operate for whatever reason.

The IGC Code recognises that the standards need to evolve, and new technology may require changes in the regulatory requirements. In addition, as it has been discussed, the IGC Code also permits experimentation under the supervision of the flag state and within specific limits. New designs requiring new regulatory standards eventually need to be approved and implemented through the IMO regulatory process. The IMO process takes, in general, longer than an approval from one administration and this may add on the cost and further delay in the development of CCS/CCUS-EOR systems. This leads to designers of such systems to rely primarily on existing ship designs when demonstration projects are developed [16]. The slowness of the international law-making is not exclusive to shipping regulations only. The well-known obstacle posed by Art.6 of the London Convention to the export of CO_2 was created by the inclusion of CO_2 to the London Convention under 2006 Resolution LP 1/1. Efforts to overcome come it led in 2009 to resolution LP.3(4) permitting CO_2 exports for storage. However, the resolution to amend the London Convention did not meet the required numbers for ratification because only a few states have an interest in CCS. Thus, a decision on its provisional application was adopted in 2019 [17]. Overall, it took 13 years to remove an obstacle created by an uncontroversial and unintended consequence of unsatisfactory drafting. The development of new rules and adoption of new-ship designs is also likely to take a lot of time despite the possibility that new ship designs may make CCS/CCUS-EOR more efficient. There are also examples where the IMO has discussed and developed specific regimes for new craft [18][19][20][21]. The development of regulatory and liability arrangements at the IMO does not, however, guarantee the universal adoption of the technology. Thus, the development of a regulatory regime for nuclear ships [20] as well as a liability convention [21], were not enough to make the technology generally acceptable to states. As a result, the few commercial nuclear ships that have been built operated on bilateral agreements between states. Thus, having an appropriate and, in the case where new technology is important, permissive legal framework is a necessary but not a sufficient condition for the adoption of CCS/CCUS-EOR systems. The three regulatory options are summarised in Figure 1.



<u>Figure 1.</u> The treatment of novel designs for CO_2 carriers for the various options discussed in the text.

5 Liability arising from the operation of CO_2 carrying ships.

A major concern for investors, innovators, regulators and the public, is the allocation of the risk of damage caused through the operation of a ship. The transport of CO_2 by ships poses risks for human life [22][23] due to the quantities involved and the onboard conditions of storage. The area at risk can be of a few hundred meters and depends on the temperature and pressure of the storage as well as the wind speed [22]. Since human life is vulnerable to large releases of CO_2 other species are also likely to be affected in case of an accident. Thus, a ship carrying CO_2 will be potentially hazardous to both human life and to parts of the marine environment on account of carrying a hazardous substance even if the environmental impacts are not likely to have long lasting effects. These risks are in addition to navigational hazards and to the pollution risk arising from bunkers, lubricating oils and other potentially hazardous material onboard the ship.

The probability of accidents for CO_2 carriers or a dual cargo LNG-CO_2 ships is unknown as we do not have systems operating long enough to enable such empirical estimates to be made. However, it is reasonable to assume that the risk of such accidents will be similar to the risks of LNG ships, which are known to be the safest in the market [24]. Thus, it is reasonable to assume that the extent of the potential liability would be similar. Whether this assumption would be proven true, would depend on the exact configuration of the CCUS system. For example, if the injection to the seabed is done by the crew of the ship there will be fewer people involved in the operation than if there was a dedicated terminal managing this process. Thus, the risk for loss of life or personal injury would be lower if it is assumed that the skills would be equivalent in both cases. Notably though the liability in the latter case would not necessarily be for the shipowner while in the case of direct injection from the ship it would be so.

5.1 Liability regimes

Liability arising from shipping incidents is regulated under a number of international legal liability regimes and supplemented by national liability laws. Through the IMO, legal regimes covering marine pollution and based on strict, limited liability supported with compulsory insurance and direct action against the insurers have been developed. These facilitate the recovery of damages by third parties against the liable shipowner who, however, retains legal rights of indemnification and recovery from parties who have caused or contributed to the damage caused. Protection from liability is also provided for the shipowner's employees and contractors including charterers, managers, and operators under the international conventions, while national rights of recovery are excluded when the international legal regime governs the damage caused. Thus, the operation of CO_2 carriers will be covered by the existing shipping liability regimes or national liability laws if the international instruments are not applicable. The international liability regimes are outlined below.

5.1.1 Spills of hazardous and noxious substances

The International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea, 1996, its Protocol of 2010 form the liability regime relevant to damages caused by CO_2 [25]. The 2010 HNS covers pollution damage but also loss of life, personal injury as well as property damage arising from hazardous and noxious substances [26]. While the 2010 HNS is not in force yet there are continuing efforts to bring it into force. The 2010 HNS is also based on strict but limited liability, compulsory insurance, and direct action against the insurer. The 2010 HNS further establishes the 2010 HNS FUND which provides additional compensation or pays out where the shipowner's strict liability regime fails to do so [27].

The 2010 HNS Convention is of particular importance for the carriage of CO_2. This is because the carriage of liquefied and refrigerated, and liquefied carbon dioxide is covered by the International Maritime Dangerous Goods Code (IMDG Code) and comes under the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) [10] [26]. This means that CO_2 carriers ships will fall under 2010 HNS Convention [26]. Therefore, the registered shipowner will be strictly liable but with liability limited according to the size of the ship and with further funds available to claimants from the 2010 HNS Fund. Loss of life, personal injury, property damage outside the ship, damage by contamination as well as the cost (and damage) from preventive measures as well as reasonable measures of reinstatement of the environment will be compensated [26].

The liability of the owner and its insurer is limited on the basis of the tonnage of the vessel and the cargo's form rather than on the amount of hazardous and noxious substances actually carried. For example, the limits for a 35,000 gt bulk CO_2 carrier would be 59,500,000 SDR (84,490,000 USD). The registered shipowner should be insured for this, otherwise the ship cannot trade. Claimants can also sue the insurer directly.

The right to limit liability is virtually certain [26]. The HNS FUND forms a second tier of compensation of up to 250,000,000 SDR (approx. 351 m USD) inclusive of any compensation already provided by the registered owner under the 2010 HNS Convention.

Under Art. 11 of the 2010 HNS loss of life and personal injury claims are paid first, within the first two thirds of the fund. The residual third is distributed pro-rata between any unpaid loss of life and personal injury claims, and all other property, environmental damage, and preventive measure claims. The 2010 HNS only permit claims for damage covered by it to be advanced under it and excludes national law remedies.

However, until the 2010 HNS Convention comes into force loss of life and personal injury claims as well as any environmental damage caused by a CO_2 carrier will be covered by whatever national system is in place. For common law countries, negligence will be one of the available legal bases.

Irrespective of the legal basis, the liability of the shipowner against third parties will be limited under one of the global limitations of liability regimes, most likely the 1976 LLMC as amended [27], which limit the shipowner's, charterer's manager's and operator's liability for most operational damages arising from the operation of a ship. The limits of liability are determined by the size of the ship with more money available for compensation of loss of life and personal injury claims and less money available for property damage [26].

5.1.2 Oil spills from a CO_2 carrier .

Owners of a CO_2 carrier, may additionally, face strict liability with respect to oil spill damage from bunker oil as well as wreck removal costs if the ship is lost. Damage for bunker oil is compensated under the 2001 BOPC [28] which provides for strict liability, compulsory insurance, and direct action against the insurer. It does not however create any special fund for compensation but instead preserves limitation of liability rights that are generally available to shipowners under national or international law [28]. Most states around the world provide such rights to limitation of liability under the 1976 LLMC as amended [27].

Wreck removal in the EEZ of some coastal states is subject to the 2007 Wreck Removal Convention [29] which imposes strict liability, with compulsory insurance and direct action against the insurer, for the location, marking and removal of hazard from a hazardous wreck. This liability as well as liability under any national liability regime applicable in the other jurisdictional areas of the coastal state may be subject to limitation under the 1976 LLMC as amended. The 1976 LLMC as amended, permits contracting states to exclude wreck removal costs from limitation. Several states have taken up this opportunity.

CO_2 carriers are unlikely to have significantly higher navigational or operational risks than similar LNG ships and therefore their operation will fit well within the existing insurance arrangements. The major legal liability regimes are shown in figure 2 and the limitation arrangements are shown in Table 1.

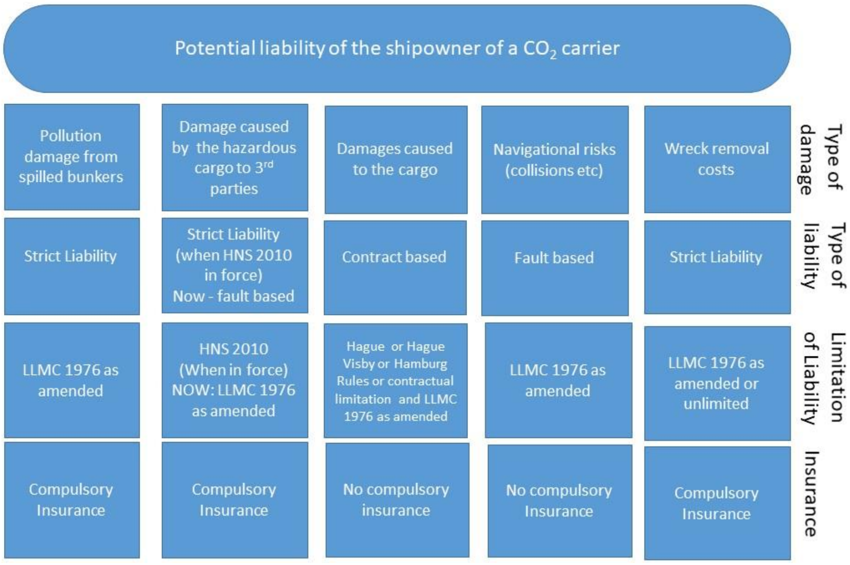


Figure 1. The exposure of liability by the shipowner of a CO_2 carrier.

Table 1. Liability and its limitation for a 20,000 gross tonnage ship.

	Type of Liability	Person Liable	Type of damage covered	Insurance	Limits in SDR(*)
HNS 2010	Strict	Registered Owner	Loss or life personal injury, property damage, pollution damage	Compulsory insurance and direct action against the insurer	37,000,000
National liability regimes	Depends / usually fault based	Depends / wrong doer	Loss or life personal injury, property damage, pollution damage	Depends	37,146,000
BOPC 2001	Strict	Registered Owner, Bareboat Charterer Manager, Operator	Pollution Damage	Compulsory insurance and direct action against the insurer	12,382,000

WRC 2007	Strict	Registered shipowner	Location, marking, wreck hazard removal	Compulsory insurance and direct action against the insurer	Many states – no limitation 12,382,000

(*) 1 SDR was equal to US$ 1.442840 on 08/06/2021. The daily value of the SDR can be found at https://www.imf.org/external/np/fin/data/rms_sdrv.aspx

5.1.3 Cargo losses and limitation amounts

The carriage of goods by sea is a matter of contract and, in general, the contractual parties are free to negotiate the terms of the contract and allocate risks and liability. Only where the receiver of the goods is different from the party which have originally contracted with the carrier, statutory protection is provided to ensure that the carriage is subject to some minimum standards and the receiver of the goods is not subjected to unreasonable terms agreed between the shipper of the goods and the carrier. The statutory provisions are normally enactments of the three international conventions currently in force, namely the Hague Rules [30] or the Hague Visby Rules [31] or the Hamburg Rules [32]. Another international instrument, the Rotterdam Rules are not yet in force [33]. With the exception of the Hague Rules which do not provide for limitation of liability for bulk cargo the others have limits of liability of 2 SDR per kg, 2.5 SDR per kg and 3 SDR per kg respectively.

Taking the SDR exchange rate with the US dollar at the time or writing, the limits of liability for 1000 kg of CO_2 would be for the Hague, Hague-Visby, and Hamburg Rules c $US 2,885, 3,607 and 4,238 correspondingly. While the density of a cargo of CO_2 would depend on the temperature and the pressure in the storage tanks, it is clear that the limitation amounts are high enough to cover the value of the lost CO_2. Thus, no limitation issues will arise in this respect, unless the contract of carriage is not subject to any of the aforementioned carriage regimes and the contracting parties have imposed much lower limits of liability. This is not illegal and would also depend on whether bills of lading will be sued or whether other shipping instruments, for example, seaway bills, which are not subject to the aforementioned liability regimes, are used.

6 The missing link between regulation and liability

It is important to note that the IMO regulatory and liability regimes are decoupled. In other words, a violation of a regulatory requirements under the regulatory conventions does not affect the degree of liability under the liability conventions, because liability is strict, nor the total amount payable to the victims of a shipping incident. Similarly, a violation of a shipping regulation does not in general affect the right to limit liability which, in turn, is regulated by a separate test based on intentional or reckless act committed by someone at the highest level of command of the ship-owning company, sometimes called the company's ~~its~~ alter ego, committed with knowledge of the particular loss.

The decoupling between regulatory standards and liability means that, even if the ship is substandard and non-compliant with SOLAS or other regulatory convention the shipowner will still be entitled to limit its liability. Thus, it is possible to utilise the highly efficient limits of liability and insurance arrangements in the shipping sector even if novel, permitted or unpermitted under SOLAS and the IGC Code, designs are utilised. Even where the operation of the CO2 carriers is within one stare or between two states such ships will in all probability still be entitled to limit their liability. Thus, the financial risks with respect to damages caused by CO_2 carriers will depend on the size of the ship involved and will be independent of whether the ship is engaged in the transport of CO2 nationally, between two states or internationally.

7 The insurance of liability for CO2 carriers.

The new carbon removal industry operations will bring opportunities for insurers. In general, insurers may increase their understanding of the new carbon removal risk operations by designing pilot offerings so as to gradually build up the necessary risk knowledge for profitable business in the future. Some insurers are already looking into such products [34]. The availability of existing limitation of liability rights facilitates insurance efforts. The importance of insurance and financial security in general cannot be understated. Ships are in general subject to ship arrest under two international conventions, defined as detention for civil liability claims [35] [36]. Such claims include loss of life and personal injury claims, property damage, contract claims, cargo claims, claims for provisions and, depending on the applicable international legal regime, for environmental claims too [37]. Such detention may seriously disrupt the operation of the CCUS system until security for the claim has been provided. Third party liability insurers routinely provide for such security. As it has been explained, because the right to limit is independent of regulatory breaches by the shipowner and the risk is likely to be low, if the LNG market provides, as it has been assumed, a reasonable paradigm, the cost of insurance is unlikely to be higher than that for LNG carriers.

8 Conclusions

Where a new design of ships complies with existing international standards, then both the regulatory and the liability frameworks are already in place, and it is only a question of whether the commercial advantages of the new design would establish or eliminate the innovative design from the market.

For CO_2 carriers the regulatory legal framework is contained in the IGC Code. The implementation through the SOLAS convention means that this regulatory framework is inapplicable to CCS and CCUS-EOR systems trading within one jurisdiction. In turn, this means that, provided that the administration of the relevant state can be persuaded for the safety of a novel design, there is no constrain in the type of vessel or the type of containment used to store the CO_2. Such a ship will have to be dedicated to the specified jurisdiction, and will not be able to negotiate its participation to CCS/CCUS-EOR systems in other parts of the world without modification.

The same, it has been argued, is true for ships operating between two states where the ship does not have to go into the jurisdictional area of another state. This argument is based on the fact that there are no enforcement mechanisms available to any third state against a foreign ship, unless its interests have been affected or the ship is in a port or a jurisdictional area of that state.

Novel designs could, however, be promoted within the existing SOLAS and IGC Code framework, provided they meet some minimum criteria of safety. In such a case, ships have an international ambit of operation even if they depart from existing designs. No constraints in the navigation of such ships can be imposed by other states. Designs which do not meet the minimum safety criteria under SOLAS and the IGC Code would, if they can be demonstrated as being safe, can be utilised if the IGC-Code is modified a process which, because it requires international consensus to be built, would have a time scale which, in all likelihood, would exceed 5 years.

Where ships are going to be used as the means of transport in CCS/CCUS-EOR systems the existing literature relies on existing designs on which the IGC Code has been based. This has standardised the procedures for approving CO_2 carriers but has also focused new designs on their compliance with the standards contained in the IGC Code instead of focusing on the optimisation of the transport capability of such ships in a safe manner. This is an unnecessary constrain and designers of CO_2 carriers and CCS CCUS-EOR systems can consider new ship designs which can reduce the cost or increase the efficiency of the CCS CCUS-EOR system, at least where that system is within one state and also where only two states directly linked are concerned. The second conclusion concerns the liability exposure by shipowners. Because the right to limit liability for shipowners, charterers, managers, and operators of ships is not conditioned upon the ship's compliance with the regulatory regime the liability exposure for shipowners is, with very rare exceptions, set. In many states, this right to limit is an advantage ships have as the means of transport over pipelines [26]. The high certainty in limitation rights would then make insurance cover available. In the efforts to minimise the costs and maximise the efficiency of the CCS/CCUS-EOR system, the designers of such systems can consider novel designs of safe ships which go beyond the constraints imposed by the IGC Code where the capture and storage system is located in one or two jurisdictions. The limitation of liability for ships must, similarly, be taken into account, when the operational costs of pipelines and ships are compared.

9 List of References

[1] Núñez-López V, Gil-Egui R, Hosseini SA. Environmental and Operational Performance of CO_2-EOR as a CCUS Technology: A Cranfield Example with Dynamic LCA Considerations. *Energies*. 2019; 12(3):448. https://doi.org/10.3390/en12030448

[2] Svensson R., M. Odenberger, F. Johnsson and L. Strömberg (2004), Transportation systems for CO2—application to carbon capture and storage, Energy Conversion and Management, 45, 15–16, 2343-2353,

[3] Business, Energy & Industrial Strategy Department (2018), Shipping CO2– UK Cost Estimation Study Final report, available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/761762/BEIS_Shipping_CO2.pdf (accessed on May 13, 2021).

[4] National Research Council 2003. Oil in the Sea III: Inputs, Fates, and Effects. Washington, DC: The National Academies Press. https://doi.org/10.17226/10388.

[5] Aparajita Datta, Rafael De Leon & Ramanan Krishnamoorti (2020) Advancing carbon management through the global commoditization of CO2: the case for dual-use LNG-CO2 shipping, Carbon Management, 11:6, 611-630, doi: https://doi.org.10.1080/17583004.2020.184087.

[6] The Convention on the Inter-Governmental Maritime Consultative Organization (Geneva, 6 March 1948, in force 17 March 1958) 289 UNTS 48.

[7] Ryngaert, C., & Ringbom, H. (2016). Introduction: Port State Jurisdiction: Challenges and Potential, The International Journal of Marine and Coastal Law, 31(3), 379-394. doi: https://doi.org/10.1163/15718085-12341405

[8] LOSC, Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 397.

[9] McDougal M, Burke W, Vlacic I. (1960) The maintenance of public order at Sea and the Nationality of Ships, (1960) Yale Law School, Faculty Scholarship Series Paper 2610.

[10] ICG CODE, IMO Resolution MSC.5(48); Chapter VII of the 1974 International Convention for the Safety of Life at Sea (SOLAS) (IMO Resolution MSC.6(48)). See also Resolution Msc.370(93) (Adopted On 22 May 2014) The International Code For The Construction And Equipment Of Ships Carrying Liquefied Gases In Bulk (IGC Code).

[11] International Convention for the Safety of Life at Sea (SOLAS), 1974, Adopted 1 November 1974, enter into force on 25 May 1980.

[12] Tsimplis M, Dbouk W. Performance-based regulation, and the development of international regulatory uniformity in offshore oil and gas operations. In: Handl G., Svendsen K. editors. Managing the Risk of Offshore Oil and Gas Accidents: The International Legal Dimension, Cheltenham, UK: Edward Elgar Publishing, 2019. p. 18-51

[13] See the Joint Industry Programme 33 (JIP33): Standardizing procurement Specifications at https://www.iogp-jip33.org/ (accessed 4/11/2021).

[14] Glenn H. Business Responses to the Regulation of Health and Safety in England, Law and Policy, 1993:15(3), 219.

[15] Harrison J., (2008), International Labour Organization. International Journal of Marine & Coastal Law, 23(1), 125-135.

[16] Baroudi H.A, A. Awoyomi, Kumar P.K. Jonnalagadda, E.J. Anthony, (2021), A review of large-scale CO2 shipping and marine emissions management for carbon capture, utilization and storage, Applied Energy, 287, 116510,

[17] See LC 41/17 REPORT OF THE FORTY-FIRST CONSULTATIVE MEETING AND THE FOURTEENTH MEETING OF CONTRACTING PARTIES, at page 14.

[18] The International Code of Safety for High-Speed Craft, 2000 (2000 HSC Code) revising the International Code of Safety for High-Speed Craft, 1994 (1994 HSC Code). Resolution MSC 97/73).

[19] MSC 99/5 Regulatory Scoping Exercise For The Use Of Maritime Autonomous Surface Ships (Mass). MARITIME SAFETY COMMITTEE 99th session Agenda item 5.

[20] Nuclear-Ship Code of safety for nuclear merchant ships – IMO Res. A.491(XII).

[21] Convention on the Liability of Operators of Nuclear Ships (Belgium, 25 May 1962 (not in force).

[22] Harper P. (2011), Assessment of the major hazard potential of carbon dioxide (CO2), UK Health and Safety Executive (HSE), available at: https://www.hse.gov.uk/carboncapture/assets/docs/major-hazard-potential-carbon-dioxide.pdf (accessed on 17/5/2021).

[23] Brown A., C. Eickhoff, J.E.A. Reinders, I. Raben, M. Spruijt, F. Neele, (2017) IMPACTS: Framework for Risk Assessment of CO2 Transport and Storage Infrastructure, Energy Procedia, Volume 114, 2017, Pages 6501-6513.

[24] Doctor R, Palmer A, Coleman D, Davison J, Hendriks C, Kaarstad O, et al. Chapter 4: Transport of CO2. IPCC Spec Rep Carbon Dioxide Capture Storage 181 2005:179–94.
[25] International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), 2010. Not in force.
[26] Weber V, Tsimplis M. The UK Liability Framework for the Transport of CO2 for Offshore Carbon Capture and Storage Operations, IJMCL, 2017: 32(1); p. 138-172
[27] 1976 LLMC, Convention on Limitation of Liability for Maritime Claims, 1456 UNTS 221 amended by its 1996 Protocol, 35 ILM 143 3 and the 2012 Protocol adopted 19 April 2012.
[28] 2001 BOPC, International Convention on Civil Liability for Bunker Oil Pollution Damage, Adopted on 23 March 2001 in London.
[29] Nairobi International Convention on the Removal of Wrecks, 2007, adopted 18/05/2007, in force 14 April 2015, UNTS Registration Number 55565.
[30] International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading (Brussels, 25 August 1924).
[31] The Hague Rules as amended by the Protocol to Amend the International Convention for the Unification of Certain Rules of Law Relating to Bills of Lading (Brussels, 23 February 1968).
[32] United Nations Convention on the Carriage of Goods by Sea (Hamburg, 31 March 1978).
[33] United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea, New York, 11 December 2008. The official Signing Ceremony took place in Rotterdam on 23 September 2009. Because these are not in force yet thy will not be discussed in detail.
[34] Streidl. F, Sustainability in Energy Insurance, Zurich, 15.12.2020, available at https://www.zurich.co.uk/news-and-insight/sustainability-in-energy-insurance, accessed on 9/6/2021.
[35] The International Convention Relating to the Arrest of Sea-going Ships (adopted 10 May 1952, entered into force 24 February 1956) 439 UNTS 193.
[36] The International Convention on the Arrest of Ships (adopted 12 March 1999, entered into force 14 September 2011) 2797 UNTS 3.
[37] Tsimplis, M., (2019), Arrest, Detention and Seizure of Ships: Availability for Environmental Claims, In: The Arrest Conventions: International Enforcement of Maritime Claims. (Myburgh, P. editor), Hart Publishing, p. 175-198.