University of Southampton

CO2 from Port to Pipeline (CO2P2P) - IDRIC Project #50
Review of the legal and regulatory framework for CO_2 shipping as part of Carbon Capture and Storage in the United Kingdom

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List of abbreviations

1992 Convention for the Protection of the Marine Environment of the North-East Atlantic	OSPAR
1996 Protocol to Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972	London Protocol
Agreement for Lease	AfL
Associated British Ports	ABP
Associated British Ports	ABP
Carbon Capture and Storage	CCS
Carbon Capture Utilisation and Storage	CCUS
Carbon Dioxide	CO_2
Conservation of Habitats and Species Regulations 2017	Habitat Regulations
Control of Major Accident Hazards Regulations 2015	COMAH
Convention for the Protection of the Marine Environment of the North-East Atlantic	OSPAR
Convention on Limitation of Liability for Maritime Claims 1976 and its 1996 Protocol	LLMC96
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972	London Convention
Dangerous Goods in Harbour Area Regulations 2016	DGHAR
Dangerous Substances in Harbour Areas Regulations 1987	DSHAR
Department for Business Energy and Industrial Strategy	BEIS
Department for Energy Security and Net Zero	DESNZ
Department for Environment, Food and Rural Affairs	DEFRA
Department for Transport	DfT
Environment Agency	EA
Environmental Impact Assessment	EIA
Environmental Damage (Prevention and Remediation) (England) Regulations 2015	EDR
Environmental Permitting (England and Wales) Regulations 2016	EPR
EU Directive 2009/31/EC on the geological storage of carbon dioxide	CCS Directive
EU Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, as amended by EU Directive 2014/52/EU	EIA Directive
Exclusive Economic Zone	EEZ
Guide to Good Practice on Port Marine Operations	GPPMO
Health and Safety	H&S
Health and Safety at Work Act 1974	HSWA
Health and Safety Executive	HSE
His/Her Majesty's Government	HMG
International Convention for the Prevention of Pollution from Ships	MARPOL
International Convention for the Safety of Life at Sea	SOLAS
International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea	2010 HNS Convention
International Environment Agency	IEA

International Gas Carrier Code	IGC Code
International Maritime Dangerous Goods Code	IMDG Code
Local Authority	LA
Management of Health and Safety at Work Regulations 1999	MHSWR
Marine and Maritime Organisation	MMO
Maritime and Coastguard Agency	MCA
Maritime Labour Convention	MLC
Merchant Shipping (Gas Carriers) Regulations 1994	Gas Carriers Regulations
Merchant Shipping (Maritime Labour Convention) (Health and Safety) (Amendment) Regulations 2014	2014 MLC Amendment Regulations
Merchant Shipping (Maritime Labour Convention) (Survey and Certification) Regulations 2013	Survey and Certification Regulations
Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 (S.I. No. 1997/2692)	1997 Regulations
North Sea Transition Authority	NSTA
Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020	EIA Regulations
Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001	Offshore Habitat Regulations
Offshore Petroleum Regulator for Environment & Decommissioning	OPRED
Oil and Gas Authority	OGA
Pollution Prevention and Control (England and Wales) Regulations 2000	PPC
Port Marine Safety Code	PMSC
Secretary of State's Representative for Maritime Salvage and Intervention	SOSREP
Statutory Harbour Authority	SHA
Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 (SI 2010/2221)	CO_2 Licensing Regulations
Strategic Environmental Assessment	SEA
United Kingdom	UK
United Kingdom Continental Shelf	UKCS

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Executive Summary

Non-pipeline transportation (NPT) of carbon dioxide (CO_2) can play an important role in upscaling Carbon Capture and Storage (CCS) in the United Kingdom (UK) and meeting His Majesty's Government's (HMG) Net Zero objectives. Given the mismatch of industrial clusters and carbon sink locations in the UK, Transport & Storage (T&S) networks need to be able to accept CO_2 from dispersed sites where no pipeline networks are in place. This includes CO_2 transport by ship, road or rail. Additionally, there are opportunities for the UK to provide geostorage services in the North and Irish Seas for other European Union (EU) countries who have limited storage capacity, taking advantage of the established industrial infrastructure already in place through the gas network and the extensive experience of the oil and gas sector.

Following the cancellation of two major CCS funding competitions in 2011 and 2015 due to a lack of understanding of commercial risks and costs, HMG has been developing a framework for the economic regulation of CO_2 T&S networks to ensure the continuity of T&S services in support of CCS in the UK. The Energy Bill is envisaged to deliver this framework which will allow T&S operators to receive revenues from their investments into T&S networks. However, it only applies to transportation by pipelines for geological storage operations. HMG is now considering whether NPT should be accommodated into the T&S business model. Particularly, it is seeking to achieve a better understanding of the role which NPT services could play in the UK's CCS plans, of the likely levels of competition between different modalities of transport in the provision of these services, and of the potential corresponding implications for economic licencing.

This report adds to existing literature comparing the modalities of transporting CO_2 as part of CCS by examining the public law aspects of the regulatory and liability regimes governing the transport of CO_2 from port to port, taking the Solent Industrial cluster as an example. Relying on the assumption that the CO_2 shipping chain, including port infrastructure, is expected to be owned and operated by one entity through a joint venture, the report underlines the range of duties incumbent upon CO_2 shipping stakeholders and the role and remit of competent authorities in enforcing these requirements, and to propose action to simplify what is a highly complex landscape to navigate. Moreover, it provides an updated overview on recent developments surrounding offshore CO_2 storage, which could bear indirect consequences on decisions to upscale CO_2 shipping as a modality of transportation to support CCS.

It notes that the regulatory landscape governing CCS in the UK is laboursome and highly complex. Several public bodies have responsibility over the enforcement of CCS-relevant laws and regulations in the UK, particularly with regards to liability for harm caused by transport and in-port storage activities and the permitting and assessment of impacts of offshore CCS projects. The report suggests a simplification of the regulatory landscape through bringing the responsibility over these specific aspects within the remit of the Maritime and Coastguard Agency (MCA)/Health and Safety Executive (HSE) or the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) and facilitating cooperation between these bodies via forums such as the CCUS Council.

With respect to occupational health and safety (H&S) in CO_2 shipping, the report notes that the regulatory regime is underpinned by a general principle for the objective assessment of risks by shipowners/operators and their prevention/reduction of those risks so far as reasonably practicable. The regime in place is mainly inspired by the transposition of international maritime conventions (*i.e.* the Maritime Labour Convention [MLC] and the International Convention for the Safety of Life at Sea [SOLAS]) into national law, and the main enforcing authority is the MCA. It is also influenced by European Directives which were transposed into UK law pre-Brexit. Whilst the MLC and EU-inspired

UK Regulations directly address the H&S of seafarers, SOLAS is more concerned with the safety of the ship itself, which is intrinsically linked to the H&S of those on board. In addition, consideration of broader H&S legislation is common in the interpretation of the conventions' provisions by the MCA and the HSE, which set a common objective of achieving comparable levels of H&S for seafarers on merchant ships and fishing vessels as applies to workers ashore. The report highlights specific developments relating to CO_2 which fit within this regime, most notably:

- The publication of EH40/2005, which includes CO_2 in its list of workplace exposure limits approved by HSE.
- The adoption of amendment 38-16 to the IMDG Code by the International Maritime Organization, which added liquified CO_2 to Class 2.2 "non-flammable, non-toxic gases".
- The adoption of resolution MSC.370(93) which replaced the text of the (International Gas Carrier) IGC Code. Chapter 19 of the latter now includes CO_2 in "high purity" and in "reclaimed quality", thus bringing vessels engaged in transporting it under the scope of Chapter VII Part C of SOLAS.
- The adoption of the ISM Code in 1993, which was made mandatory via Chapter IX of SOLAS.

The framework for the prevention of marine pollution from CO_2 shipping derives from two main IMO instruments: the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention/London Protocol). More broadly, the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), applicable in the North-East Atlantic and North Sea, requires States to take *all possible steps* to prevent and eliminate pollution of the maritime area as well as to take the necessary measures to protect the maritime area against the adverse effect of human activities. The report analyses these instruments and highlights a potential confusion around whether and how the MARPOL 73/78 regime applies to the carriage of CO_2 by ships, and argues that recent amendments affecting the London Protocol do not hamper its mandate for the protection of the marine environment from CO_2 shipping activities. To settle potential conflicts in the interpretation of MARPOL 73/78, and in recognition of the anticipated increase in the carriage of liquified CO_2 by sea in support of CCS activities globally, the report recommends that liquified CO_2 is added to the list of substances in chapter 17 and/or 18 of the IGC Code for the specific requirements under Annex II of MARPOL 73/78 to become applicable to the carriage of liquified CO2 by sea globally.

The report then unpacks the legislative framework governing the liability aspects of liquified CO_2 shipping in the UK, highlighting the Environmental Damage (Prevention and Remediation) (England) Regulations 2015 (EDR) regime, the Convention on Limitation of Liability for Maritime Claims (LLMC), and the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea Convention (HNS Convention). The HNS Convention is still not in force pending receiving sufficient number of ratifications from contracting States. The report notes that the framework established by these instruments is comprehensive, highlighting that liability thereunder is strict but limited, and that mandatory insurance to cover potential liabilities incurred is generally required. It adds that, following the addition of CO_2 to Chapter 19 of the IGC Code, the framework applies to its transport by road, rail, inland waterways, sea or air in the UK, but the enforcement of the regime is currently split across several bodies depending on the geographical location of the harm subject to the liability claim. Moreover, the liability of operators is limited differently under the EDR/LLMC and the HNS Convention regimes, which could lead to inconsistency in the framework governing different heads of claims in a shipping context once the HNS Convention enters into force. Therefore, the report proposes that instruments transposing the Convention into UK national law would adopt a broader scope than the Convention for the limitation

thereunder to cover liability arising out of loading/unloading activities and ensure consistency in the framework governing the liability aspects of CO_2 transport in support of CCS in the UK once the HNS enters into force.

With regards to in-port storage, the report presents a highly complicated regulatory landscape which reflects a complex governance structure surrounding UK ports. To address this, the MCA produced and now requires Statutory Harbour Authorities (SHAs) to demonstrate compliance with the Port Marine Safety Code (PMSC) which is widely recognised as establishing a national standard for every aspect of port marine safety in the UK. The report analyses the requirements under the PMSC before analysing specific regulations potentially governing H&S and environmental protections aspects of CO_2 storage in UK ports. It highlights that following the addition of liquified CO_2 to the International Maritime Dangerous Goods (IMDG) Code, it falls within the remit of the Dangerous Goods in Harbour Areas Regulations 2016 (DGHAR), which imposes specific requirements on ports stakeholders (*e.g.* notice; having effective emergency plans in place before goods are permitted into the harbour area). However, the question of whether liquified CO_2 is covered by the Control of Major Accident Hazards Regulations 2015 (COMAH) is debatable. Given that CO_2 poses some risks to health and to the environment and that it is expected to be stored in larger quantities in UK ports to enable the delivery of CCS plans, the report suggests for CO_2 to be added as a new substance in Schedule 1 of the COMAH to avoid confusion around whether the regulation of CO_2 storage activities in UK ports falls under its scope.

The report then examines key environmental permitting regulations in the UK which could potentially govern CO_2 storage activities as part of CCS in UK ports. The Environmental Permitting (England and Wales) Regulations 2016 (EPR) and the Pollution Prevention and Control (England and Wales) Regulations 2000 (PPC) require operators of facilities falling within their remit to satisfy the regulator – the Environment Agency – that risks of environmental pollution have been identified and reduced through the adoption of an effective environmental management system. The report finds that these regulations provide for several regimes which – if their specific conditions are met - could potentially simultaneously govern the storage of CO_2 in UK ports. To address the ensuing uncertainty and to ensure that uniform environmental protection standards apply with regards to the processing and handling of CO_2 as it passes through the CCS stages and undergoes phase changes, the report recommends that CO_2 capture, liquefaction and storage activities are expressly included in the list of activities which bring installations where they are performed within the scope of the regulations.

Liability from environmental harm potentially caused by CO_2 storage activities within ports is governed by the EDR and the Merchant Shipping Act 1995 (MSA95). The report analyses the implications of these instruments and notes uncertainty around whether the storage of CO_2 is an activity for which a permit is granted by an authority pursuant to regulation 10 of the EDR. It therefore suggests that regulation 11 of the EDR is applicable, resulting in a complex enforcement regime whereby the Regulations are enforced by different public bodies depending on the geographical location of the harm in question. It also notes that the limitation of liability which SHAs can benefit from in this regard is limited to liability arising out of damage to the ship and/or her cargo whilst on board the ship, not in respect of loss of life or personal injury or property damage beyond the ship.

The last section of this report explores the main international conventions relevant to CO_2 storage in the marine environment, and presents an overview of the UK's approach to the regulation of offshore CO_2 storage as part of CCS. It provides an update on aspects which had been identified as key barriers for CCS activities in past reports (particularly in a transboundary context), and briefly unpacks some aspects of the permitting and environmental protection framework for offshore geological storage in the UK to highlight additional regulatory requirements incumbent upon CCS stakeholders and that

regulatory oversight in their respect is split amongst multiple bodies. Most notably, the report highlights the adoption of resolution LP.5(14) in 2019 to allow the provisional application of the 2009 amendment to article 6 of the London Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter to allow the export of CO_2 for storage in sub-seabed geological formations in advance of its ratification.

1. Introduction

Carbon capture, utilisation and storage (CCUS) are technologies that can play varying roles in meeting global energy and climate goals. The latest Report of Working Group III of the Intergovernmental Panel on Climate Change (IPCC), 'Climate Change 2022 – Mitigation of Climate Change'[1] [1] highlighted the effectiveness of these technologies in enabling the mitigation of carbon dioxide (CO_2) emissions from large point sources, such as power plants/refineries or industrial facilities that use either fossil fuels or biomass as fuel. The captured CO_2 can be either used on-site (emphasising the "utilisation" component of CCUS), or compressed and transported via different modalities (*e.g.* pipeline, shipping, rail or truck) to be either used in other applications or injected into deep geological formations (including depleted oil and gas reservoirs or saline aquifers – commonly referred to as "Carbon Capture and Storage" [CCS]) where it is permanently stored.

It is essential that CCS deployment is in parallel with continued efforts to increase energy efficiencies and other approaches to reduce CO_2 and other greenhouse gas emissions. The need for the rapid expansion of CCS as a measure to meet the Paris Agreement climate objective of limiting global temperature rise to 1.5°C is reflected in the 2022 IPCC Report [1] and in various energy outlook reports published by leading global organisations including the International Energy Agency (IEA) [2] and the International Renewable Energy Agency (IRENA) [3]. For example, the IPCC Report provided that modelled mitigation strategies to achieve pathways that limit warming to 1.5°C with no or limited overshoot or to 2°C include "transitioning from fossil fuels without CCS to very low- or zero-carbon energy sources, such as renewables or fossil fuels with CCS, demand side measures and improving efficiency, reducing non-CO_2 emissions, and deploying Carbon Dioxide Removal (CDR) methods to counterbalance residual GHG emissions" [1]. Moreover, in the UK, the Climate Change Committee's (CCC) Sixth Carbon Budget, 'The UK's path to Net Zero' [4], recommended that future climate mitigation efforts should combine achieving emissions reductions in the transport, industry, buildings, and agriculture sectors, and phasing out gas-fired power, whilst recognising an important role for CCS as part of that. The CCC report looked at different scenarios for reducing emissions to realise the legally binding net-zero by 2050 target under the Climate Change Act[2] [5]. All of these scenarios depend on the use of CCS, with the least demanding scenario (the Widespread Engagement scenario) relying on the capture of 70 million tons of CO_2 from different processes (*e.g.* hydrogen production and electricity supply) by 2050 (see Figure 1).

[1] The report constitutes a formal scientific input to the United Nations Framework Convention on Climate Change, and is meant to be used by government and the private sector to inform their actions to achieve climate goals.

[2] As amended by The Climate Change Act 2008 (2050 Target Amendment) Order 2019, which raised the minimum percentage by which the net UK carbon account for the year 2050 must be lower than the 1990 baseline from 80% to 100%.

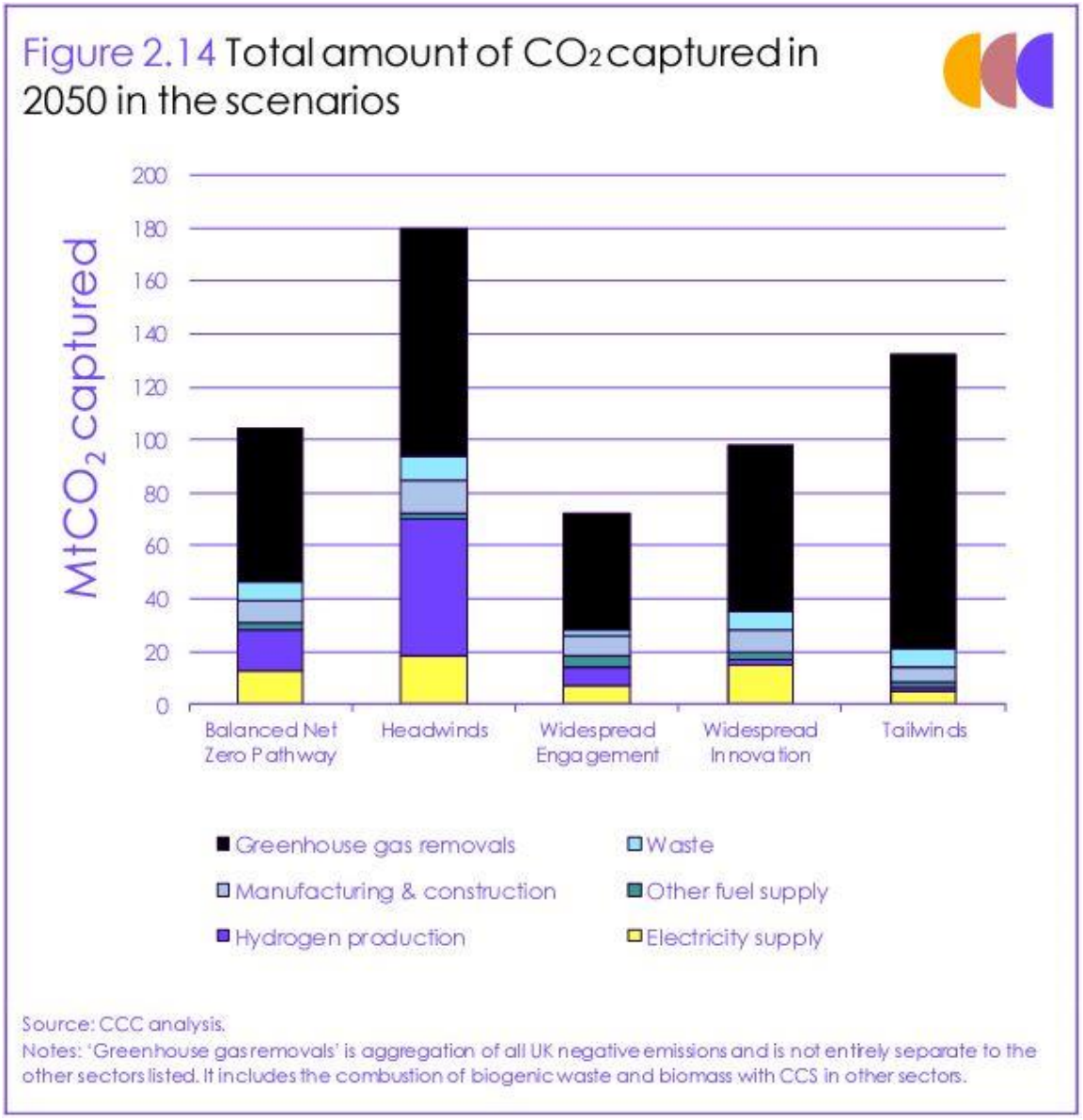

Figure 1. Total amount of CO_2 captured in 2050 under the scenarios examined in the CCC report (reproduced from [4], p.81).

In January 2023, the final report of Rt Hon Chris Skidmore MP's Independent Review of Net Zero reiterated that industry is responsible for around 16% of the UK's greenhouse gas emissions, with industrial clusters accounting for around 50% of all industrial greenhouse gas emissions [6]. This underpins the strategy laid out in Rt Hon Boris Johnson MP's 'The Ten Point Plan for a Green Industrial Revolution' (November 2020) according to which CCUS is to be deployed in two industrial clusters by the mid-2020s, and in a further two clusters by 2030[3] [7] (see Figure 2) and the CCC's 6th Carbon Budget Report conclusion that CCUS is "a necessity, not an option" for reaching net-zero greenhouse gas emissions by 2050 (December 2020). His Majesty's Government's (HMG) Industrial Decarbonisation Strategy (March 2021) further revealed plans to achieve one fully net-zero cluster in the UK by 2040, reiterating the vital role which CCUS will play in the delivery of this ambition [8].

[3] Commonly referred to as the 'two-phased approach' to cluster sequencing.

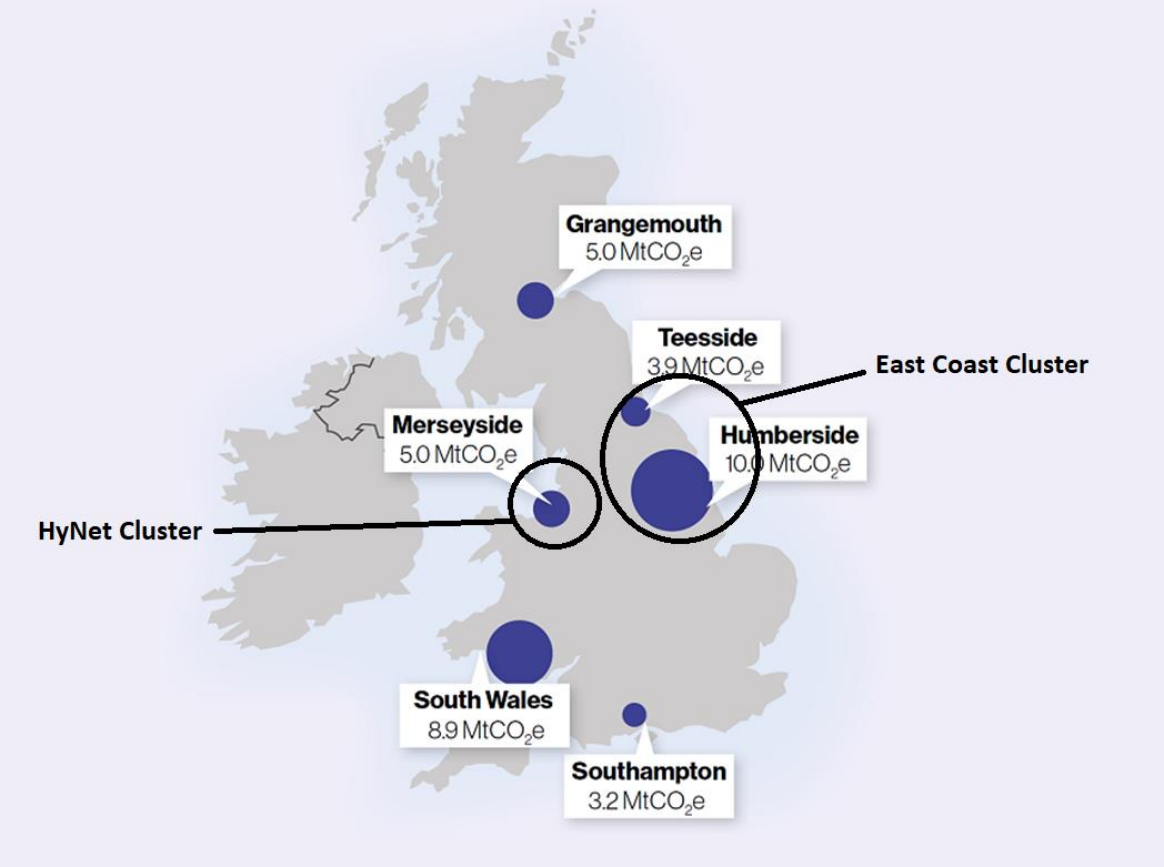

Figure 2. Map of major UK industrial cluster emissions – 2018 ([8], based on NAEI 2018 data which did not capture non-ETS emissions in a cluster – annotated to reflect the development below on cluster sequencing)

By combining low carbon hydrogen production and renewable energy, these industrial clusters could evolve into "SuperPlaces" that constitute hubs that are at the forefront of technological development in the UK's transition to net zero [7-8]. HMG's Net Zero Strategy, published in October 2021 and subject to the abovementioned Skidmore MP's review, highlighted the production of electricity and hydrogen from low carbon generation as key features of this transition which are supported/enabled by CCUS technologies [9]. Beyond the UK context, HMG also recognises that there are opportunities for the UK to provide geostorage services in the North and Irish Seas for other EU countries who have limited storage capacity, taking advantage of the established industrial infrastructure already in place through the gas network as well as "extensive experience from oil and gas sectors in the right places" [6].

On 29 May 2018, the House of Commons' BEIS Committee launched an inquiry to assess HMG's commitment to CCUS technologies.[4] Following the cancellation of two major competitions at a late stage due to concerns of the high costs of the technology (in 2011 and 2015), there were serious question marks around whether there was sufficient policy support for upscaling CCUS in the UK. Indeed, the Committee's end-of-inquiry Report (April 2019) found that, despite the UK being perceived as having "one of the most favourable environments globally for CCUS", no commercial-scale plant has yet been constructed in the UK due to a "turbulent history" qualified by a "lack of sustained policy support for the technology, despite a decade of repeated […] calls from official bodies and parliamentary inquiries to bring forwards its deployment" [10]. Unpacking the reasons behind the cancellation of the funding competitions in 2011 and 2015, the National Audit Office found that both

[4] As opposed to inviting expert input on ways to achieve cost reductions, entrusted to the CCUS Cost Challenge Taskforce.

had suffered from a lack of understanding of commercial risks and costs and a lack of early cross-departmental agreement on budgeting [11]. The CCC's conclusion in its 6th Carbon Budget Report that CCUS technologies are "a necessity not an option" has since lead to a step change in the policy landscape surrounding them, as reflected in the strategy documents discussed above (*e.g.* the Net-Zero Strategy; the Industrial Decarbonisation Strategy). This was coupled by increased support by the oil and gas industry and commitments to collaborate with HMG across several areas in the North Sea, including the development of CCUS and hydrogen (*e.g.* North Sea Transition Deal, March 2021 [12]; the CCUS Council [13]; the Carbon Capture and Storage Association [14]). Moreover, additional confidence in the upscaling of CCUS was afforded by the confirmation of £1 billion of Government investment to support the development of the technologies in the Energy White Paper (December 2020).

In line with the Ten Point Plan and the Industrial Decarbonisation Strategy's two-phased approach to cluster sequencing, BEIS launched a consultation in February 2021 to invite views and expertise on a potential approach to determine a natural sequence for locations to deploy CCUS in the UK [15]. This resulted in a process [16-17] which led to the identification of the Hynet and East Coast as Track 1 clusters which will benefit from initial support to enter operation by mid-2020s (March 2023 – see Figure 2) [18].[5] This was complemented by the Spring Budget 2023 announcement of a longer-term funding package of up to £20b for CCUS in the UK, a step which was very positively received by the CCUS industry [19]. As part of this plan, CO_2 transport and storage (T&S) networks will provide the enabling infrastructure for CCS from a range of sources, which will in turn require sustainable funding models that can attract private finance at a cost that represents value for money to taxpayers and consumers [20]. Thus, BEIS consulted on its proposed commercial frameworks for T&S, power, and industrial carbon capture business models in December 2020 [21]. The outcomes of these consultations informed the establishment of a framework of economic regulation for CO_2 T&S under the Energy Bill [22].[6] The latter aims to provide long-term revenue certainty to establish and scale-up CO_2 T&S networks in the UK [22]. It sets the Office of Gas and Electricity Markets (Ofgem) as the economic regulator of CO_2 T&S which grants economic licenses to "Transport and Storage operators" (T&S operator) for CO_2 transportation by pipeline for geological storage operations. Based on the T&S business model, granted licenses will determine the allowed revenue which a T&S operator may receive taking into account efficient expenditures and a "reasonable return" on its capital investment [20].[7] Following the February 2023 re-shuffle of Prime Minister Rt. Hon. Rishi Sunak MP's cabinet, passing the Energy Bill to support the "emerging CCUS and hydrogen sectors" became one of the priority outcomes for the new Department for Energy Security & Net Zero (DESNZ) [23]. This comes within the context of seizing the "opportunities of net zero to lead the world in new green industries". Although the Department's immediate focus would be on the energy component of the former BEIS Department through building energy resilience and easing the cost of living by bringing energy costs down, longer term objectives include coordinating net zero efforts across Government whilst ensuring "properly functioning" energy markets.

[5] "Clusters" are regional groupings where several CCUS facilities share infrastructure, especially for transport and storage. The East Coast Cluster includes Net Zero Teesside Power, bpH2 Teesside and Teesside Hydrogen CO2 Capture; whereas the HyNet Cluster includes Hanson Padeswood Cement Works Carbon Capture and Storage Project, Viridor Runcorn Industrial CCS, Protos Energy Recovery Facility, Buxton Lime Net Zero and HyNet Hydrogen Production Plant 1.

[6] At the time of writing of this report, the Bill was going through the 2nd reading stage in the House of Commons.

[7] Which fall under Ofgem's oversight. In practice, T&S operators will be awarded an economic licence to design, build, own and operate a T&S network in return for receiving an allowed revenue by charging regulated T&S fees to users of the T&S network.

In its analysis of the prospects for CCS in 2004, the International Environmental Agency (IEA) noted that CO_2 shipping is an "established technology on a kilotonne scale", adding that it may become "an important issue" due to geological storages not necessarily coinciding with industrial clusters [24]. Indeed, an Element Energy Report commissioned for the CCC in November 2020 examined various transport and storage options for CCS in the UK, and found that "[s]horeline-based clusters with easy access to ports and in areas where offshore pipeline construction is unfeasible are likely to develop CO_2 shipping solutions as a lower cost solution to transport CO_2 to operating terminals with offshore T&S infrastructure" [25]. The wider project within which this report fit is an example of these instances as it examines the transport of CO_2 from the Solent industrial cluster, with the most likely geostorage options to be initially developed in the North or Irish Seas more than 400 km away (see Figure 3.). In recognition of this reality, BEIS's updates on the business model for Transport and Storage (January 2022; [26] – [27]) considered the question of accommodating non-pipeline transport (NPT, *i.e.* by ships, road, or rails) into the T&S business model,[8] and concluded that it will be "vital" for HMG's long-term net-zero objectives to ensure that T&S networks have the capacity to be able to accept CO_2 through NPT. BEIS invited views on whether some aspects of NPT should be subject to the economic regulation model applicable to transport by pipelines, which respondents advanced will depend on "the level of competition for the provision of the different services". Through engaging with industry, HMG continues to seek to achieve a better understanding of the role which NPT services could play in the UK's CCS plans, of the likely levels of competition in the provision of these services, and of the potential corresponding implications for economic licencing.[9]

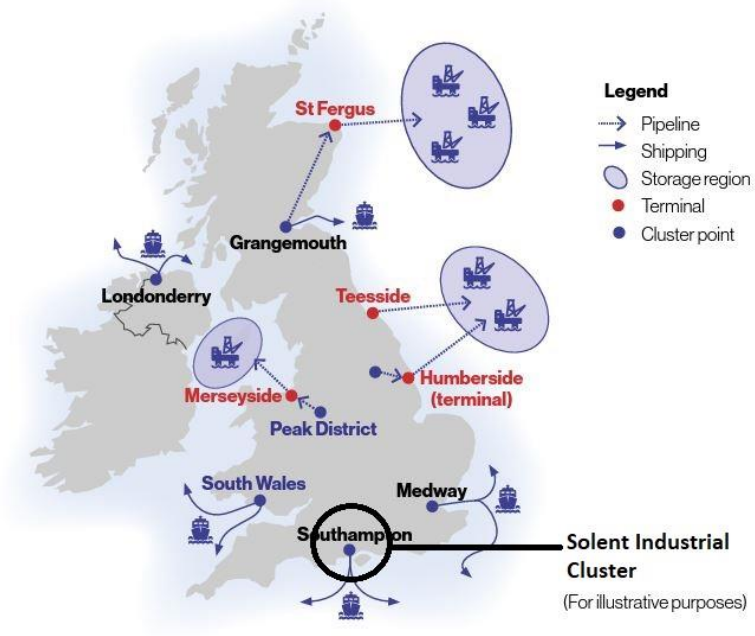

Figure 3. Annotated map illustrating that CO_2 injection points do not always coincide with the geographical location of industrial clusters like the Solent cluster (reproduced from [8]).

[8] Referred to as the T&S Regulatory Investment (TRI) model, which consists of both the regulatory model and other support arrangements which will facilitate investment in T&S infrastructure.

[9] At the time of the writing of the report, DESNZ's Carbon Capture, Usage and Storage, a vision to Establish a Competitive Market (the 'CCUS Vision') was published in December 2023. The Vision clearly recognised a "requirement for multiple forms of non-pipeline CO_2 transport" to enable "flexible and open access CO_2 transport networks". It referred to multiple forms of NPT but conceded that it was "not possible to determine and in what ways each of the transport options will be utilised in the 2030s" (page 41).

BEIS's consideration of the economic regulation of T&S networks is concerned with ensuring their continuity to support CCS activities. This falls within a broader effort achieve cost reductions across the various elements of the CCS process,[10] and to afford the wider CCS industry with the prerequisite certainty to enable its deployment at scale [28-29-30-31]. Within this context, numerous reports and academic publications compared the costs of transporting CO_2 as part of CCS via different modalities. This study will complement these analyses by examining the legal and regulatory framework governing the transport of CO_2 from port to port, taking the Solent Industrial cluster as an example. This involves loading the CO_2, once it has been liquified, from in-port temporary storage facilities onto ships that would carry it to a temporary storage facility in another industrial cluster connected to nearby geological storage via pipelines (see Figure 4). The CO_2 shipping chain, including port infrastructure, is expected to be owned and operated by one entity (*e.g.* a joint venture) [32].[11] Therefore, this report will not examine the *private law*[12] implications of the contractual relationships tying stakeholders in a traditional shipping context (*i.e.* shipowners, charterers, operators, insurers, cargo interest, *etc.*). It will instead primarily focus on the *public law*[13] aspects of the regulatory and liability regimes governing CO_2 shipping and in-port storage, underlining the range of duties incumbent upon various CO_2 shipping stakeholders, and proposing action to simplify what is a highly complex landscape to navigate. Moreover, it provides an updated overview on recent developments surrounding other aspects of the CCS process, which could bear indirect consequences on decisions to upscale CO_2 shipping as a modality of transportation to support CCS. This includes an examination of the legal and regulatory framework surrounding CO_2 storage, to highlight barriers which prohibit it. This is done with the assumption that CO_2 storage provides the *raison d'être* for its transport as part of CCS, and that it would therefore have implications on the level of demand for the development of CO_2 shipping infrastructure within this context. Additionally, aspects such as transport by pipelines remain relevant, particularly with regards to networks within ports and connecting ships to docking terminals.

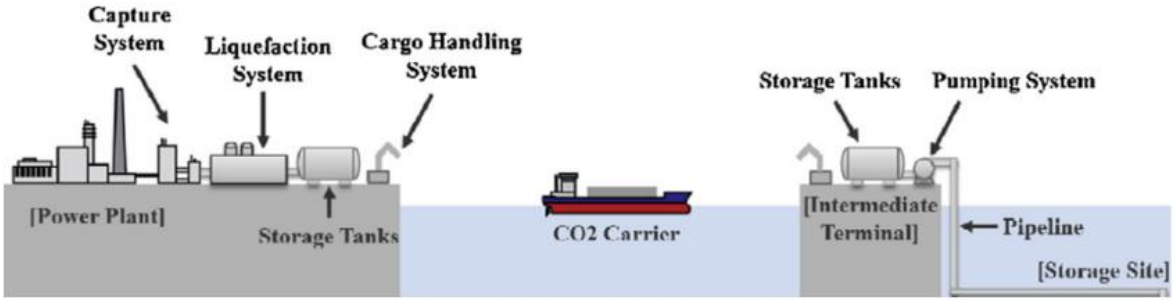

Figure 4. Components of the CO2 capture, storage and shipping chain ([33], [34])

Accordingly, this report comprises two main sections: Section (2) unpacks the regulatory and environmental liability regimes governing CO_2 shipping in the UK. As part of this, the analysis of the regulatory regime will focus particularly on the requirements incumbent upon shipping operators with regards to health and safety and environmental protection. Section (3) examines the regulation of CO_2 storage. It will address the frameworks governing both the temporary in-port storage of CO_2 and its

[10] High investment costs are a main driver behind the cancellation of the previous funding competitions in 2011 and 2016.

[11] Given that all shipping infrastructure is likely to be dedicated to a single CCS project for several years or decades, joint ventures are likely to be common practice and are already being considered by shipping and infrastructure companies.

[12] Private law governs relationships between individuals in a given legal system. Most common examples of private law are contract law and labour law.

[13] Public law governs the relationship between individuals (including companies) and the State/Government.

permanent storage in reservoirs under the seabed. It will also consider the regime applicable to pipeline transport within ports infrastructures where relevant.

2. The regulatory and liability regimes governing liquified CO2 shipping

2.1. The regulatory regime governing occupational health and safety and environmental protection from liquified CO_2 shipping

The following sections will provide an overview of the framework governing the occupational health and safety and environmental protection aspects of the regulation of CO_2 shipping in the UK. They will highlight the key national Regulations and international conventions making up the framework, the regulating bodies entrusted with achieving the standards they set, and the main duties incumbent upon shipping stakeholders within them (summarised in Table 1 below). The regulatory approach governing the relationship between regulating bodies and shipping stakeholders bears significant consequences on the manner in which duties are successfully performed. In this regard, a distinction is made between "performance-based" and "prescriptive-based" types of regulation. The former type is characterised by the regulator specifying a certain performance goal while leaving it up to the regulated entity to decide how it purports to achieve it; whilst the latter aims at minimizing the risks of operations through the adoption of laws and guidelines prescribing specific (and often detailed and technical) requirements which regulated entities s must abide by [35].

Legal instrument	Overview and main provisions	Regulator	Regulatory approach
The Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 (S.I. No. 1997/2692)	• Transposed the European Directive 89/391/EEC (the Framework Directive) into national law. • Provide the general duties for "employer" *vis-à-vis* seafarers and other "workers" on board ships to ensure their health, safety and welfare at work. • The main principle contained in these Regulations is that all safety measures should be based on an assessment of the risks involved in a particular task, and the H&S of workers is ensured so far as is reasonably practicable through the identification of the most effective measures to limit that risk. • The Regulations also impose a duty upon seafarers to take reasonable care for the occupational H&S of themselves and others, and to cooperate with their employer in matters of health, safety and welfare.	MCA	Performance-based
The Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Chemical Agents) Regulations 2010 (SI 2010/330)	• Transposed Directive 98/24/EC on the protection of the health and safety of workers from risks related to chemical agents at work into national law. • Require employers to control the exposure of workers to substances that are hazardous to health in the air at the workplace, in line with the short-term and long-term workplace exposure limits set in HSE's latest Guidance Note EH40. • Require employers to determine whether any hazardous chemical agents are present at the workplace and to assess any risk to the H&S of workers arising from their presence. • Require employers to establish procedures and action plans to deal with accidents, incidents and emergencies	MCA	Hybrid Prescriptive with regards to compliance with workplace exposure limits Performance-based with regards to other aspects such as adopting procedures and action plans to respond to emergencies

	in the workplace in relation to the hazardous chemical agents.		
Merchant Shipping (Maritime Labour Convention) (Survey and Certification) Regulations 2013	• Met the requirement under the MLC for the UK to ensure that ships flying its flag carry and maintain a "maritime labour certificate" and a "declaration of maritime labour compliance". • Grant the MCA the authority to issue and renew certificates and declarations, and to carry out surveys and inspections on board vessels flying the UK flag wherever they may be. • Allows the MCA to have oversight over a system for the classification and certification of vessels in the UK, supported by recognised classification societies.	MCA	Performance-based
Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997	• Transposed Chapter VII Part A of SOLAS into national law. • They impose a general duty on every operator and/or every employer of persons aboard a ship and/or every master of a ship to ensure that, so far as is reasonably practicable, when dangerous goods are being handled, stowed or carried on the ship nothing in the manner in which those goods are handled, stowed or carried as the case may be is such as might create a significant risk to the health and safety of any person • Without prejudice to the above, they also require operators to provide information, instruction, training and supervision to all employees in connection with the handling, stowage and carriage of dangerous goods in the ship	MCA (working closely with the HSE to ensure that H&S standards are complied with in harbours)	Performance-based
Merchant Shipping (Gas Carriers) Regulations 1994	• Transposed Chapter VII Part C of SOLAS into national law • Impose a requirement that ships governed by the Regulations (which include ships flying the UK flag or other flags while they are within the UK or its territorial waters) are constructed, equipped and operated in accordance with the respective requirements of the IGC Code, and that the ships and their equipment are regularly maintained so as to continue to conform to the provisions of the Code. • Detail the surveys which MCA surveyors shall carry out to ensure that structure, equipment, fittings, arrangements and materials requirements are complied with for gas carriers covered by the Regulations, and provide the basis for the issuing of "International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk" for compliant ships.	MCA	Performance-based
Merchant Shipping (International Safety Management (ISM) Code) Regulations 2014	• Transposed Chapter IX Part A of SOLAS into national law. • Makes mandatory the ISM Code which imposes a requirement on shipowners/operators to assess all identified risks to their ships, personnel and the	MCA	Performance-based

	environment, both at sea and ashore, and establish appropriate safeguards to address them. • Expanded the scope of application of Chapter IX Part A of SOLAS to UK ships wherever they may be and to other ships while they are in UK waters.		
Merchant Shipping (Prevention of Pollution from Noxious Liquid Substances in Bulk) Regulations 2018	• Transposed Annex II of MARPOL 73/78 into national law • Liquified CO_2 does not fall under the definition of "harmful substances" laid out in the Regulations, but IMO guidance documents suggest that stakeholders involved in the carriage of CO_2 by sea must comply with the general obligation of prevention of harm to the marine environment laid out in article 1(1) of MARPOL. • Suggest that if the UK wants to engage in the international transport of liquified CO_2 by sea, an agreement on a provisional assessment for the proposed operation must be established with the Governments of the other concerned Parties to the MARPOL Convention, on the basis of the guidelines included in appendix I to Annex II of MARPOL.	MCA	Performance-based
London Convention 1972 and its 1996 Protocol	• Protect the marine environment from human activities by mandating the effective control of all sources of marine pollution and prevention of pollution of the sea by the dumping of wastes and other matter. • The 1996 Protocol superseded the London Convention and introduced a more stringent approach to the regulation of dumping of wastes at sea by prohibiting all dumping of any wastes or other matter except for those listed on a 'reverse list' in Annex 1 which require a permit that must be issued in accordance with Annex 2. • Annex 1 was amended in 2007 to include "carbon dioxide streams from carbon dioxide capture processes for sequestration". • However, wastes or other matter can only be dumped being "*mindful of the Objectives and General Obligations of this Protocol set out in articles 2 and 3*". Accordingly, the consideration of whether CO_2 can be dumped at sea during shipping operations should be in line with the general obligation imposed on contracting States to "take effective measures both individually and collectively to protect and preserve the marine environment from all sources of pollution, and to harmonise their policies in this regard"	MCA	Prescriptive

Table 1. Occupational health and safety regulation in the UK – main legislations and requirements, enforcing bodies, and regulatory approach.

.1.1 The UK's regime for occupational Health and Safety for seafarers

Commenting on the health and safety (H&S) aspects of CCS, the Health and Safety Executive (HSE) admitted that the process is "emerging" and thus "not *specifically* addressed by GB health and safety legislation" (emphasis added) [36]. However, it added that existing legislation can be applied to the various elements of the CCS value chain to effectively regulate it for this purpose, pointing specifically to the Health and Safety at Work etc. Act 1974 (HSWA) [37] which applies to processes both onshore

and, since April 2013, offshore. The main objective of the latter Act is to impose a duty on employers to ensure the H&S of workers and members of the public, "so far as is reasonably practicable" [38]. This duty places the main responsibility for occupational H&S on the employer who would need to satisfy the regulator of adequate risk assessment and risk aversion (preventative; precautionary) measures adopted – it is an example of the performance-based approach adopted by the HSE in the UK with regards to the regulation of certain risks. The HSE also highlighted that existing UK legislation around the management of major accident hazards[14] does not neatly apply to CCS, despite the HSE's conclusion that "the technical evidence suggests that CO2 has a major accident potential in line with other hazardous substances currently regulated through permissioning regimes" [39]. In fact, section 3(2)(f) of the Control of Major Accident Hazards Regulations 2015 (COMAH) specifically excludes the "the storage of gas at underground offshore sites" from the scope of the Regulations, and CO_2 is not currently classed as a "dangerous fluid" under the Pipeline Safety Regulations 1996 (PSR).[15] To cope with these gaps, the HSE's view is that "the general duties under the existing legislation means that CCS operators will be required to take a *proportionate approach* to managing *all CCS risks*" (emphasis added) [36].

The UK Maritime and Coastguard Agency (MCA) is responsible for implementing UK and international law and safety policies to ensure safety at sea and prevent pollution and loss of life. The MCA develops Legislation and Guidance for HMG on maritime matters and provides certification for seafarers. Working closely with the HSE on H&S aspects, a strategic aim of the MCA is to ensure comparable levels of H&S for seafarers on merchant ships and fishing vessels as applies to workers ashore [41]. It collaborates with the HSE to develop compatible legislation and guidance notes on the subject and ensure consistency in their enforcement. The developments below unpack the main instruments of the UK's regime for occupational H&S for seafarers, with a focus on the requirements they entail for shipping stakeholders involved in the transport of CO_2 within the context of this study (*i.e.* from port to port, within the UK).

The UK's regime for occupational H&S for seafarers is largely inspired by two international conventions regulating international shipping, namely, the Maritime Labour Convention (MLC), and International Convention for the Safety of Life at Sea (SOLAS). It is also influenced by European Directives which were transposed into UK law pre-Brexit. Whilst the MLC and EU-inspired UK Regulations directly address the H&S of seafarers, SOLAS is more concerned with the safety of the ship itself, which is intrinsically linked to the H&S of those on board. Other existing Regulations in the UK will not be considered due to their irrelevance to the shipping context being considered in this report. For example, UK REACH, a Regulation which applies to most chemical substances that are manufactured in or imported to the UK and aims to achieve a "high level of protection" of human health and the environment from the use of chemicals specifically excludes the transport of substances as well as some substances from its remit, including wastes [42].

.1.1.1 The Maritime Labour Convention (MLC)

The UK's regulatory regime for occupational H&S for seafarers is the outcome of the transposition of European legislation into UK national law and subsequent amendments following the entry into force of the MLC [43].

The Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1997 (S.I. No. 1997/2692) (the 1997 Regulations) [44] transposed the European Directive 89/391/EEC (the

[14] Most notably, the Control of Major Accident Hazards Regulations 2015; the Control of Major Accident Hazards (Amendment) Regulations 2015; the Control of Major Accident Hazards Regulations 2015 (Guidance).
[15] The HSE called for further investigation to determine whether CO_2 should be re-classified [40].

Framework Directive) [45] in the UK. It provides the general duties for "employer" *vis-à-vis* seafarers and other workers on board ships to ensure their health, safety and welfare at work. Regulation 2 defines "employer" as the "person by whom a worker is employed under a contract of employment"; and "worker" is defined as "any person employed by an employer under a contract of employment, including trainees or apprentices". The main principle contained in these Regulations is that all safety measures should be based on an assessment of the risks involved in a particular task, and the H&S of workers is ensured "so far as is reasonably practicable" through the identification of the most effective measures to limit that risk (regulation 5). In particular, Regulation 5(2)(b) imposes a duty on the employer to make the necessary arrangements to ensure, "so far as reasonably practicable, safety and the absence of risk to health in connection with the use, handling, stowage and transport of articles and substances". The Regulations also impose a duty upon seafarers to take reasonable care for the occupational H&S of themselves and others, and to cooperate with their employer in matters of health, safety and welfare (regulation 21). In particular, regulation 21(2) imposes a negative duty on seafarers not to use any machinery, equipment, dangerous substance, transport equipment, or undertake other activities "other than in accordance with any relevant training or instructions which have been received or provided by the employer".

The European Framework Directive is also complemented by several "daughter directives" which address specific risks at work, including the exposure to hazardous substances or physical agents. These aim to detail how risks should be assessed and establish limit values for occupational exposure where relevant. A European Community Shipowners' Associations (ECSA) report noted that 11 out of the 19 individual directives listed under article 16 paragraph 1 of the Framework Directive are applicable to the shipping industry [46]. These include Directive 98/24/EC on the protection of the health and safety of workers from risks related to chemical agents at work [47], implemented in part via Commission Directive 2000/39/EC of 8 June 2000 establishing a list of indicative occupational exposure limit values related to hazardous chemical agents at work [48]. Directive 98/24/EC is transposed in the UK via The Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Chemical Agents) Regulations 2010 (SI 2010/330)[16] (Chemical Agents Regulations) [49]. The MCA supplements these Regulations by publishing Merchant Shipping Notices/Marine Guidance Notes (MSN/MGN) to provide interested parties with guidance for complying with them [50].[17] MSN 1888 (M+F) Amendment 2 (December 2020) highlighted that the HSE and the HSE Northern Ireland have implemented "similar protection from [the risks related to exposure to hazardous chemical agents at work] through the Control of Substances Hazardous to Health Regulations 2002 (as amended) ['COSHH'] and the Control of Substances Hazardous to Health Regulations (Northern Ireland) 2003 (as amended) respectively" [50]. This is important as CO_2 is classed as a 'substance hazardous to health' under the COSHH [51]. The MCA's Code of Safe Working Practices for Merchant Seafarers [52], endorsed by the National Maritime Occupational Health and Safety Committee (UK Chamber of Shipping, Nautilus International and Maritime and Transport Workers), provides best practice guidance for improving health and safety on board ships in the UK. It includes sections dealing specifically with hazardous substances and mixtures and provides guidance on measures which can be adopted to eliminate or control the exposure thereto (at paragraph 21.3). For example, it recommends that testing for oxygen deficiency is conducted prior to permitting entry to enclosed spaces, and that entry should not be authorised if the atmosphere measures over 50% of the

[16] As amended by S.I. 2012/1844, S.I. 2015/21 and the Merchant Shipping and Fishing Vessels (Health and Safety at Work) (Miscellaneous Amendments) (EU Exit) Regulations 2018.
[17] Including general guidance in identifying any risks to those working on board vessels as a result of exposure to chemical agents, which could have an adverse effect on their health and safety.

workplace exposure limit provided for in the most recent HSE Guidance Note EH40 (mentioned below).

Regulation 2 of the Chemical Agents Regulations distinguished between "chemical agents" and "hazardous chemical agents" (Directive 98/24/EC, article 2(b)): "chemical agents" refer to "any chemical element or compound, on its own or admixed, as it occurs in the natural state or as produced, used or released, including release as waste, by any work activity, whether or not produced intentionally and whether or not placed on the market"; whereas "hazardous chemical agents" are defined by reference to other European Directives and means those which may present harmful effects on human health (as opposed to being dangerous for the environment) [49]. "Health and safety" includes the occupational H&S of persons whilst on board a ship and whilst boarding or leaving the ship (Chemical Agents Regulations, regulation 2). The Regulations apply to UK ships, including "Government ships".[18]

Employers also have a duty to control the exposure of workers to substances that are hazardous to health in the air at the workplace. With regards to some hazardous chemical agents, the European Commission sets binding occupational exposure limit values which must be transposed into the Regulations of Member States (Directive 98/24/EC, article 3).[19] Articles 2 and 3 of Commission Directive 2000/39/EC achieved this by requiring EU Member States to establish national occupational exposure limit values for the chemical agents listed in its Annex by 31 December 2001.[20] The Annex did not include CO_2. In the UK, this process falls under the HSE's remit, which is delivered through the publication of EH40 documents, for use with the COSHH [51]. The latest published EH40 document, EH40/2005, includes CO_2 in Table 2 which lists the workplace exposure limits approved by the HSE [53]. It set short-term and long-term workplace exposure limits which employers should control to 15,000 parts per million and 5,000 parts per million respectively. However, the Chemical Agents Regulations still require employers to determine whether any hazardous chemical agents are present at the workplace and to assess any risk to the H&S of workers arising from their presence in line with the general duties under the 1997 Regulations (regulation 6; and Directive 98/24/EC, article 4.1). Based on such assessment, employers are required to adopt specific protection and prevention measures to ensure that risks to the H&S of workers at work are "eliminated or reduced to a minimum"[21] (pursuant to regulation 8 of the Chemical Agents Regulations and article 6 of Directive 98/24/EC). In doing so, they are assisted by the "general principles of prevention" outlined in regulation 5 of the 1997 Regulations (article 6.2. of the Framework Directive) and by a list of required measures under regulation 7 of the Chemical Agents Regulations (article 5.2 of Directive 98/24/EC). These include the adoption of "suitable working procedures including arrangements for the safe handling, storage and transport within the workplace of hazardous chemical agents and waste containing such chemical agents". Regulation 9 of the Chemical Agents Regulations also requires employers to establish procedures and action plans to deal with accidents, incidents and emergencies in the workplace in relation to the hazardous chemical agents identified in the risk assessment. Regulation 27 of the 1997 Regulations reserves MCA surveyors the right to inspect any UK ship and to then detain it should they be satisfied that there has been a failure to comply in relation to that ship

[18] Defined under section 308(4) of the Merchant Shipping Act 1995 as "ships not forming part of Her Majesty's Navy which belong to Her Majesty, or are held by any person on behalf of or for the benefit of the Crown".
[19] This is done based on an independent scientific assessment of the relationship between the H&S of hazardous chemical agents and the level of occupational exposure, pursuant to article 3.
[20] Article 3.10 provides that the measurement/evaluation of workplace air concentrations in relation to occupational exposure limit values shall be performed based on non-binding practical guidelines drawn by the Commission.
[21] Echoing the "as low as reasonably practicable" requirement laid out in the 1997 Regulations.

with the requirements of the Regulations.[22] According to the regulation, the ship may be detained until the H&S of all workers and other persons aboard ship is secured, but added that inspectors should not detain or delay the ship "unreasonably" in the exercise of these powers. Should a dispute arise out of the shipowner's duty to ensure the H&S of workers so far as is reasonably practicable, regulation 26 of the 1997 Regulations provides that it shall be for them to prove that "it was not reasonably practicable to do more than was in fact done to satisfy the duty."

In 2006, the MLC was adopted under the auspices of the International Labour Organization (ILO). It is widely regarded as the "seafarers' bill of rights", and comprehensively sets out seafarers' rights to decent working conditions. It addresses various aspects of work on board a ship, and requires signatory States to adopt laws, regulations and guidelines to ensure, *inter alia*, that "seafarers' work environment on board ships promotes occupational safety and health and safety protection and accident prevention" (MLC, regulation 4.3). To ensure that all signatories implement the standards set by the Convention, the MLC requires each member State to establish "an effective system for the inspection and certification of maritime labour conditions" (MLC, regulation 5.1). It also requires flag States to ensure that ships flying their flags carry and maintain a "maritime labour certificate" certifying that "the working and living conditions of seafarers on the ship, including measures for ongoing compliance […], have been inspected and meet the requirements of national laws or regulations or other measures implementing this Convention" (MLC, regulation 5.1.3), and a "declaration of maritime labour compliance" which specifies the relevant national legislation/regulations implementing the MLC and sets out the measures adopted by the shipowner to ensure compliance with their requirements on the ship in question (MLC, regulation 5.1.4). These requirements are satisfied in the UK via the adoption of the Merchant Shipping (Maritime Labour Convention) (Survey and Certification) Regulations 2013 [54] (Survey and Certification Regulations), which grant the MCA the authority to issue and renew certificates and declarations, and to carry out surveys and inspections on board vessels flying the UK flag to ensure compliance therewith, wherever they may be (Survey and Certification Regulations, regulations 4, 5, 6, 11 and 16).[23] The MCA also has oversight over a system for the classification and certification of vessels in the UK [55]. Accordingly, all seagoing vessels registered in the UK, including merchant ships, are assigned to a specific class by "Recognised Classification Societies" (*e.g.* Lloyds' Register) which determine the certification they must hold and details the inspection and survey regime required to comply therewith.[24] Such classification is done based on the type of cargo that they carry (*e.g.*, general cargo, oil, chemicals, gas), their gross tonnage (gt) and the nature of voyages they undertake. Table 2 provides a list of certification requirements that apply to chemical tankers or gas carriers in the UK [55]:

Certificate name	Chemical tanker/gas carrier specifications
Cargo ship safety radio certificate	>300gt + international voyages only
Cargo ship safety equipment certificate	>500gt + international voyages only
Cargo ship safety construction certificate	>500gt + international voyages only
Cargo ship safety certificate	>300gt
Load line certificate	>24m (if built on or after 21 July 1968) or >150gt

[22] Regulation 24 makes the non-compliance with the general principles of prevention laid out in regulation 5 a criminal offence by providing that "[a]ny contravention of regulation 5 of these Regulations shall be an offence punishable on summary conviction by a fine not exceeding the statutory maximum or, on conviction on indictment, by imprisonment for a term not exceeding two years or a fine, or both".
[23] The MCA issues guidance to support shipowners with implementing the requirements of these Regulations.
[24] The certificates that should be carried for vessels registered in the UK vary based on their type, gross tonnage, type of cargo and whether they are on a domestic or international voyage.

Oil pollution prevention certificate	>400gt
Minimum safe manning document certificate	>500gt
Safety management certificate	>500gt
Ship security certificate	International voyages only
Sewage pollution certificate	>400gt or carrying >15 persons on international voyages only
Air pollution certificate	>400gt
Anti-fouling certificate	>400gt
Certificate of fitness (chemical or gas) certificate	All

Table 2. UK certification requirements for marine chemical tankers and gas carriers.

Following the ratification of the MLC by the UK Government on 7 August 2013, the MCA launched a consultation inviting views to review existing merchant shipping legislation in line with the MLC. This included a consultation on amending the 1997 Regulations to give full effect to regulation 4.3 and Standard A4.3 of the MLC, related to H&S protection and accident prevention. In particular, this concerned amending definitions under the 1997 Regulations, which affects the scope of H&S provisions on board ships in the UK. As highlighted above, the 1997 Regulations defined "worker" as "any person employed by an employer under a contract of employment, including trainees or apprentices". This definition is too narrow and as such was not compatible with the MLC's requirement to protect all "seafarers", which include "any person who is employed or engaged or works in any capacity on board a ship to which this Convention applies" (MLC, article II(f)). The Merchant Shipping (Maritime Labour Convention) (Health and Safety) (Amendment) Regulations 2014 (2014 MLC Amendment Regulations) [56] addressed this by defining "seafarer" as "any person, including a master, who is employed or engaged or works in any capacity on board a ship which is not a fishing vessel and whose normal place of work is on such a ship" (regulations 2(f)). The MCA's MGN 471(M) explained the differences between the definitions under the MLC and the 2014 MLC Amendment Regulations, highlighting that the words "including a master" were added to avoid doubts around masters not being covered by the Regulations in their capacity as the shipowners' representative on board the ship [57]. The words "whose normal place of work is on a ship" were added to ensure that individuals such as surveyors, pilots and visiting technical consultants are not included in the definition. Moreover, the MLC defines "ship" as "a ship other than one which navigates exclusively in inland waters or waters within, or closely adjacent to, sheltered waters or areas where port regulations apply" (MLC, article II.1.(i)). This entails that the occupational H&S protection and accident prevention standards provided for in the MLC, and the survey and inspection requirements it stipulates do not apply to ships navigating exclusively within those areas. However, given that "many earlier regulations on seafarer living and working conditions applied to all sea-going ships in the UK" (including the Chemical Agents Regulations),[25] the MCA's guidance explained that the UK "is not disapplying most of the MLC standards to ships operating in 'waters within, or closely adjacent to, sheltered waters or areas where port regulations apply'" [57]. Nevertheless, it added that "the survey

[25] These apply to UK Ships, defined as a ship which (a) is a United Kingdom ship within the meaning of section 85(2) of the [Merchant Shipping] Act [1995]; (b) is a Government ship; or (c) is a hovercraft registered under the Hovercraft Act 1968. Section 85(2) of the Merchant Shipping Act 1995 defines UK ships as those which are (a) registered in the UK; and (b) not registered under the law of any country but is wholly owned by persons each of whom is (i) "a British citizen, a British Dependent Territories citizen or a British Overseas citizen" or (ii) "a body corporate which is established under the law of a part of the United Kingdom and has its principal place of business in the United Kingdom."

and inspection provisions on the MLC are not applied to such vessels and certain other standards, where inappropriate are not applied" [57].

.1.1.2 International Convention for the Safety of Life at Sea (SOLAS)

The SOLAS Convention is generally regarded as the most important international treaty concerning the safety of merchant ships [58]. Its main objective is to improve safety at sea by specifying minimum standards for the construction, equipment and operation of ships. It places the responsibility on flag States to ensure the enforcement of these standards through the promulgation of laws and regulations and provides for this purpose for several certificates[26] as proof that this has been done. It also provides the basis for port State control, a procedure through which the competent authorities of Contracting States can inspect ships of other Contracting States should there be "clear grounds for believing that the ship and its equipment do not substantially comply with the requirements of the Convention" (SOLAS, Annex, Chapter I, Part A, regulation 1). There have been five versions of the Convention: the first one was adopted in 1914, instigated by the Titanic disaster, the second in 1929, the third in 1948, the fourth in 1960, and the fifth in 1974. The latest version provides for a tacit acceptance procedure according to which future amendments would enter into force on a specified date unless objections to the amendment are received from an agreed number of Parties before that date. The Convention in force today is generally referred to as "SOLAS, 1974, as amended". It includes provisions setting out general obligations, followed by an Annex divided into 14 Chapters. The Chapters have been transposed into national law through corresponding Regulations. The developments below will detail those which are relevant to the context of CO_2 shipping considered in this report.

The first SOLAS (1914) prohibited "the carriage of goods which by reason of their nature, quantity and mode of stowage" endangered the lives of the passengers or the safety of the ship. However, the qualification of the goods as "dangerous" or not was a matter left to the Member States, which were also requested to advice on the precautions which should be taken in the packing and mode of transport [59]. The Convention never entered into force, but it had established the principle to rely on national authorities to decide on the definition and treatment of dangerous goods, and "resulted in the development of many diversified regulations and practices embedded in national, regional or individual out-of-date port regulations" [59]. This principle was carried over to later versions of SOLAS including SOLAS 1929, until, in an attempt to formulate safety standards for the carriage of dangerous goods by sea, a new Chapter VI was added to the 1948 SOLAS Convention, which dealt specifically with the "Carriage of Grain and Dangerous Goods". However, the 1948 Convention's provisions were deemed inadequate by the Conference which then adopted "Recommendation 22" through which it stressed the importance of international uniformity in setting standards for safety precautions [60]. In addition, the Conference also established that goods should be considered dangerous "on the basis of their properties and characteristics and a labelling system should be developed using distinctive symbols indicating the kind of danger for each class of substances, materials and articles", and called for the development of uniform international Regulations on the subject [59]. However, such efforts were fruitless until after the United Nations Committee of Experts on the Transport of Dangerous Goods established the minimum requirements applicable for the transport of dangerous goods by *all modes* in a 'United Nations Recommendations on the Transport of Dangerous Goods' report in 1956 [61]. As a result, Chapter VII of the revised 1960 SOLAS Convention dealt exclusively with the carriage of dangerous goods. The Convention was subsequently further revised when the 1974 version entered

[26] These include: Passenger Ship Safety Certificate; Cargo Ship Safety Construction Certificate; Cargo Ship Safety Equipment Certificate; Cargo Ship Safety Radiotelegraphy Certificate; Cargo Ship Safety Radiotelephony Certificate. (SOLAS, Annex, Chapter I, Part A, regulation 12).

into force in May 1980. Since then, several amendments to SOLAS 1974 concerning the carriage of dangerous goods have also been adopted [62].

The revised Chapter VII of SOLAS 1974 is comprehensive. It applies to all ships covered by SOLAS and to cargo ships of less than 500 gross tonnage and deals with dangerous goods both in bulk and in package forms (SOLAS, Annex, Chapter VII, regulation 2.1). Of relevance to this report, Part A includes provisions for the classification, packing, marking, labelling and placarding, documentation and stowage of dangerous goods in packaged form. Part C, concerned with the construction and equipment of ships carrying liquefied gases in bulk and gas carriers constructed after 1 July 1986, imposes a requirement to comply with the International Gas Carrier Code (IGC Code).

.1.1.2.1 Chapter VII Part A of SOLAS

The general rule under this Chapter is for the prohibition of the carriage of dangerous goods in packaged form unless carried out in accordance with the provisions contained therein (regulation 2.3). It ties the definition of "dangerous goods" to the substances, materials and articles covered by the International Maritime Dangerous Goods (IMDG) Code (regulation 1.2.) and requires that the carriage of such goods in package form shall be done in compliance with the relevant provisions of the Code (regulation 3). The latter was adopted as a substantive resolution of the IMO as a recommendation to members for adoption or use as the basis for national Regulations in pursuance of their obligations under SOLAS 1974 [63]. Although initially non-mandatory, the Maritime Safety Committee (MSC) at its seventy-fifth session agreed to make it mandatory as of 2004 and incorporated it into both SOLAS and the International Convention for the Prevention of Pollution from Ships (MARPOL – discussed below), in recognition of the need to provide a mandatory application of common international standards and facilitate the multimodal transport of dangerous goods. Since its adoption in 1965, it has undergone several changes to respond to developments in reasonable time including through the identification of goods which are considered dangerous for transport. It sets out in detail the requirements applicable to each individual substance/material/article, covering matters such as packing, container traffic and stowage, with particular reference to the segregation of incompatible substances. It does so by allocating them to one of nine "classes", based on the main danger they present:

- Class 1 – Explosives
- Class 2 – Gases
- Class 3 – Flammable Liquids
- Class 4 – Flammable solids and other flammable substances
- Class 5 – Oxidising substances and organic peroxides
- Class 6 – Toxic and infectious substances
- Class 7 – Radioactive material
- Class 8 – Corrosive substances
- Class 9 – Miscellaneous dangerous substances and articles

In its 96th session (11-20 May 2016), the MSC adopted amendment 38-16 to the IMDG Code, to reflect latest changes to the United Nations Recommendations on the Transport of Dangerous Goods [64]. The amendment added liquified CO_2 to Class 2.2 "non-flammable, non-toxic gases" [65], thus subjecting it to the requirements of the IMDG Code. Pure chemicals and dangerous goods transported in sufficient quantities are allocated individual UN Numbers. Refrigerated liquid CO_2 was allocated UN Number 2187 [65]. Moreover, dangerous goods in most classes are subdivided into three packing groups (PG) according to the degree of danger they present in transport (PG I represent the highest

degree of danger and PG III represent lower danger). Liquified refrigerated CO_2 was not included in any of those groups, and no subsidiary risks attached thereto were included in the Code.[27]

The provisions of the IMDG Code are applicable to all ships to which SOLAS 1974 applies[28] and which are carrying dangerous goods as defined in Chapter VII (1.1.1, IMDG Code). Importantly however, although primarily designed for mariners, the provisions of the IMDG Code affect other industries as well, including storage, terminal operators, handling and transport services from manufacturers to consumers. These stakeholders are guided by the Code's provisions on classification, terminology, identification, packing and packaging, marking, labelling and placarding, documentation and marine pollution aspects [66].

Chapter VII Part A is transposed into national law via the Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997 ('Dangerous Goods and Marine Pollutants Regulations') [67]. They apply to UK ships wherever they may be carrying dangerous goods in bulk or packaged form or marine pollutants in packaged form, and to other ships while they are within the UK waters (Dangerous Goods and Marine Pollutants Regulations, regulation 5). They impose a general duty on every "operator, every employer of persons aboard a ship and every master of a ship"[29] to ensure that, so far as is reasonably practicable, "when dangerous goods are being handled, stowed or carried on the ship nothing in the manner in which those goods are handled, stowed or carried as the case may be is such as might create a significant risk to the health and safety of any person" (Dangerous Goods and Marine Pollutants Regulations, regulation 6). Without prejudice to this general duty, the Regulations specifically require operators to provide "information, instruction, training and supervision to all employees in connection with the handling, stowage and carriage of dangerous goods in the ship" (Dangerous Goods and Marine Pollutants Regulations, regulation 6(2)(b)). Non-compliance with this duty is an offence punishable on summary conviction in accordance with regulation 6(3), but the handling of dangerous goods in accordance with "the appropriate provisions of the IMO Recommendations" is a defence to such charge (Dangerous Goods and Marine Pollutants Regulations, regulation 6(4)). Regulation 9 puts the burden of proving that it was not reasonably practicable to do more than was in fact done to satisfy the duty or requirement on the shoulders of the accused operator/employer. Specific requirements applicable to the carriage of packaged goods are contained in Part II of the Regulations, whilst Part III contains provisions for the Carriage of Dangerous Goods or Marine Pollutants in Bulk. Both of these parts make reference to the IMO Codes discussed above (*e.g.* IMDG; IBC).

The MCA is the competent authority with regulatory oversight over the carriage of dangerous goods and marine pollutants in the UK. It regularly publishes MSNs to provide guidance to relevant stakeholders (*i.e.* owners, ship operators and managers, masters and officers of merchant ships, agents, charterers, cargo pickers, cargo consolidators, hauliers, freight forwarders, shippers, consignors, training providers, inspectors of cargoes, port authorities and terminal operators and others involved in the transport of dangerous goods and bulk chemicals by sea) around amendments to applicable international standards. The latest of such MSN, MSN 1906(M), was published on 18 October 2021 [68]. Given that the Dangerous Goods and Marine Pollutants Regulations apply to UK

[27] Many dangerous goods present the hazards of more than one Class or Division. Such goods are assigned to a Class according to their primary hazard. The other hazard or hazards are referred to as "Subsidiary Risks".
[28] SOLAS applies to "ships entitled to fly the flag of States the Governments of which are Contracting Governments" (SOLAS, article 2).
[29] Defined in relation to a ship as the "owner, charterer, manager and agent of the ship" (Dangerous Goods and Marine Pollutants Regulations, regulation 2); the master of a ship is assumed to be an agent of the shipowner and/or charterer of the ship.

ships wherever they may be, the MCA works closely with the HSE to ensure that H&S standards are complied with in harbours [69].

.1.1.2.2 Chapter VII Part C of SOLAS

As indicated by its title, Chapter VII Part C of SOLAS regulates the construction and equipment of ships carrying liquefied gases in bulk.[30] It achieves this through making mandatory the application of the IGC Code[31] as it may be amended by the IMO (regulation 13.1).[32] It applies to "gas carriers", which are defined with reference to the products listed in Chapter 19 of the IGC Code.[33] The Regulations under this Part impose requirements on "gas carriers" constructed on or after 1 July 1986 including those of less than 500 gross tonnage (regulation 12.1), but they could also apply to carriers which have undertaken "repairs, alterations and modifications of *a major character* […] in so far as the Administration deems reasonable and practicable" (emphasis added; regulation 12.2). Other gas carriers, irrespective of their date of construction, which have undergone less significant alterations are expected to continue to comply with "at least the requirements previously applicable to [them]"[34] (regulation 12.2). Moreover, irrespective of the date of construction, vessels which have been converted into gas carriers are deemed to be "gas carrier constructed on the date on which such conversion commenced" (regulation 12.3).

The implication for gas carriers falling within the scope of this Part is that they must comply with the requirements of the IGC Code, and those under regulations 8 (Surveys of life-saving appliances and other equipment of cargo ships), 9 (Surveys of radio installations of cargo ships) and 10 (Surveys of structure, machinery and equipment of cargo ships) of Chapter I Part A of SOLAS. This includes surveying and certification requirements provided for in the IGC Code, which are subject to verification by the competent authorities of other Contracting parties when the ship in question is in their port (the MCA in the UK), in line with regulation 19 of Chapter I of SOLAS (port State control). Certificates issued pursuant to the IGC Code are deemed to meet the requirements under regulations 12 and 13 of Chapter I Part B of SOLAS. Most notably, this includes the Cargo Ship Safety Construction Certificate, the Cargo Ship Safety Equipment Certificate, and the Passenger Ship Safety Certificate under regulation 12.

The latest amendment to the IGC Code was adopted through resolution MSC.370(93) (adopted on 22 May 2014), which replaced the "complete text" of the Code [71].[35] It provided revised international standards for the design and construction of ships carrying liquefied gases in bulk constructed on or

[30] These aspects of the regulation of CO_2 shipping have direct implications on both the H&S of crew on board the vessels, but also on achieving higher levels of environmental protection by reducing minimising risks to the ship and its equipment.

[31] Paragraph 1 of the IGC Code's Preamble sets out its aims by providing that: "[t]he purpose of this Code is to provide an international standard for the safe carriage, by sea in bulk, of liquefied gases and certain other substances that are listed in chapter 19. Through consideration of the products carried, it prescribes the design and construction standards of the ships involved and the equipment they should carry to minimize the risk to the ship, its crew and the environment."

[32] The Code was adopted in 1983 by resolution MSC.5(48) [70]

[33] Regulation 11.2 defines "gas carriers" as: "a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other product listed in chapter 19 of the International Gas Carrier Code".

[34] Regulation 12.2 adds: "Such a ship if constructed before 1 July 1986 shall, as a rule, comply with the requirements for a ship constructed on or after that date to at least the same extent as before undergoing such repairs, alterations, modifications or outfitting".

[35] The current version of the Code has been amended by IMO Resolutions MSC.93/22/Add.1/Corr.3 and MSC.93/22/Add.1/Corr.5.

after 1 July 2016 (section 1.1 of Chapter 1, IGC as amended by MSC.370(93)).[36] Chapter 19 thereof includes CO_2 in "high purity" and in "reclaimed quality",[37] thus bringing vessels engaged in transporting it under the scope of the requirements described above and detailed below. In particular, the IGC Code requires that both types of CO_2 are carried on board type "3G" vessels,[38] and subjects them to specific requirements listed in paragraphs 17.21 and 17.22 respectively. To illustrate, paragraph 17.21 recognises the potential for the cargo to solidify if a cargo tank relief valve fails in the open position and requires that "means of isolating the cargo tank safety valves" are adopted to avoid this risk. It added that "discharge piping from safety relief valves shall be designed so they remain free from obstructions that could cause clogging". Another example of what the IGC Code would entail for CO_2 shipping stakeholders is the requirement to supply "the precise 'triple point' temperature of a particular carbon dioxide cargo […] before loading the cargo".

Chapter VII Part C of SOLAS is transposed into the UK regulatory regime via the Gas Carriers Regulations 1994 (Gas Carriers Regulations), which entered into force on 1 October 1994 [72]. The Regulations apply to "1986-1994 gas carriers and to new gas carriers" flying the UK flag wherever they may be and to ships flying other flags while they are within the UK or its territorial waters (regulation 2(3)). "Gas carrier" is also defined under the Regulations as "a self-propelled cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas listed in Chapter 19 of the IGC Code or any other substance so listed" (Gas Carriers Regulations, regulation 1). The Regulations give effect to the requirements under the IGC Co de in the UK by imposing that ships governed thereby are constructed, equipped and operated in accordance with the respective requirements of the Code (Gas Carriers Regulations, regulation 3). They also detail the surveys which surveyors appointed by the Secretary of State shall carry out to ensure that structure, equipment, fittings, arrangements and materials requirements are complied with for gas carriers covered by the Regulations (Gas Carriers Regulations, regulation 4).[39] Upon the "satisfactory completion" of the "initial"[40] or "periodical survey",[41] ships which have complied with the relevant requirements of the IGC Code shall be issued an "International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk" by the Secretary of State. This Certificate shall be kept on board the vessel and made available for inspections at "all reasonable times" (Gas Carriers Regulations, regulation 5). It is only when such Certificate is issued, covering the substances which the ship will be loading or carrying, that ships to which the Regulations apply would be permitted to load and/or carry these substances (Gas Carriers Regulation, regulation

[36] for ships constructed between 1 July 1986 and 1 July 2016, the requirements of the IGC Code which are applicable as adopted by resolution MSC.5(48) as amended by resolutions MSC.17(58), MSC.30(61), MSC.32(63), MSC.59(67), MSC.103(73), MSC.177(79) and MSC.220(82), are applicable. Moreover, irrespective of the date of its construction, a ship which is converted to a gas carrier on or after 1 July 2016 is deemed to be as a gas carrier constructed on the date on which such conversion commences.

[37] Reclaimed quality CO_2 is understood to be that which has been captured from industrial processes [32].

[38] Type 1G ships are gas carriers intended for the transportation of products of the greatest overall hazard and types 2G/2GP and type 3G are gas carriers intended for the transportation of products of relatively lower hazards.

[39] These include: an "initial survey"; a "periodical survey at intervals not exceeding 5 years"; a minimum of one "intermediate survey"; an "annual survey"; "an additional survey". Details of these surveys and what they entail are provided under regulation 4 of the Gas Carriers Regulations.

[40] This is the first survey issued for gas carriers, which, according to regulation 4 "shall include a complete examination of its structure, equipment, fittings, arrangements and materials in so far as the ship is covered by the IGC Code; such a survey shall be such as to ensure that the structure, equipment, fittings, arrangements and materials fully comply with the applicable provisions of the IGC Code".

[41] This consists of a survey issued "at intervals not exceeding 5 years which shall be such as to ensure that the structure, equipment, fittings, arrangements and materials comply with the applicable provisions of the IGC Code".

9). However, this can also be permitted by an approval by the Secretary of State to that effect, pursuant to regulations 9(1)(b) and 9(2)). In addition, the Regulations impose requirements that gas carriers and their equipment shall be maintained so as to continue to conform to the provisions of the IGC Code, and for the shipowner or master of the ship to notify the Secretary of State whenever an accident occurs to a ship or a defect is discovered which affect the safety of the ship or crew (regulation 6, Gas Carriers Regulations). In the case of non-compliance with the requirements of these Regulations, the ship in question shall be liable to be detained by the MCA, pursuant to section 95 of the Merchant Shipping Act 1995 [73]. The MCA publishes MSNs to specify the implications of amendments to the ICG Code for the relevant stakeholders [74].

.1.1.2.3 Chapter IX Part A of SOLAS

Chapter IX contains provisions on the Management for the Safe Operation of Ships and makes mandatory the International Safety Management (ISM) Code. The latter was adopted by the IMO as Resolution A.741(18) in November 1993 after investigations into shipping accidents highlighted shortcomings in ship management both at sea and ashore. It is intentionally drafted in broad terms and based on general principles to accommodate a wide variety of ships and to allow operators to develop their own safety management approaches whilst achieving its objectives of ensuring safety at sea, preventing human injury, loss of life and the prevention of damage to the marine environment.[42] It does so by requiring shipowners and/or operators (or "ISM Companies")[43] to establish a safety management system (SMS) to ensure compliance with rules and Regulations related to the objectives of the Code, and by requiring flag State authorities to ensure the effective implementation and enforcement thereof [76]. The SMS is meant to be a documented system enabling ISM Company personnel to effectively implement its safety and environmental protection policy which include both shore-side and on-board aspects. Accordingly, the safety management objectives of the ISM company should, *inter alia*, assess all identified risks to its ships, personnel and the environment and establish appropriate safeguards to address them.

Chapter IX of SOLAS makes the ISM Code mandatory for ships engaged in international voyages. However, European legislation which also provides for the mandatory application of the ISM Code, *i.e.* EC Regulation 336/2006 [77], applies to a wider range of ships and companies operating them. This includes "cargo ships and passenger ships operating to or from ports of the Member States, on a regular shipping service, regardless of their flag" which are of more than 500 gt (EC Regulation 336/2006, article 3.1(c) – article 3.2(d)). The Merchant Shipping (International Safety Management (ISM) Code) Regulations 2014 ('ISM Regulations'), which transposes Chapter IX part A into national law, provide for the application of the ISM Code on all vessels to which the SOLAS Convention and EC Regulation 336/2006 apply [78]. Regulation 3 thereof provides that they apply to UK ships "wherever they may be", and to other ships while they are in UK waters.

In the UK, the competent authority is the MCA. It retains direct responsibility for the assessment and audit of UK shipping companies and ships against the ISM Code and publishes statutory guidance to support stakeholders including surveyors with complying with the requirements of the Code [74]. Audits carried out by MCA surveyors are done in compliance with the IMO's ''Guidelines on Implementation of the ISM Code by Administrations'' [79] and guidelines published by the

[42] This is commonly referred to as "Safety Culture" [75].
[43] "ISM Company" means: (a) where a person who is not the owner of the ship has assumed responsibility for the operation of the ship and has agreed with the owner to take over all the duties and responsibilities imposed by the ISM Code, that person; or (b) in all other cases, the owner of the ship.

International Chamber of Shipping in association with the International Shipping Federation [80] and the International Association of Classification Societies [81].

Compliance with the shore-side aspects of SMSs is ensured through the issuing of a Document of Compliance ('DOC') by the MCA which evidences that the ISM Company's shore-side management structure meets the requirements of the ISM Code. Carrying a valid DOC is essential for obtaining a Safety Management ('SMC') Certificate which is only issued after an audit is carried out on board the ship ('SMC audit') [76]. Interim versions of these two documents can also be issued in accordance with paragraph 14.1 and 14.2 of the ISM Code. The DOC is valid for a period of up to five years and is subject to an annual audit to ensure the continuing compliance with the requirements of the ISM Code and amendments to it. Equally, a SMC is valid for five years from the date of completion of the initial audit, and the MCA should carry at least one intermediate verification thereof during that period [76]. Both documents can be withdrawn by the MCA in the case of major non-conformity, until sufficient corrective action has been taken to address it.

The master of the ship plays a pivotal role in the on-board implementation of the safety and environmental protection policy set out by the ISM Company which should set out how the objectives of the ISM Code will be achieved and define the responsibility, authority and interrelation of all personnel who manage, perform and verify work relating to and affecting safety and pollution prevention [76]. The ISM Company should provide the master with clear guidance in this regard and ensure that the SMS clearly emphasizes the master's authority to make decisions with respect to safety and pollution prevention. Moreover, ISM Companies are required to designate a person(s) ashore, having direct access to "the highest level of management", to ensure the safe operation of each ship and to provide a link between the Company and those on board [78].

.1.2 The UK's regime for environmental protection from CO_2 shipping

The UK's regulatory regime for the prevention of marine pollution from shipping derives from two main IMO instruments: the International Convention for the Prevention of Pollution from Ships (MARPOL) [82] and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention) [83]. The 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR; discussed in more detail in section 3.2 below) [84], a regional agreement aimed at protecting the waters of the North-East Atlantic and North Sea, is also relevant. The Convention embraces the precautionary principle (article 2.2(a)) and requires States to take *all possible steps* to prevent and eliminate pollution of the maritime area as well as to take the necessary measures to protect the maritime area against the adverse effect of human activities (article 2.1(a)).

.1.2.1 MARPOL, Annex II – applicable?

The UK's regulatory regime for the prevention of marine pollution from shipping derives from MARPOL which was adopted on 2 November 1973. The Convention was updated in 1978 through the adoption of a Protocol by the International Conference on Tanker Safety and Pollution Prevention in response to a series of tanker accidents in the late 1970s, and in 1997 through the adoption of another Protocol which added a new Annex thereto [85]. The Convention, as modified by the Protocols is known as the "MARPOL 73/78". It aims to achieve "the complete elimination of intentional pollution of the marine environment by oil and other harmful substances and the minimization of accidental discharge of such substances" (Preamble, MARPOL 73/78). To achieve this, it imposes a general obligation upon Contracting States to give effect to its provisions and requires the participation of various stakeholders around their implementation, including regulators, shipowners, and port-authorities. In addition to its

substantive text, the Convention contains two Protocols[44] and, since the 1997 Protocol, six Annexes, each containing technical provisions regulating specific categories of vessel-source pollution:

- Annex I – Prevention of pollution by oil
- Annex II – Prevention of pollution by noxious liquid substances in bulk
- Annex III – Prevention of pollution by harmful substances carried by sea in packaged form
- Annex IV – Prevention of pollution by sewage from ships
- Annex V – Prevention of pollution by garbage from ships
- Annex VI – Prevention of air pollution

Whilst Annexes III-VI are optional, Annexes I and II are mandatory for all Parties to MARPOL 73/78. The following paragraphs will examine the applicability of Annex II to the carriage of CO_2 by sea, highlighting the key requirements which it would entail for shipping stakeholders and enforcing authorities.

Without getting into the technical details of the requirements imposed by Annex II, it is worth noting that the general rule under it is for the prohibition of the discharge into the sea of any effluent containing substances deemed to present a harm to the marine environment (and potentially to health, as explained below) unless such discharge is made in compliance with the detailed conditions specified in the Annex. It contains specific requirements with regards to the design, construction, equipment and operation of ships certified to carry noxious liquid substances in bulk identified in Chapter 17 of the IBC Code (Annex II MARPOL 73/78, regulation 11,), which in contrast with the requirements of the IGC Code (see developments under "2.1.1.2 Chapter VII Part A of SOLAS" above), are imposed with the aim to "minimize the accidental discharge into the sea of such substances"[45] (as opposed to ensuring H&S in shipping operations). It also imposes requirements around discharge operations of certain cargo residues and imposes that certain cleaning and ventilation operations are only conducted in compliance with approved procedures and arrangements based upon IMO standards [86].

Article 2(2) of MARPOL 73/78 broadly defines "harmful substances" as "any substance which, if introduced into the sea, is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea, and includes any substance subject to control by the present Convention". The IMO's guidance on the Convention added that this broad definition also includes "those identified in each Annex or provisionally identified through a relevant IMO circular" [86]. It added that the definition also encompasses "other substances that meet the definition of a harmful substance" and that "means exist within the regulations for dealing with new substances, or with other substances for which the method of carriage by sea has changed" (detailed below). "Discharge" in relation to harmful substances is defined under article 2(3)(a) of MARPOL 73/78 as "any release howsoever caused from a ship and includes any escape, disposal, spilling, leaking, pumping, emitting or emptying". It entails therefore, that even if CO_2 is not identified as a noxious substance in Annex II – which is in fact the case - it may still fall under the broader definition set out in the article 2(2) of MARPOL 73/78. In such instance, the specific requirements under Annex II would not apply, but the general obligation of prevention of harm to the

[44] Protocol I on "Provisions concerning reports on incidents involving harmful substances", and Protocol II on "Arbitration".

[45] Regulation 11.1. of Annex II provides: "The design, construction, equipment and operation of ships certified to carry noxious liquid substances in bulk identified in chapter 17 of the International Bulk Chemical Code, shall be in compliance with the following provisions *to minimize the uncontrolled discharge into the sea of such substances*" (emphasis added).

marine environment under article 1(1) of MARPOL 73/78 would be incumbent upon Contracting States.[46]

Annex II of MARPOL 73/78, transposed into national law via the Merchant Shipping (Prevention of Pollution from Noxious Liquid Substances in Bulk) Regulations 2018 [87], applies to all noxious liquid substances except oil (which is regulated under Annex I). In other words, the discharge of such substances from shipping activities is in principle prohibited unless it is performed in compliance with the Annex II requirements. The latter defines "noxious liquid substances" under regulation 1(10) as "any substance indicated in the Pollution Category column of chapter 17 or 18 of the International Bulk Chemical Code or provisionally assessed under the provisions of regulation 6.3 as falling into category X, Y or Z". Accordingly, Category X substances are considered to present a major hazard if discharged into the marine environment, Category Y substance as presenting a hazard, and Category Z substances as presenting a minor hazard. In addition, a fourth category ("Other Substances") includes those liquid substances which are considered at present to present no hazard to the marine environment (Annex II MARPOL 73/78, regulation 6). It is based on this categorisation that specific requirements of the Annex are determined [86]. These substances might present a safety hazard in addition to their pollution hazard. Therefore, when listed in Chapter 17 of the IBC Code, the substances are listed as presenting a pollution hazard (P), or a safety *and* pollution hazard (S/P) [86].

Given that liquified CO_2 is not included in Chapter 17 or 18 of the IBC Code,[47] an evaluation of whether CO_2 could fall under the broader definition of "harmful substances" under article 2(2) of MARPOL 73/78 is appropriate. This requires an assessment of potential hazards to human health and to the marine environment deriving from the carriage of liquified CO_2 on board ships. With regards to risks to personnel and to equipment on board vessels, a report by Equinor on the Norwegian Northern Light Project noted that CO_2 is generally not classified as a toxic/harmful substance, despite having neurological impact on humans [90]. It provided that, "[l]ike nitrogen, CO_2 will displace oxygen. But unlike nitrogen, people would be at severe threat from increasing CO_2 concentrations well before they would be in danger because of reduced oxygen concentration". Due to the risk posed by the process of formation of dry ice in the event of a release of liquified CO_2, the report highlighted that frost injuries and cold burns could be caused to personnel on board and that this could also pose a threat against equipment integrity. In line with this view, the UK's HSE's noted that CO_2 is classed as a 'substance hazardous to health' in applicable UK Regulations (*i.e.* the COSHH) [91] (see section 2.1.1 above, under "The Maritime Labour Convention"). With regards to environmental risks, this would include the release of CO_2 into the atmosphere and into the marine environment in solid and liquid form.[48] However, the international air pollution requirements of MARPOL's Annex VI is not invoked in these instances, as it establishes limits on nitrogen oxides (NOx) emissions and regulates the

[46] Paragraph 1 of article 1 (General obligations under the Convention) reads: "The Parties to the Convention undertake to give effect to the provisions of the present Convention and those Annexes thereto by which they are bound, in order to prevent the pollution of the marine environment by the discharge of harmful substances or effluents containing such substances in contravention of the Convention".

[47] The latest amendment of IBC Code is the 2022 amendment (MEPC.345(78)) [88]; and the latest amendment to Chapters 17 and 18 were made in Resolution MEPC.318(74) - (adopted on 17 May 2019; entered into force on 1 January 2021) [89].

[48] During accidental or planned depressurisation of liquid CO2 in the system, the fluid transitions from its initial liquid or two-phase liquid-vapour envelope to a *solid, liquid and vapour* three-phase stage when depressurising below the triple point (0.51 MPa, 217 K) (emphasis added), see [92]; see also IPCC [93], which provides at p.189: "[Liquid CO2's] interactions with the sea would be complex: hydrates and ice might form, and temperature differences would induce strong currents. Some of the gas would dissolve in the sea, but some would be released to the atmosphere. If there were little wind and a temperature inversion, clouds of CO2 gas might lead to asphyxiation and might stop the ship's engines".

deliberate and accidental emissions of "ozone-depleting substances" which are defined in accordance with the Annexes to the Montreal Protocol on Substances that Deplete the Ozone Layer which do not include CO_2 (MARPOL 73/38, Annex VI, regulation 12(2)). On the other hand, the release of CO_2 into the marine environment[49] would lead to pH reduction and ocean acidification, with varying consequences on marine organisms [94].

This analysis suggests that CO_2 falls under the broader definition of "harmful substances" under article 2(2) of MARPOL, given that it is a substance which is "liable to create hazards to human health" and to "to harm living resources and marine life" (MARPOL 73/78, article 2(2)). This entails that contracting States are subject to the article 1(1) requirements with regards to CO_2 (see footnote 46). Specifically, they must give effect to the provisions of the Convention (including article 2(2)) in order to *prevent the pollution of the marine environment* by its discharge. This interpretation is consistent with the general obligation imposed under article 2.1(a) of the OSPAR Convention (discussed below) for contracting States to "prevent and eliminate pollution [by taking] the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected".

Moreover, as CO_2 is not categorised in accordance with regulation 6.1 of Annex II, if the UK wants to engage in the international transport of liquified CO_2 by sea, an agreement on a provisional assessment for the proposed operation must be established with the Governments of the other concerned Parties to the MARPOL Convention, on the basis of the guidelines included in appendix I to Annex II of the Convention (the "provisional assessment"[50] procedure under regulation 6.3. Annex II MARPOL 73/78). The latest such assessment has been published in December 2022 [95].

.1.2.2 The London Convention

The London Convention is one of the early global conventions to protect the marine environment from human activities. Its objective is the effective control of all sources of marine pollution and prevention of pollution of the sea by the dumping of wastes and other matter. It requires Contracting Parties to prevent the dumping of waste and other matter into the seas where it is 'liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea' (article I). It places an absolute prohibition upon the dumping of wastes or other matter listed in Annex I and requires a prior special permit to be obtained for dumping those listed in Annex II. All other substances may be dumped, but require a prior general permit issued in accordance with Annex III (article IV).

The definition of "wastes and other matter" under the Convention is very broad and includes "any material and substance of any kind, form or description" (Article III, paragraph 4); whereas "dumping" is defined as "any *deliberate* disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures" (emphasis added; article III, paragraph 1 (a)). Despite the addition of "industrial waste"[51] to the Annex I list of substances that may not be dumped in 1996, it remains uncertain whether this encompasses CO_2. According to the Convention's Scientific Group, CO_2 derived

[49] Whether directly or through release into the atmosphere and subsequent ocean carbon sequestration.
[50] The IMO Guidance defines this assessment as "an agreement among the producing or shipping country, the flag State and the receiving State". It added that "Guidelines for the provisional assessment of liquid substances transported in bulk are given in MEPC.1/Circ.512" and that the carriage of substances which have not yet been provisionally assessed is prohibited under the MARPOL Convention [86].
[51] Defined as "waste materials generated by manufacturing or processing operations" under Annex I, para 11. See the reports from the consultative meetings of the parties: LC 21/13, LC 26/15, LC 27/16, LC 28/15, LC 29/17, LC/SG 29/15, all available at [97].

from fossil fuels (and arguably from other industrial processes) falls within this category, and the disposal thereof into the Ocean would violate the Convention [98]. Although this interpretation was in line with the views of the UK Government, participants at subsequent Consultative Meetings questioned it and no consensus has been reached on this issue amongst the Contracting Parties to the Convention [99]. It is safe to conclude therefore that CO_2 is not included in Annex I or Annex II. This entails that it can be dumped under the Convention, provided that a general permit is obtained pursuant to Annex III which lists the provisions to be considered by Contracting States while establishing the criteria governing the issuing of permits for the dumping of matter at sea.

In 1996, the London Protocol [100] was adopted to further modernise the Convention and, eventually, replace it - it entered into force on 24 March 2006 and there are currently 53 Parties to it, including the UK, Norway, the Netherlands, Denmark, France, Germany and Belgium. It is a standalone treaty, which supersedes the London Convention for the States which are party to it. It maintained the London Convention definitions for "wastes" and "dumping" as well as the exception to the latter. However, it introduced a more stringent approach to the regulation of dumping of wastes at sea by prohibiting all dumping of any wastes or other matter except for those listed on a 'reverse list' in Annex 1 (article 4.1) which require a permit that must be issued in accordance with Annex 2 (article 4.2).

Annex 1 was amended in 2007 based on a proposal by Australia which was co-sponsored by France, Norway, and the UK, which resulted in a new category of matter being added to the Annex – "carbon dioxide streams from carbon dioxide capture processes for sequestration". As detailed in Section 3 below, this amendment was proposed to overcome regulatory barriers for the storage of CO_2 under the seabed as part of CCS. However, for transport purposes, it must be noted that paragraph 1 of Annex 1 provides that the wastes or other matter it lists "may be considered for dumping *being mindful of the Objectives and General Obligations of this Protocol set out in articles 2 and 3*" (emphasis added). Accordingly, the consideration of whether CO_2 can be dumped at sea during shipping operations should be in line with the general obligation imposed on contracting States to "take effective measures both individually and collectively to protect and preserve the marine environment from all sources of pollution, and to harmonise their policies in this regard" (article 2). This obligation applies "even when there is no conclusive evidence to prove a causal relation between inputs and their effects" as the Protocol binds States to the application of the precautionary approach through taking preventative measures to achieve the aims of article 2 (article 3.1). In line with the polluter-pays principle, it places the burden of bearing the cost of such measures on the shoulders of the proponents of authorised shipping activities (article 3.2). The risk of leakage of environmental harm is addressed in article 3.3 which requires States to ensure that such harm or the likelihood thereof is not transferred from one part of the environment to another or transformed into a different type of pollution.

.2 The liability regime governing liquified CO_2 shipping

Clarity around the liability regime governing CO_2 shipping in the UK affords certainty for investment decisions in CCS technologies through contributing to a better understanding of value chain risks faced by the different stakeholders in a CCS project [101]. Interdependencies arise from interfaces between the different stages of a CCS project, which highlight a need for the identification of key liability concerns facing respective CCS stakeholder groups (*i.e.* those involved in capture, transport, and storage activities). This would allow the determination of the points of risk transfer along the CCS value chain and enable the allocation of financial and contractual risks between different operators [101].

Liability concerns for CO_2 shipping stakeholders can arise from a variety of potential scenarios. The following developments will focus on presenting the applicable regime in the case of accidents occurring while the CO_2 is being carried on board a ship and the expected consequences of such events on shipping operators. Liability within this context is addressed in relation to (1) what it would entail for shipping operators with regard to the compensation for the damage which can be caused to third parties (*civil liability*);[52] and (2) the powers which public authorities would have to impose specific action on operators (*e.g.* remediation) or recover the costs thereof in the case of leakage (*public liability*). Before presenting the aforesaid framework (sub-section(b)), this section will start with clarifying important overarching points for liability in the UK legal framework (sub-section (a). The framework applicable to the case in which accidents occur while transporting CO_2 from the loading port's storage facility to the ship, and from ships to storage facilities at the port of discharge will be covered in Section 3.

.2.1 Overarching points

.2.1.1 The polluter-pays principle

The polluter-pays (PP) principle is widely accepted for establishing liability – it is enshrined in Principle 16 of the Rio Declaration [102] and, within the context of the marine environment, in article 235 of the United Nations Convention on the Law of the Sea (UNCLOS) [103]. Originally, the principle entailed that States ensure that environmental damage costs are internalised to avoid subsidising polluting practices, but its application has been extended to require that the "polluter" compensates for pollution incidents. The determination of who the polluter is "as much a matter of legal principles as of enforcement considerations" [104]. However, with regards to the transport of CO_2 for CCS purposes, the "polluter" would likely be the carrier of the CO_2 (ships) or the pipeline operator (pipeline) [104]. Given that liability aspects influence the overall financial risk for investment in each of these modalities, and that a combination of both would be vital for accommodating the anticipated "huge volumes" of CO_2 to be transported [24], it is important to consider the liability regime/standards governing them and how this could favour one of them over the other through imposing differing liability standards for the same types of risks. In this regard, it is notable that CO_2 shipping is governed by an "extensive international legal framework" whereas the transport by pipelines "is largely a matter of national rules" [104].

On 12 May 2022, the Department for Environment Food & Rural Affairs (DEFRA) published its policy paper on the Draft environment principles policy statement, introduced by the Environment Act 2021 [105]. The Act is an implementation of the HMG's ambitions to leave the environment in a better state than in which we found it. Through the reliance on set environmental principles, it allows the delivery

[52] Third parties are understood to mean those who do not have a contractual relationship with the proponents of the risk-creating activity/wrongdoer.

of a system that "places environmental considerations at the heart of policymaking across government" [106]. The principles are:

- The integration principle
- The prevention principle
- The rectification at source principle
- The polluter pays principle
- The precautionary principle

According to the policy paper, the polluter pays principle means that, "where possible, the costs of pollution should be borne by those causing it, rather than the person who suffers the effects of the resulting environmental damage, or the wider community" [106]. It added that the principle can be used "through different phases of policymaking", including the design stage of a policy to deter/prevent environmental damage before its occurrence. Thus, the paper recognised the dual role of the principle in deterring damage before it occurs ("incentivising individuals or groups to avoid causing environmental damage and encourage sustainable practices"), and in restoring/redistributing the costs of environmental damage when it occurs.

It lays out the conditions for the application of the principle, giving priority to the prevention of harm: policymakers should apply it where (1) there is evidence of, or potential for, environmental harm or a negative environmental effect; **and** (2) prevention of that harm is not possible or proportionate. The paper also provides guidelines for the application of the principle by policymakers, highlighting the questions which they should consider in making decisions/developing policies. These are:

- Who the polluter is?
- How much the polluter should pay?
- How the polluter should pay?

With regard to the first of these questions – the paper highlights that policymakers should consider the *driver* for the pollution being caused, and who is it *fair* to expect to pay for the pollution (acknowledging that it might be more effective to distribute the cost across a particular sector responsible for the pollution in some situations). As for the second question, the paper highlights that "the amount the polluter pays should be proportionate to the environmental damage and the wider costs and benefits to society of the activity in question" [106]. It explicitly rules out that having due regard to the policy statement creates an obligation on minsters to create a tax in response to the polluter pays principle, and that "[i]f it is decided it would be appropriate for the consumer to pay, the costs of environmental damage (such as pollution control and remediation) would be reflected in the cost of goods and services" [106].

.2.1.2 Environmental Tort Law

Torts are a type of civil wrong (as opposed to criminal wrongs) alongside other wrongs such as breach of contract and equitable torts (*e.g.* unjust enrichment), for which courts impose liability [107]. Albeit a branch of private law, it is relevant to consider the general position around torts under UK environmental law because it could find application in scenarios that fall beyond the scope of statutes/regulations governing the liability aspects of risk-creating activities such as the temporary storage or transport of CO_2 (as elaborated upon below). It entails that injured parties or authorities acting on their behalf would still have the chance to be compensated for damage which has been unfairly caused to them, should they be able to satisfy the burden of proof of the type of tort which is applicable to the situation at hand.

The basic theoretical justification behind the division between tortuous and contractual liabilities resides in the fact that, based on the "will theory", contractual duties are based on voluntary obligations whereas tortious obligations are coercive [108]. Practically, this entails that the law interferes in enforcing the terms which the parties have negotiated in the case of contracts, whereas tortious obligations are imposed by the law without such basis. Another key difference is the fact that contract law aims to protect the interest of parties based on their expectations (their intention behind the negotiated terms of the contract),[53] whereas damages in tort aim to protect reliance interests [108]. In addition, contractual liability is in principle *in personam* (directed towards a particular person) as opposed to tortuous liability which is in principle *in rem* (enforceable against all). Apart from "exceptional cases", contractual liability is *prima facie* strict, and tortuous liability is *prima facie* fault-based [108].[54] Moreover, another classic difference between contracts and torts relates to the purpose of damages which claimants can recover under each: "damages in [contracts] are calculated to put the claimant in a position comparable to that he would have been in had the defendant performed the contract and in [the case of torts] to restore the party who has suffered loss to the position he would have been in had the tort not been committed" [108] (see Table 3 for a summary of the distinction between tortuous and contractual liabilities). However, the division between the two can be in blurred in some instances. For example, where a duty of care has been negotiated in the terms of the contract (which submits the practical content of the clause to the rules applicable to the tort of negligence) [108].

Contracts	Torts
Voluntary obligations	Coercive
Law protects the expectation interest	Law protects reliance interests
Law protects economic interests	Law aims to remedy physical damage to persons/properties
In personam	*In rem*
Liability *prima facia* strict	Liability *prima facia* fault-based
Damages to put the claimant in a position comparable to that he would have been in had the defendant performed the contract	Damages to restore the party who has suffered loss to the position he would have been in had the tort not been committed

Table 3. Key differences between liability in tort and contractual liability in the UK legal system.

There are multiple types of torts recognised in English law which can be classed under: intentional torts, negligence and strict liability [108]. However, it is difficult to identify common general principles about the law of tort (in a similar way as to the law of contracts) because what makes a certain conduct "wrongful" is generally context specific [108]. The following is a brief overview of the three categories of torts:

- **Intentional torts**: these seek to protect a variety of interests including persons, property, economic interests, and reputation and privacy [108]. In comparison with the tort of negligence, some intentional torts are *actionable per se* (without proof of

[53] The intention to create legal relations – one of the key elements of a valid contract.
[54] Strict liability is triggered without proof of fault on behalf of the wrongdoer, whereas fault-based liability is conceived as liability predicated on some sort of wrongdoing.

damage), and cover a broader range of interests. Importantly, in these torts, it is the defendant's state of mind when acting that makes the conduct wrongful.[55]

- **Negligence**: with regards to this tort, fault entails the violation of a duty of care (a reasonable standard of conduct, assessed objectively).[56] Following the landmark *Donoghue v Stevenson* case [109], this tort has an applicable framework of rules which is outlined as follows:

➢ The defendant must owe the claimant a duty of care
➢ The defendant must be in breach of that duty (careless or negligent)
➢ The breach of the duty must cause the claimant's loss
➢ The loss caused must not be too remote (must be within the foreseeable risk for which the defendant is responsible)
➢ The defendant must not be able to raise any defence to the claimant's action [106].

- **Strict liability**: for this category of tort, the fact that reasonable care was taken by the defendant is not a valid defence from their part. The most relevant examples of these torts are the rule in *Rylands v Fletcher* [110],[57] and the breach of statutory duty. Importantly, certain statutes (for example the Civil Aviation Act 1982, the Environmental Protection Act 1990, and the Merchant Shipping Act 1995 in respect of oil pollution) also give rise to strict liability.[58] The latter are different from the tort of the breach of statutory duty in that liability arises *indirectly* whereas a statute imposes a duty but does not identify a civil remedy in the event of its breach [111]. The tort is viewed as a combination of statute and the tort of negligence as the duty imposed on the defendant is defined/contained in the statute itself, but the wrongful action lies in the common law of negligence [111].

The rule in Rylands v Fletcher

The rule is: "If a person brings, or accumulates, on his land anything which, if it should escape, may cause damage to his neighbour, he does so at his peril. If it does escape, and cause damage, he is responsible, however careful he may have been, and whatever precautions he may have taken to prevent the damage" (Lord Cranworth). Thus, the rule consists of *at least* three "principal" elements, namely "dangerous thing", "non-natural use" and "escape of the thing" [112].

Academic literature examined developments in UK case-law to evaluate the prospects of the rule being extended to the general clause of strict liability for abnormally dangerous activities and things (a development which has been enshrined in statute in the USA) [113]. The House of Lords' position in *Transco*[59] [114] left this for the consideration of the legislator and confined it to the tort of nuisance without being prepared to detach it from "its most limiting element" – "use of land" [113]. However, it was advanced that the establishment of the "test of danger or mischief" and analysis by Lord Bingham "sets the ideal bases for the possible conceptualization of a general rule of strict liability by British case-law in the near future" [113]. In the case-law subsequent to *Rylands*, "most of the

[55] Academic literature discusses the distinction between "wrongfulness" and "fault", see [107].
[56] Often referred to as the standard of a reasonable person.
[57] A special principle, within the tort of private nuisance (a tort based on the interference by one occupier of land with the right in or enjoyment of land by another occupier of land as such), which deals with the isolated escape of dangerous things *from the "non-natural use" of land*.
[58] Lord Walker admitted in *Transco* that the operative scope of the rule under *Rylands v Fletcher* has been restricted by (1) the growth of statutory regulation of hazardous activities, and (2) the continuing development of the law of negligence.
[59] Summarised in box 1 below.

seemingly wide ambit [of the rule] was in effect restricted to an exceptionally small number of cases" [113]. As observed by Lord Bingham, "few claimants have succeeded in reliance on the rule in *Rylands v Fletcher* alone" [113]. It was advanced that the requirement for "the thing" to escape from the land of the keeper "seriously restricts the ambit of the rule" as it confines the rule to cases of damage to property and personal injury caused on the same premises does not fall under the rule [113].[60] Commenting on the question of whether or not the defendant (the Council) was an ordinary user of its land, Lord Bingham advanced that "[i]t is of course true that water in quantity is almost always capable of causing damage if it escapes. But the piping of a water supply from the mains to the storage tanks in the block was a routine function which would not have struck anyone as raising any special hazard."[61] He distinguished *Rylands v Fletcher* by adding: "[i]n truth, the council did not accumulate any water, it merely arranged a supply adequate to meet the residents' needs. The situation cannot stand comparison with the making by Mr Rylands of a substantial reservoir. [The use by the council of its land] was entirely normal and routine."[62]

The "non-natural use" of "the *dangerous* thing" elements of the rule never developed into a singular test which has in the past depended on the circumstances of the case at hand. Academic commentary on this point distinguished Case-Law where the court held that bringing water into a building through a water conduit was not non-natural use from the decision in *Rylands v Fletcher* where the accumulation of large quantities of water (which entered the land naturally) was considered to be non-natural [112]. This suggests that *Rylands* can only be applied where a certain threshold of the level of danger is exceeded – that "there must be some "special use bringing with it increased danger to others" [110]. The decision in *Cambridge Water Co Ltd v Eastern Counties Leather* supports this view [115] (see Box 2. below). In *Cambridge Water*, the House of Lords found that the storage of substantial quantities of chemicals was a "classical case" of "non-natural use".[63] However, the defendant in that case (Eastern Counties Leather) was not held to be liable for the water pollution inflicted as the contamination was felt more than a mile away from the place where the "escape of the thing" happened, and that the damage caused had accumulated over several years. Thus, the court decided that foreseeability of the damage of the relevant type was a prerequisite of liability under *Rylands v Fletcher* (in the same way as it applies to claims based in negligence).[64]

[60] Lord Bingham, at [9] saw this as an inference from the fact that the rule in *Rylands v Fletcher* is a "sub-species of nuisance" given that the latter is "based on the interference by one occupier of land with the right in or enjoyment of land by another occupier of land as such" and that death and/or personal injury does not relate to any such right.

[61] *Transco*, paragraph [13].

[62] *Ibid.*

[63] Part of the reasoning was based on the fact that in tort of nuisance, the focus is more on the acts of the defendant, whereas in the rule in *Rylands vs Fletcher*, the focus is "always on the event of an escape of some mischievous thing which the defendant brought onto [the plaintiff]'s land". It is important to note that on the facts of the case, the judge had found that spillages were likely to occur (at page 275). In *Charing Cross Electricity Supply Co v Hydraulic Power Co* [116], *Rylands v Fletcher* was extended to apply to cases in which the site of the plaintiff's injury was occupied by him only under a licence and not under any right of property in the soil.

[64] *The Wagon Mound no 1* [117] is the relevant authority for assessing the remoteness of damage.

Transco v Stockport Metropolitan Borough Council (2004)

A leak developed in an underground water pipe belonging to the Stockport Borough Council. The cause of the leak was never determined but, due to large waters escaping, a nearby railway embankment was fully saturated leaving a 27m long section of a gas main exposed and unsupported. Wary of the high risk of explosion, Transco (responsible for the maintenance of the gas pipeline) repaired the embankment and sought to recover costs from the Council.

Given that the cause of the water pipe rupture was never determined, the claim could not be based on negligence from the part of the Council. Transco therefore claimed that the Council was liable without proof of negligence under the rule in *Rylands v Fletcher*. The House of Lords rejected the claim, leaving Transco to bear the costs of the repairs. It justified its decision by the fact that the council did not bring something onto its land that was likely to cause danger if it escaped and that the normal use of the land did not create a greater risk than is normally associated with domestic or commercial plumbing.

Box 1. Summary of *Transco v Stockport Metropolitan Borough Council* [2004] 1 All ER 589

Cambridge Water Co Ltd v Eastern Counties Leather (1994)

The defendant owned a leather tanning business. Spillages of small quantities of solvents occurred over a long period of time which seeped through the floor of the building into the soil below. These solvents made their way to the borehole owned by the Claimant water company. The borehole was used for supplying water to local residents. The water was contaminated at a level beyond that which was considered safe and Cambridge Water had to cease using the borehole. Cambridge Water brought actions based on negligence, nuisance and the rule in *Rylands v Fletcher*.

The House of Lords held that Eastern Counties Leather were not liable as the damage was too remote. It was not reasonably foreseeable that the spillages would result in the closing of the borehole. The foreseeability of the type of damage is a pre-requisite of liability in actions of nuisance and claims based on the rule in *Rylands v Fletcher* in the same way as it applies to claims based in negligence.

Box 2. Summary of *Cambridge Water Co Ltd v Eastern Counties Leather* [1994] 1 All ER 53

.2.1.3 The environmental impact of CO_2 leakage on the marine environment

The nature and extent of harm which leakage of liquified CO_2 from ships could cause are not fully understood. Academic literature on the subject referred to IPCC reports [93] to conclude that it is difficult to envisage examples of environmental and related damage in such events [104]. It is appropriate to reproduce the relevant passage from the IPCC report (at p.188-189) here:

> "An accident to a liquid CO2 tanker might release liquefied gas onto the surface of the sea. However, consideration of such an event is a knowledge gap that requires further study. CO2 releases are anticipated not to have the long-term environmental impacts of crude oil spills. CO2 would behave differently from LNG, because liquid CO2 in a tanker is not as cold as LNG but much denser…"

Literature commenting on this passage advanced that "a conceivable scenario" would be one where the cargo escapes following a CO_2 carrier sinking in an environmentally sensitive area, highlighting that the effects of such an event would vary depending on different characteristics (*e.g.* the depth of the sea, the speed of the escaping gas, the physical and chemical reaction of the gas with the water, and the speed of the currents) [104]. Due to the "very good safety record of LNG transport", there is no background for detailed examples which could be referred to by analogy to CO_2 shipping [104].

.2.2 Legislative framework governing the liability aspects of liquified CO_2 shipping

.2.2.1 Overview

The polluter-pays principle is implemented via a comprehensive framework which channels a substantial part of the strict liability towards the shipowner. It is designed as such so that recovery by victims of harm caused by the activity is not hindered by the need to prove highly technical issues to establish fault, nor by complicated parallel proceedings. The framework generally requires that insurance is in place (internalising the cost of the risk – financial security), while part of the risk is born by society – the ultimate beneficiary of the risky activity (limitation of liability, reflecting the size of potential liability which would otherwise bar smaller entities from entering the market).

The relevant instruments which make up this framework include the European Environmental Liability Directive (ELD) [118] as transposed into national Law, the 1976/1996 Convention on Limitation of Liability for Maritime Claims (LLMC) [119], and the 2010 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea [120].[65] The ELD's implementation into national Law and the LLMC are currently in force, whereas the 2010 HNS Convention is a regime which may become applicable in the future. These are summarised in Table 4 below.

Legislation	Overview and main provisions	Enforcing authority
Environmental Damage (Prevention and Remediation) (England) Regulations 2015/810	• Transposed the Environmental Liability Directive into national Law, thereby implementing the polluter-pays principle with regards to damage caused by CO_2 shipping in the UK and establishing in such instances an obligation for operators of CO_2 carriers to adopt measures to (1) prevent/halt environmental pollution, and (2) to remediate environmental damage caused by its activity by restoring the affected environment to its "baseline" condition. • The strict liability regime provided for by the Regulations applies in respect of damage caused to activities listed in Schedule 2 to a protected species or natural habitats, surface water or groundwater, marine waters, and land. Schedule 2 activities include transport by road, rail, inland waterways, sea or air of dangerous goods or polluting goods. And "dangerous goods" is defined in accordance to the IMDG	• In relation to land by the local authority • In relation to damage to marine waters up to 12 nautical miles from the Baseline in England – The MMO • In relation to damage to marine waters beyond 12 nautical miles from (a) the baselines in England, or (b) the baselines in Northern Ireland – the Secretary of State for DEFRA • In relation to damage to "a protected species or natural habitat or a site of special scientific interest on any other part of the continental shelf

[65] The original version of this Convention was the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea 1996 (adopted on 3 May 1996, not yet in force). It was amended by the 2010 Protocol (see IMO LEGCONF.17/DC/1, 29 April 2010) which led to the consolidated version of the Convention – the 2010 HNS Convention (adopted 30 April 2010, not yet in force).

	Code and Chapter 19 of the IGC Code which both include liquified CO_2. • Claims against polluters must be brought by the "enforcing authority" on behalf of the victim(s) of the harm caused. The "enforcing authority" is defined with reference to regulations 10 or 11. • The operator's liability is strict (no proof of fault is required), but action must be brought against within period of five years from the date of the completion of the measures to which the proceedings relate, *or* the identification of the operator liable to carry out the measures (whichever is later). • The Regulations are without prejudice to the right of an operator to limit liability in accordance with the LLMC96.	or in the sea up to the limit of the exclusive economic zone" – the EA • Collaboration between regulatory bodies is common in instances triggering the application of the EDR – the MCA would first be notified by the operator of the ship involved in a CO_2 leakage incident. The MCA would then coordinate its actions with those of other bodies such as the SOSREP and the MMO.
Merchant Shipping Act 1995	• Transposed the LLMC96 into national Law. • Recognised a right for shipowners and to salvors to limit their liability in respect of maritime claims brought against them under certain conditions. • The limitation of liability is determined based on a tonnage-based system and depends for its operation upon the person alleged to be liable constituting a limitation fund with the court or other competent authority in any State party where legal proceedings have been initiated for claims subject to limitation.	The Court or competent authority (including arbitration panels) where legal proceedings to establish the limitation fund have been initiated for claims subject to limitation.
2010 HNS Convention	• Not yet in force • Would apply in relation to damage caused by any [HNS] in connection with their carriage by sea on board the ship, thus excluding scenarios where damage occurs before or after loading the cargo from or to the ship. • The liability of the registered shipowner would be strict in respect of damage and injury arising in connection with the carriage of liquified CO_2 in packaged form or in bulk, including damage caused outside the ship (property damage or loss of life/personal injury), financial loss arising from damage to the environment, costs for reasonable measures for the reinstatement of the environment, and costs of and damage caused by preventive measures. • Once the Convention enters into force, it would bar claims for compensation for damage from being made against the owner otherwise than in accordance with this Convention (including claims brought under Common Law). This does not apply to damage occurring before and after the cargo is loaded onto the ship (*e.g.* while in	The Court or competent authority (including arbitration panels) where legal proceedings to establish a fund have been initiated for claims subject to the first tier of limitation under the Convention.

	storage tanks in port) in relations to which concurrent proceedings may be brought against the owner/its agents. • The Convention limits shipowners' liability by providing for a two-tier system of liability which claimants have access to: a first tier covered by the shipowner, and a second tier covered by the HNS Fund. With regards to the former, the extent of the liability is determined in relation to the size of the vessel and the form of the cargo (packed; in bulk); whereas claims made against the HNS Fund are capped to a limit unrelated to the size of the vessel. • For owners to benefit from the first-tier limitation of liability under the Convention, they must constitute a fund for the total sum representing the limit of their liability with "the court or other competent authority of any one of the States Parties in which action is [or can be] brought […]".	

Table 4. Environmental liability for damage caused by CO2 shipping – main legislations, requirements, and enforcing authorities.

.2.2.2 The ELD as transposed into national Law

The ELD is a public liability instrument[66] which aims to implement the polluter-pays principle by imposing on the operator of a potentially polluting activity the obligation to adopt measures to (1) prevent/halt environmental pollution, and (2) to remediate environmental damage caused by its activity by restoring the affected environment to its "baseline" condition.[67] It was transposed into national Law via the Environmental Damage (Prevention and Remediation) (England) Regulations 2015/810 (the Environmental Damage Regulations – hereinafter 'EDR') [121]. The liability of operators is strict and in accordance with regulation 26 of the EDR, but the competent authority should act within a period of five years from the date of the completion of the measures to which the proceedings relate, *or* the identification of the operator liable to carry out the measures (whichever is later).

The "operator" is defined under the EDR (regulation 2(1)) as "the person who operates or controls an activity, including the holder of a permit or authorisation relating to that activity, or the person registering or notifying an activity for the purposes of any enactment". Therefore, the type of charterparty in place would determine the application of this definition in a shipping context: under a time charterparty, shipowners remain responsible for the technical operation of the vessel and must cover all costs associated with crewing, maintenance of the vessel and insurance whereas commercial control of the vessel and fuel/port charges are handled by the charterer; in a voyage charterparty, both the technical and commercial management of the ship are handled by the shipowner, and they also cover the costs associated with crewing, maintenance of the vessel, insurance, bunkers, port

[66] It applies to State claims (through the competent authority) for damage caused to land, water, and to protected species/habitats, but does not cover civil liability claims brought by private entities/parties (who could request from the relevant competent authority to take action on their behalf pursuant to article 12 of the ELD; EDR, regulation 29).

[67] The operators must remediate damage to the environment by restoring it to its "baseline condition" by way of "primary", "complementary" and "compensatory" remediation, defined in Annex II of the Directive/Schedule 3 of the EDR.

charges, and all costs associated with the voyage. In a voyage charterparty, there is little doubt that the shipowner would constitute the "operator" in the sense defined under the EDR. The situation is less clear when it comes to time charterparties. Any disputes between a CO_2 owner chartering a vessel and the registered shipowner they charter it from would be resolved based on the terms of their agreed charterparty [104].

The ELD/EDR regime applies to environmental damage caused by activities listed in Annex 2 of the ELR/Schedule 2 of the EDR (EDR, regulation 5) to a protected species or natural habitats, surface water or groundwater,[68] marine waters, and land (EDR, regulation 4). Regulation 4(5) EDR defines "environmental damage to marine waters" as "damage to marine waters such that their environmental status is significantly adversely affected",[69] and "marine waters" is defined with reference to article 3.1(a) of Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for Community action in the field of marine environmental policy [123] (EDR, regulation 2(1)):

> "(a) waters, the seabed and subsoil on the seaward side of the baseline from which the extent of territorial waters is measured extending to the outmost reach of the area where a Member State has and/or exercises jurisdictional rights, in accordance with the UNCLOS,[70] with the exception of waters adjacent to the countries and territories mentioned in Annex II to the Treaty and the French Overseas Departments and Collectivities; and
>
> (b) coastal waters as defined by Directive 2000/60/EC,[71] their seabed and their subsoil, in so far as particular aspects of the environmental status of the marine environment are not already addressed through that Directive or other Community legislation".

Schedule 2 activities include "[t]ransport by road, rail, inland waterways, sea or air of dangerous goods or polluting goods", and "dangerous goods" with regards to transport by sea are defined under article 3(g) of Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC [124] as:

- goods classified in the IMDG Code
- dangerous liquid substances listed in Chapter 17 of the IBC Code
- liquefied gases listed in Chapter 19 of the IGC Code

[68] "Surface water" and "groundwater" are defined by reference to Directive 2000/60/EC of the European Parliament and of the Council, according to which the former means "inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters" and the latter means "all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil."

[69] This is understood to consider the ecological, chemical or quantitative status or the ecological potential of the water. The Department for Environment, Food and Rural Affair (DEFRA)'s Marine Strategy defines "good environmental status" as "the environmental status of marine waters where these provide ecologically diverse and dynamic ocean and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generation" [122].

[70] Discussed in Section 3 below.

[71] Directive 2000/60/EC defines "coastal water" as "surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters". "Transitional waters" are defined as "bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows".

- solids referred to in Appendix B of the BC Code

As discussed in section 2.1.1 above, liquified CO_2 is classified in the IMDG Code and it is also included in Chapter 19 of the IGC Code. Therefore, the scenario whereby an accident related to the carriage of CO_2 by sea is brought under the scope of the EDR/ELD regime. This entails that two main duties are imposed on shipping operators, namely:

(a) The duty of operators to adopt "all practicable steps to prevent […] damage" and to notify relevant details to the authorities. This duty is triggered as soon as it is established that their activity "causes an imminent threat of environmental damage, or an imminent threat of damage where there are reasonable grounds to believe that the damage will become environmental damage" (EDR, regulation 13(1)).
(b) The duty to remediate pursuant to Schedule 3 of the EDR. This duty is triggered as soon as the enforcing authority has established that the damage caused by the activity constitutes "environmental damage" in the meaning set under the Regulations (EDR, regulation 17) and has notified the operator about it pursuant to regulation 18.

Regulation 8 of the EDR provides for exemptions for their application. This includes situations where the environmental damage is caused by acts of terrorism, an exceptional natural phenomenon (provided that the operator took "all reasonable precautions" to protect against the damage caused), activities the sole purpose of which is to protect against natural disasters, and incidents in respect of which liability or compensation falls within the scope of international conventions covering liability for oil pollution damage (EDR, regulation 8(3)). Thus, although liability under the EDR is strict, it is not absolute.

The competent authority for enforcing the EDR is defined with reference to regulations 10 or 11. Accordingly, the "enforcing authority" will be determined based on whether the regulated activity requires a permit or registration under the Environmental Permitting (England and Wales) Regulations 2016 (Environmental Permitting Regulations) [EPR] [125]. In the affirmative regulation 10 of the EDR applies and the authority will in principle be identified according to the agency/body/authority which had the initial responsibility for granting the permit for the activity (EDR, regulation 10). The EPR apply to a wide range of activities that have the potential to impact the environment, including industrial processes, waste management, energy production and water and wastewater management. Some of those might be relevant for shipping operations within ports (*e.g.* ship maintenance and repair, bunkering operations, waste management), and operators of ships might also be subject to requirements under the EPR with regards to causing or knowingly permitting water discharge activities within ports. However, the EPR primarily apply to "installations" where one or more activities listed in Schedule 1, Part 2 are undertaken (Part 1.1(1), Schedule 1, EPR). The latter includes the *capture* of CO_2 streams from an installation for the purposes of geological storage (paragraph 6.10, Part 2, Schedule 1), but does not refer to the *transport* of CO_2.[72] Moreover, the requirements with regards to water discharge activities discussed in section 3.1.2.1 below are not concerned with permitting shipping operators to carry CO2 on board their vessels, but with the protection against the discharge of harmful substances into freshwaters, coastal waters or relevant territorial waters (paragraph 3(1), Schedule

[72] The EPR also apply to installations where activities which are "directly associated" to those listed in Part 2 of Schedule 1 are undertaken (paragraph 1(2), Part 1, Schedule 1, EPR). However, one of the conditions for an activity to be considered "directly associated" is for it to be carried out "on the same site as the [main] activity" (paragraph 1(2), Part 1, Schedule 1, EPR). Therefore, the shipping of CO_2 cannot be considered as an activity which is "directly associated" with the capture of CO_2 streams from installations as laid out in paragraph 6.10 of Part 2 of Schedule 1.

21, EPR). This entails that the shipping of CO_2 *per se* is not considered an activity which is permitted via the EPR and that therefore, regulation 11 of the EDR is applicable. The latter provides that in such instances (where the activity in question is not covered by the Environmental Permitting Regulations), the Regulations are to be enforced in accordance with the provisions in the table in Schedule 2A. Accordingly, the Regulations are enforced with regards to damage to land by the local authority, with regards to marine waters up to 12 nautical miles from the Baseline in England by the Marine Management Organisation (MMO), and with regards to damage to marine waters beyond 12 nautical miles from (a) the baselines in England, or (b) the baselines in Northern Ireland, by the Secretary of State for Environment, Food and Rural Affairs. On the other hand, the Environment Agency is the enforcing authority with regards to damage to "a protected species or natural habitat or a site of special scientific interest on any other part of the continental shelf or in the sea up to the limit of the exclusive economic zone". However, collaboration between regulatory bodies is common in instances triggering the application of the EDR.[73] For example, in the event of an accident on board a CO_2 carrier while navigating within 12 nautical miles from the Baseline in England, the operator of the ship must first notify the MCA of the accident. The latter would then notify other bodies such as the Secretary of State's Representative for Maritime Salvage and Intervention (SOSREP) [126]. The MCA would also carefully consider the circumstances of the case considering H&S and environmental concerns and assesses whether suitable action has been taken by the operator of the ship in line with the requirements of the EDR. Based on such assessment, it could for example advise the operator to undertake suitable preventative measures to minimise the level of potential damage. In parallel, it would contact the MMO to ask whether the damage should be considered for action under the EDR [127]. Accordingly, the MMO would examine whether the activity in question (*i.e.* transporting dangerous goods by sea) is included in Schedule 2 of the Regulations and whether it causes an imminent threat of environmental damage (pursuant to regulation 13) or that the damage caused by the activity constitutes "environmental damage" (pursuant to regulation 17) [127].

.2.2.3 The Convention on Limitation of Liability for Maritime Claims (LLMC)

Even though the ELD standardised environmental liability rules amongst EU Member States, the Directive's inherent principles as transposed by the EDR in the UK "differ significantly from the basis of the various maritime liability regimes […] especially with respect to remediation" [104]. The core difference is that the EDR established a strict liable regime (with exemptions) whereas maritime liability regimes are "primarily based on the strict *but limited* liability of the registered owner (with some exceptions), including liability in respect of reasonable measures of reinstatement for environmental damage" (emphasis added) [104]. The Convention on Limitation of Liability for Maritime Claims 1976[74] and its 1996 Protocol[75] (LLMC96) [119], transposed into national Law via the Merchant Shipping Act 1995 (MSA95) [73] (section 185, MSA95),[76] provides the basis for the limitation of liability for maritime claims. The following sections present an overview of the regime LLMC96 puts in place in the UK.

[73] In fact, regulation 12 of the EDR provides that "if there is more than one type of environmental damage, so that there is more than one enforcing authority, these Regulations are to be enforced by any or all of the enforcing authorities".

[74] Adopted 19 November 1976, entered into force 1 December 1986; ratified by the UK on 31 January 1980, entered into force in the UK on 1 December 1986.

[75] Adopted 2 May 1996, entered into force 13 May 2004; ratified by the UK on 11 June 1999, entered into force in the UK on 13 May 2004.

[76] The LLMC96 is reproduced in whole in Schedule 7 of the MSA95.

.2.2.3.1 Compatibility with the liability regime

The potential challenge stemming from the incompatibility of the ELD/ELR regime with maritime liability regimes is avoided by the provisions of article 4(2) of the ELD and article 7(2) of the EDR. Accordingly, the Regulations are "without prejudice to the right of an operator to limit liability in accordance with the Convention on Limitation of Liability for Maritime Claims 1976" (as set out in Schedule 7 to the MSA1995, amended to reflect the LLMC96),[77] and therefore a claim arising under the ELD *could* be subject to the LLMC's limits (if the cost of prevention/remediation under the ELD/ELR exceed the LLMC limits). Moreover, article 2 of the LLMC96 as transposed in Schedule 7 of the MSA1995 setting out the claims which are subject to limitation provides that the claims it sets out shall be subject to limitation "whatever the basis of liability may be", subject to articles 3 (which lists specific exceptions which do not include the ELD/EDR regime) and article 4 (which bars limitation if the loss in question was *intentionally* caused by the liable party) of the Convention. This entails that claims brought against the operator of a CO_2 carrier in tort can also be limited pursuant to the LLMC96.

.2.2.3.2 Who can limit liability?

The LLMC96 regime applies to shipowners and to salvors pursuant to article 1(1). The term "shipowner" includes the owner, charterer, manager or operator of a seagoing ship (LLMC96, article 1(2)) who could therefore benefit from the right to limit liability. Insurers of claims subject to limitation under the Convention also benefit from it "to the same extent as the assured himself" (LLMC96, article 1(6)). Academic literature advanced that, in accordance with articles 11-13, "persons entitled to limit liability under the 1996 LLMC may bring claims against each other" and that "[t]heir contractual relationship will determine the legal basis of such claims" [104]. For example, the time-charterer/operator of a ship will be entitled to limit liability for the period the shipowner would have been entitled to limit it against third parties/enforcing authorities and, in addition, the operator will be entitled to limit liability against the shipowner should an indemnity claim be brought against it.

.2.2.3.3 Claims to which limitation could apply

Article 4 of LLMC96 sets a very high threshold for barring shipowners and salvors from limiting their liability for actions brought against them, restricting this to scenarios where the loss in question resulted from "his personal act or omission, committed with the intent to cause such loss, or recklessly and with knowledge that such loss would probably result". This supported views that the right to limitation is "virtually certain" [104], even though the limitation amount will depend on the tonnage of the ship as defined under the International Convention on Tonnage Measurements of Ships 1969 and on the type of the claim made [129].[78] The claims to which limitation could apply are listed in article 2, paragraph 1 of the Convention, which applies whatever the basis of liability may be and whether they are enforced by personal action against the owner or other person(s) or against the ship, namely:

a) "claims in respect of loss of life or personal injury or loss of or damage to property (including damage to harbour works, basins and waterways and aids to navigation), occurring on board or in direct connection with the operation of the ship or with salvage operations, and consequential loss resulting therefrom;
b) claims in respect of loss resulting from delay in the carriage by sea of cargo, passengers or their luggage;

[77] Via S.I. 1998/1258 [128].
[78] The two systems which are used to determine the limits of liability rely on either the ship's value or a value calculated on the basis of the size/tonnage of the ship. The limits under the 1996 LLMC are calculated on the basis of the tonnage of the ship in question.

c) claims in respect of other loss resulting from infringement of rights other than contractual rights, occurring in direct connection with the operation of the ship or salvage operations;
d) claims in respect of the raising, removal, destruction or the rendering harmless of a ship which is sunk, wrecked, stranded or abandoned, including anything that is or has been on board such ship;
e) claims in respect of the removal, destruction or the rendering harmless of the cargo of the ship;
f) claims of a person other than the person liable in respect of measures taken in order to avert or minimise loss for which the person liable may limit his liability in accordance with this Convention, and further loss caused by such measures".

Thus, claims relating to loss of life, personal injury, loss of/damage to property, as well as consequential losses are all subject to limitation under the LLMC96 regime, provided that they occur either on board or in direct connection with the operation of the ship. Within a CCS context, and with regards to article 2.1.(a), such claims would arguably arise due to the characteristics of liquified CO_2 being transported and the risks it poses for H&S and for the ship, including during the loading/unloading operations in harbours. Scenarios under article 2.1.(b) could arise in situations where the shipper of the CO_2 is bound by a contractual agreement to deliver the cargo at a specified time for its subsequent injection, or where a storage facility incurs financial losses due to having to wait for the vessel to return and load the next shipment of CO_2 [104]. Article 2.1.(b) is a particularly broad provision which could apply in a multitude of scenarios [104]. This includes "claims from parties that may have suffered losses not linked to property damage", such as for example claims arising from the loss of use of the sea or loss of profit (which arguably encompasses fishermen, owners of yachts, aquaculture farm owners, local shop owners, local municipalities, local governments, and the coastal State) [104]. It must be noted, however, that pursuant to Schedule 7, Part II, paragraph 3 of the MSA95, wreck removal claims are in principle not subject to limitation, unlike claims based on cargo removal operations (pursuant to article 2.1(e) of the LLMC96). In this regard, it was advanced that "if a ship carrying CO2 becomes a wreck, then it will also be subject to the 2007 Nairobi Convention on the Removal of Wrecks" and that under the latter, liability is excepted insofar as it would conflict with liability arising under the 2010 HNS Convention (discussed below) [104]. Consequently, should the HNS Convention enter into force, it is "expected that [Hazardous and Noxious Substances] damages will be exempted from the LLMC and the HNS Convention would be "the only legal instrument regulating ships carrying HNS cargo" [104].

.2.2.3.4 Determining the limits of liability

The 1976/1996 LLMCs both provide for a tonnage-based system for determining the limits of liability (as opposed to a determination based on the age or market value of the vessel). The Conventions refer to the International Convention on Tonnage Measurement of Ships. The UK transposed the provision through the MSA95 and provided that a ship's tonnage would be its gross tonnage "calculated in such a manner as may be prescribed by an order made by the Secretary of State" (Schedule 7, Part II, paragraph 5(2)) before adding that such order should be made in a way that would "give effect to the regulations in Annex I of the International Convention on Tonnage Measurement of Ships 1969" (Schedule 7, Part II, paragraph 5(3)). Consistently, it was advanced that "it is for the [flag State] to determine the gross tonnage of the vessel [129].

The limitation regime provides for two limits of liability – one in respect of claims for loss of life or personal injury and the other in respect of any other claims (property damage) (MSA95, Schedule 7, Part I, article 6.1). In additions, the 1976/96 regime (as transposed into national Law) provides for a separate limit for loss of life and personal injury to passengers calculated based on the number of

passengers which the ship is authorised to carry according to the ship's certificate (MSA95, Schedule 7, Part I, article 7.1). These limits of liability apply for passengers in conjunction with other systems of passenger limitation [129].

.2.2.3.5 Establishing the limitation fund

According to Schedule 7, Part I, article 11 of MSA95, the shipowner, and "any person alleged to be liable", may constitute a limitation fund with the court or other competent authority in any State party where legal proceedings have been initiated for claims subject to limitation. "Legal proceedings" include arbitration proceedings, and the right to establish the limitation fund is restricted to States party to the relevant LLMC Convention they are party to [129]. The limitation under the 1976 LLMC is lower than that under the 1996 LLMC [130], which entails that "a limitation fund established in a State Party to the 1976 LLMC will not be recognised as sufficient for limitation proceedings or the arrest of a ship in a State Party to the 1996 LLMC" [129]. The UK ratified the 1996 Protocol on 11 June 1999, and it entered into force on 13 May 2004.

Article 11.1[79] of Schedule 7 to the MSA95 (relevant to the constitution of the fund) does not stipulate who is to start the proceedings in question, which allows shipowners/charterers to "pre-empt" the situation through "forum shopping" [129]. This could be done by applying for a limitation decree and constituting a limitation fund in any State Party to the desired limitation convention [129]. Thus, the shipowner could institute proceedings to contend that their liability is limited (their right to limit liability is the subject of such claim) or that they are not liable at all (a negative declaratory relief), and that contention in itself would constitute "legal proceedings… in respect of claims subject to limitation" [129]. This position is based on the premise that "if the shipowner seeks to establish his right to limited liability, […], then he is permitted to establish a limitation fund in any of the countries in which he is seeking to limit so long as that country has jurisdiction over the issue of limitation" [129]. It is also supported by an interpretation of article 10 of Schedule 7 of the MSA95 [129]. The article allows for limitation to be invoked irrespective of the constitution of a limitation fund. Paragraph 3 provides that "[q]uestions of procedure arising under the rules of this article shall be decided in accordance with the national law of the State Party in which action is brought",[80] which it was argued, "permit[s] a diversity of views between contracting States" [129]. Focusing specifically on the UK, the argument was based on an interpretation of Part 61 of the Civil Procedure Rules (CPR) [131], relevant to the procedure applicable to admiralty claims. More specifically, CPR, r 61.11 deals with limitation claims under the MSA95. CPR, r61.11(19) provides that a limitation fund may be established by a person (a shipowner for example) *before or after* a limitation claim has been started; and CPR, r61.11(20) adds that in the latter scenario, thereafter, "if a limitation claim is not commenced within 75 days after the date the fund was established…the fund will lapse". Thus, practically, according to this interpretation of article 10 of Schedule 7 of the MSA95, the shipowner of a ship flying the UK flag would be able to establish a limitation fund before substantive liability proceedings are initiated against them. However, in the scenario where the ship is arrested before a fund has been established, the shipowner would naturally have an interest in establishing it at the place of arrest [129].

[79] The first sentence of the article reads: "Any person alleged to be liable may constitute a fund with the Court or other competent authority in any State Party in which legal proceedings are instituted in respect of claims subject to limitation."

[80] For example, national procedural rules could require that limitation claims (and the constitution and administration of a limitation fund) should be submitted in the *fora* where the claims on the merits of the case were initiated (which excludes the pre-emptive limitation claims or negative declaratory reliefs which the shipowner may initiate in line with the abovementioned interpretation of article 11.1).

The purpose of limitation funds is to "provide security up to the limit prescribed and to *free the vessel and shipowner from potential encumbrances*"[81] (emphasis added) [129]. Therefore, it can be defeated by choosing to wait for at least one claimant to start proceedings and establish jurisdiction on the merits, which can be a "lengthy and complicated affair" [129]. This is further supported by the fact that liability under the LLMC regime is both limited and known. The shipowner "can thus avoid multiple litigation and security demands in various jurisdictions, and can continue to trade, leaving the claimants and the court managing the limitation fund to arrange for the appropriate distribution of the claims" [104].

.2.2.4 International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention) – the regime for Hazardous and Noxious Substances (not yet in force)

The HNS Convention is part of the IMO's liability conventions which have been developed as a response to the *Torrey Canyon* oil spill in 1967. It is the "latest piece in the puzzle needed to ensure that those who have suffered damage [from incidents occurring during the transport of hazardous and noxious substances (HNS) by sea] have access to a comprehensive and international liability and compensation regime" - thus implementing the polluter-pays principle [132]. It covers a variety of HNS including liquefied gases, and channels liability to the "owner" of a "ship" in relation to "damage caused by any [HNS] *in connection with their carriage by sea on board the ship*" (emphasis added). This arguably excludes the scenarios where damage occurs before or after loading the cargo from or to the ship. Article 1 adopts a very broad definition of "ship" and defines it as "any seagoing vessel and seaborne craft, of any type whatsoever", whereas "owner" means "the person or persons registered as the owner of the ship or, in the absence of registration, the person or persons owning the ship". However, article 1.3. also provides that "in the case of a ship owned by a State and operated by a company which in that State is registered as the ship's operator, 'owner' shall mean such company."

The first HNS Convention was adopted in 1996 but, due to an insufficient number of ratifications,[82] never entered into force and therefore never became binding on signatory States that have agreed on the text of the Convention. It was then superseded by the 2010 Protocol, which has also not entered into force at the time of drafting of this report (see commentary under footnote 64 above). The amended Convention is generally referred to as "the 2010 HNS Convention". The 2010 HNS Protocol [134] will enter into force 18 months after the date on which it is ratified by at least twelve States, including four States each with not less than 2 million units of gross tonnage, and having received during the preceding calendar year a total quantity of at least 40 million tonnes of cargo that would be contributing to the general account (HNS Protocol, article 21). Estonia became the sixth State to ratify it in January 2022. It joins Canada, Denmark, Norway, South Africa and Turkey, who have already deposited instruments of ratification to the Protocol [135].[83] On the 3rd and 4th of April 2023, a

[81] It was advanced that, in accordance with article 13(2) of the LLMC96, "[o]nce a limitation fund has been established in accordance with the rules of the LLMC as amended, any security through the arrest of the ship or attachment of other property or security in any other form may be released" [104].

[82] Ratification is a process by which a State confirms that it is bound by a treaty that it had already signed. See [133] at page 5.

[83] Eight States (Canada, Denmark, France, Germany, Greece, the Netherlands, Norway and Turkey) had signed the 2010 HNS Protocol, but only Canada, Denmark, Estonia, Norway, South Africa and Turkey have ratified it so far. The Convention's website has however noted that there has "been significant progress reported by a number of other States in recent months and it is anticipated that a number of those States will ratify in the near future".

workshop on the 2010 HNS Convention organised by Canada in co-operation with the IMO and the International Oil Pollution Compensation Funds (IOPC Funds) was held at the IMO headquarters in London. It was attended by 200+ representatives from States and industry and focussed on assisting States with the ratification of the 2010 HNS Protocol [136]. Once it enters into force, the 2010 HNS Convention is expected to replace the liability regime under the ELD/EDR with regards to the transport of dangerous goods/hazardous goods by ships, but liability arising out of loading/unloading activities in ports would arguably still fall under the scope of the EDR. However, the UK has not yet adopted legislation which would enable its transposition into its legislative framework [104]. It is recommended that transposing instruments would adopt a broader scope than the HNS Convention to cover liability arising out of loading/unloading activities and ensure consistency in the framework governing the liability aspects of CO_2 transport in support of CCS in the UK once the HNS enters into force.

.2.2.4.1 Is CO_2 for the purposes of CCS an HNS cargo?

Article 1, paragraph (5)(a)(iv) of the HNS Convention categorises CO_2 as a 'class iv' substance, which is a category for goods in packaged form.[84] However, given that CO_2 would be unlikely to be carried in this manner and in line with the spirit of the Convention, it was argued that CO_2 carried in bulk should also fall under the Convention [104]. This interpretation is supported by the fact that "liquefied gases" are defined in article 1, paragraph (5)(a)(v) by reference to Chapter 19 article 1.1.6 of the IGC Code. As discussed in paragraph 2.1.1 above, CO_2 is included in the IGC Code, thus bringing it within the scope of the HNS Convention. Moreover, it was advanced that if CO_2 in packaged form falls under the Convention then it should equally apply to CO_2 in bulk [104].

.2.2.4.2 The regime under the 2010 HNS Convention

Nature of the liability

The liability of the registered shipowner under the 2010 HNS Convention is strict in respect of damage and injury arising in connection with the carriage of CO_2 (the 2010 HNS Convention, article 7(1)). This entails that the claimant only needs to prove that damage was caused by the CO_2 while it was being carried by the ship (a causal link between the damage and the HNS carried on board the ship) without having to prove fault on behalf of the shipowner.

Claims procedure

The Convention provides for a two-tier system of liability which claimants have access to: a first tier covered by the shipowner, and a second tier covered by the HNS Fund. With regard to the former, the extent of the liability is determined in relation to the size of the vessel; whereas claims made against the HNS Fund are capped to a limit unrelated to the size of the vessel.

Article 7.4 of the 2010 HNS Convention addresses the scenario of concurrent proceedings being brought against the owner, by prioritising the application of the Convention.[85] This protection is extended to include the owner's servants/agents, pilots, "any" charterer ("howsoever described"),[86] salvors, *etc.* (2010 HNS Convention, article 7.5). However, the protection is removed if "the damage resulted from […] personal act or omission [of the owner/their agents] , committed with the intent to

[84] A distinction is traditionally made between "packaged goods" and "goods carried in bulk" in the context of maritime transport of dangerous goods. "Packaged goods" are those loaded on board ships in enclosed containers (*e.g.* barrels, pails, boxes, vehicles, containers), while bulk carriage means that the goods are loaded "directly and without intermediate form of containment in a hold, tank or cargo space, which is a structural part of or permanently attached to a ship" [67].

[85] The article provides that "no claim for compensation for damage shall be made against the owner otherwise than in accordance with this Convention".

[86] This arguably includes an operator who owns the CO_2 and charters the vessel to transport it.

cause such damage, or recklessly and with knowledge that such damage would probably result" (2010 HNS Convention, article 7.5).

It was therefore advanced that the entry into force of the 2010 HNS Convention would bar claims made against the owner or its agents under Common Law (see section 2.2.1) and national legislation [104]. This channelling also protects charterers from claims in negligence about damage caused during the shipping element of the CCS process (when the cargo is on board the vessel) [104]. Importantly, damage occurring before and after the cargo is loaded onto the ship (*e.g.* while in storage tanks in port) is not covered by the provisions of article 7.4 [104]. Therefore, concurrent proceedings could be brought against the owner or his agents in such scenarios.

To protect against the frustration of claims made thereunder, the 2010 HNS Convention imposes compulsory insurance on the owners by requiring them to "maintain insurance or other financial security, such as the guarantee of a bank or similar financial institution" pursuant to article 12.1. article 12.2. also imposes a requirement that a compulsory insurance certificate is issued for each ship by the relevant competent authority (*i.e.* the MCA in the UK), attesting that appropriate insurance or other financial security is in force in accordance with the provisions of this Convention. Importantly, article 12.8 of the 2010 HNS Convention provides that "any claim for compensation for damage may be brought directly against the insurer […]" (this is commonly referred to as "direct action" against the insurer).

Extent of liability

The shipowner's liability is two-tiered and limited (see Figure 5). With regards to the first tier, liability is limited in respect of any one incident to an aggregate amount calculated based on the tonnage of the vessel and the form of the cargo (packed, bulk; 2010 HNS Convention, article 9), rather than on the amount of hazardous and noxious substances actually carried. With regards to the second tier, the HNS Fund[87] provides compensation up to 250,000,000 Special Drawing Rights (SDR)[88] (approx. 335m USD) inclusive of any compensation already provided by the owner under the 2010 HNS Convention. The second tier could be tapped onto by claimants in three scenarios:

1. Where the damages exceed the owner's limit of liability under Chapter II of the Convention (2010 HNS Convention, article 14.1(c));
2. The owner and his insurer are financially incapable of covering their part of the liability (2010 HNS Convention, article 14.1(b));
3. The owner is exempted from liability under the 2010 HNS Convention (2010 HNS Convention, article 14.1(a))

Liability under the 2010 HNS Convention is limited in respect to the first tier in the same way that it is under the LLMC and is virtually unbreakable [104]. For owners to benefit from it, article 9.3. of the 2010 HNS Convention imposes a requirement for a fund "for the total sum representing the limit of liability established in accordance with paragraph 1" to be constituted with "the court or other competent authority of any one of the States Parties in which action is [or can be] brought under Article 38".

[87] The Fund is established under article 13 of the 2010 HNS Convention.
[88] See [137], at the time of the writing of this report (May 2023), the value of 1 SDR is approximatively 1.34.

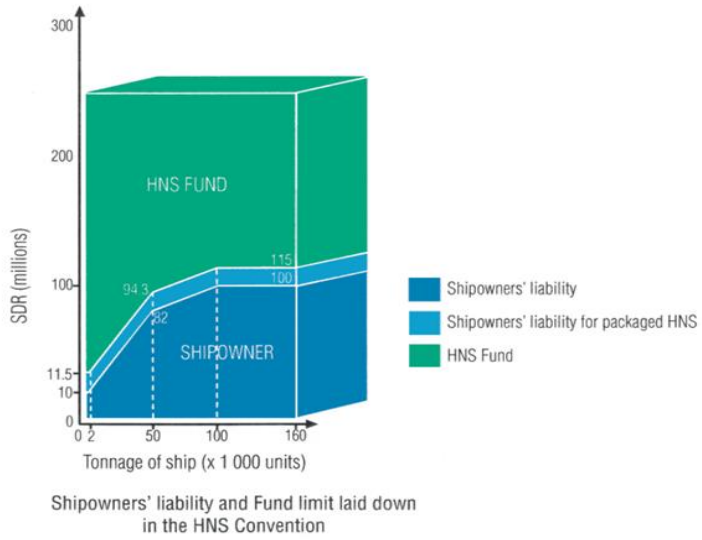

Figure 5. Compensation amounts under the 2010 Convention. Reproduced from [120].

Heads of claims

The 2010 HNS Convention applies to claims brought in respect of damage caused by any HNS in connection with their carriage by sea on board the ship. In accordance with the definition of "damage" in article 1.6, the Convention could find application in a CCS context with regards to:

(a) Loss of life and personal injury on board as well as outside the ship caused by CO_2
(b) Property damage outside the ship caused by CO_2
(c) Physical damage by contamination to property outside the ship
(d) Financial loss arising from damage to the environment
(e) Costs for reasonable measures for the reinstatement of the environment
(f) Costs of and damage caused by preventive measures [104].

Where a claim is made under the HNS Fund, and in the scenario where all the above heads of claims have occurred, loss of life and personal injury claims would be paid first, within the first two-thirds of the fund (2010 HNS Convention, article 11), while the remaining third would be distributed *pro rata* to cover the other heads of claims and any unpaid loss of life and personal injury claims [104].

Exemptions of liability

Article 7(2) lists exemptions to such liability, including the cases where the owner establishes that damage resulted from acts of war or *force majeure*, or that the damage was wholly caused by "an act or omission done with the intent to cause damage by a third party", or that the damage was wholly caused by negligent acts of government/governmental authorities in respect of maintaining navigational aids. Moreover, the owner may be relieved wholly or partially from liability if it proves that "the damage resulted wholly or partly either from an act or omission done with intent to cause damage by the person who suffered the damage or from the negligence of that person" (article 7(3)). The owner also escapes liability when it has not been informed by the shipper of the dangerous and noxious nature of the cargo and where that lack of information caused, at least partly, the damage or led to a failure to obtain the compulsory insurance required by (2010 HNS Convention, article 9).

The HNS Fund is only exempted from liability where the damage was caused by war, hostilities, insurrections *etc.*, or where the damage was caused by ships excluded from the application of the 2010 HNS Convention (which it is advanced is unlikely to be the case for the transport of CO_2 for CCS purposes).

3. Regulation of CO2 storage in the UK

This Chapter examines the legal and regulatory frameworks governing two types of CO_2 storage, namely, the temporary in-port storage of liquified CO_2 (3.1) and its permanent storage in reservoirs under the seabed (3.2).

3.1 In-port storage of CO_2 as part of CCS

This section will unpack the legal and regulatory framework governing the H&S (3.1.1) and environmental protection (3.1.2) aspects of the handling of hazardous goods within a harbour environment before laying out the regime governing the liability for environmental damage potentially caused by CO_2 storage (3.1.3). It will primarily focus on the regime applicable in the port of Southampton, but will refer to laws, regulations and guidance documents underpinning it where appropriate.

A complex legal and regulatory framework

A 2023 MCA report on the challenges faced by UK ports in transitioning towards decarbonisation reviewed the legislative framework applicable to the sector. It found that forty-seven pieces of legislation "relate to port management and/or the handling of hazardous goods within a port environment" [138]. In addition, it highlighted that there are approximately 12 "key" guidelines documents which are published by HMG or devolved administrations in additions to Guidance Notes published by the MCA, the HSE and other governmental authorities [138]. The main legislative instruments which address the regulation of H&S and environmental protection aspects within ports in the UK (commonly referred to as "harbour areas" in the instruments) are presented in Table 5. Most of the ports stakeholders engaged with in the drafting of the 2023 MCA report claimed that the abundance of relevant laws and regulations creates difficulties in understanding where roles and responsibilities for various management aspects in harbour areas lie [138]. This in part due to a complex governance structure for ports in the UK, characterised by the following elements [139]:

- Whilst the Department for Transport (DfT) oversees the UK-wide maritime transport policy, ports policy is devolved in the UK. However, the main legislations pre-date Scottish and Welsh devolution settlements.
- There is no uniform definition of what constitutes a port in the UK. But ports around the UK are managed by Statutory Harbour Authorities (SHA), the legal entities entrusted with managing harbour areas depending on factors such as the type and size of the port in question.
- Different governmental authorities govern specific aspects within a port authority environment. Most notably, the MCA carries out the UK's "Port State" functions to implement provisions under international conventions which the UK had ratified (*e.g.* MARPOL; SOLAS); the Marine and Maritime Organisation (MMO – an agency under DEFRA) and its equivalents in Wales (Welsh Government Marine and Fisheries) Scotland (Marine Scotland Directorate) and Northern Ireland (Department of Agriculture, Environment & Rural Affairs) have responsibility for protecting the marine environment; the HSE has the overarching responsibility over H&S aspects in ports in the UK [140]. However, compliance with the Port Marine Safety Code (PMSC – discussed below), developed to address the complexity of the applicable H&S framework in ports and widely recognised as establishing a national standard for every aspect of port marine safety in the UK, falls within the remit of the MCA.
- SHAs are responsible for the management and running of harbours. Their respective powers, duties and geographical areas of jurisdiction are set out in local Acts of Parliament or Harbour Orders under the Harbours Act 1964 (in Great Britain) [141] or the Harbours Act (Northern

Ireland) 1970 [142], in Northern Ireland. These have much in common, but the detail varies from port to port. However, other actors might also have specific duties within the port environment, notably with regards to the transfer of dangerous liquids and gases between ship and shore. This includes for example berth operators and masters of ships.

- Ports in the UK principally operate on a commercial basis without Government support. This entails that they are often in competition with each other (both domestically and abroad) and potentially with other modes of transport. The main sources of revenue for UK ports include harbour dues, other charges for the use of the harbour, and income from property [143].

Port of Southampton governance

According to estimates from June 2022, there are 426 ports in the UK.[89] These are split across three types of ports: trust ports (75), private ports (181), and municipal ports (170). Trust ports are managed by a local independent board and do not have shareholders or owners; private ports are private entities which often own large trust ports that were privatised in the 1990s; and municipal ports are publicly owned by the local authority. Figure 6 compares the volume of freight passing through UK ports, broken down by cargo types [144]. This 2022 data shows that 449.60 million tons of cargo passed through UK major ports in 2022, including 180.03 million tons of liquid bulk cargo. 31.28 million tons of the total freight (around 7%) passed through the port of Southampton in 2022, including 19.9 million tons of liquid bulk cargo. More recent data shows that total freight tonnage through UK major ports decreased by 6% when comparing Q1 2024 to Q1 2023, with liquid bulk tonnage showing an 11% decrease, dropping to 40.5 million tonnes [x]. This trend did not affect the port of Southampton, as the data shows a slight increase in liquid bulk freight tonnage from 4.89 million tons in Q1 2023 to 4.9 million tons in Q1 2024. However, there was a noticeable and consistent drop in liquid bulk freight across the UK to 168.10 million tons when comparing the yearly data between 2022 and 2023 (drop of 6.6%), and to 18.6 million tons for Southampton (drop of 6.5%) [x]. Importantly, the 2022 data shows that out of the 180.03 million tons of liquid bulk cargo passing through UK ports 22.26 million tons (12.36%) were liquified gases, with only 0.39 million tons of the latter (1.75%) passing through Southampton [144].[90] However, with CO_2 shipping being an attractive NPT option for the Solent and South Wales industrial clusters in particular, it is expected that the largest increase in liquified CO_2 freight in support of CCUS plans will impact these clusters' ports. This will arguably affect handling and storage operations, leading to the introduction of new risks which might not be addressed in existing regulations.

[89] Privately maintained list of these ports can be accessed at Ports.org.uk.
[90] There is no public data available specifically for liquified CO_2 as a sub-category of liquid bulk cargo.

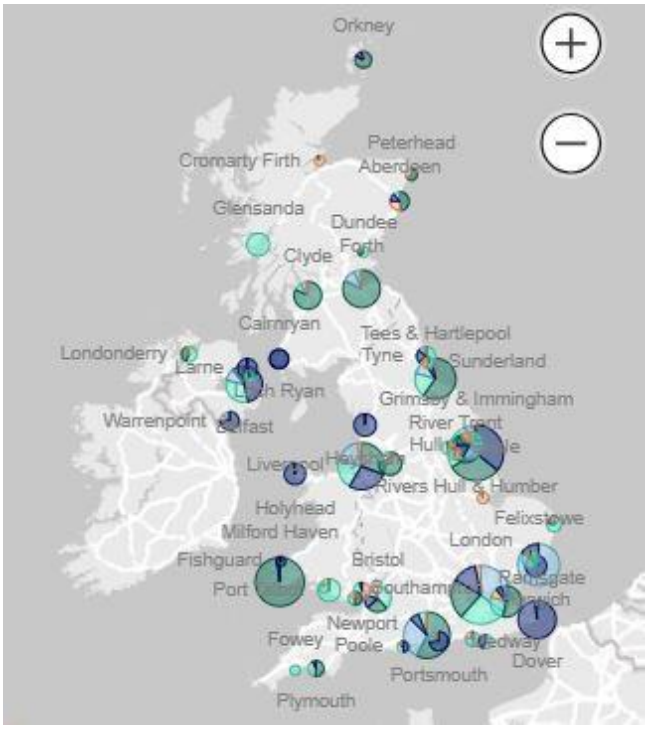

Figure 6. UK Ports by cargo based on data from 2022 [reproduced from [144]]

The Harbours, Docks and Piers Clauses Act 1847 refers to "the undertakers", who are defined as the persons authorised by "the special Act" to construct the harbour, dock, or pier, or otherwise carry into effect the purposes of such Act. The "special Act" is construed to mean "any Act which shall be hereafter passed authorizing the construction or improving of a harbour, dock, or pier". The Southampton Harbours Acts 1863, 1877, 1882 and 1887 are examples of such "special Acts". By virtue of the latter, the remit of the port of Southampton was defined,[91] and the management thereof was vested in the "Southampton Harbour Board". By virtue of the Southampton Harbour Reorganisation Scheme 1967 the functions of the "Southampton Harbour Board" were transferred to the "British Transport Docks Board", and by virtue of Transport Act 1981 and The Associated British Ports (Appointed Day and Designation of Holding Company) Order 1982 (SI 1982/1887), the "British Transport Docks Board" was replaced by the "Associated British Ports" (ABP) as of 31 December 1982. Since that date, the Port of Southampton has been privately owned and managed by ABP Southampton.

Section 83 of the Harbours, Docks & Piers Clauses Act 1847 (incorporated by section 4 of the British Transport Docks Act 1964 and applied by section 51 of that Act), section 53 of the Southampton Harbour Act 1863, sections 52 and 53 of the British Transport Docks Act 1964, and section 16 of the British Transport Docks Act 1972 all recognise the right for port authorities to make byelaws[92] "as they

[91] The definition was amended by virtue of section 3 of The Port of Southampton Harbour Revision Order 2020 which expanded it to include the dock estate. The latter was defined as the "land adjacent to the wet harbour area for the time being vested in, or occupied or administered by A.B. Ports as part of its harbour undertaking at Southampton and occupied wholly or mainly for the purposes of activities there carried on, which may include docks, quays, piers, wharves, berths, locks, breakwaters, landing places, yards, roads, car parks, sheds, other buildings and all other works and conveniences, land and premises", adding that "wet harbour area" means "those parts of the area […]which are covered by water at the level of low water".

[92] Byelaws are local laws made by a local council under an enabling power contained in a public general act or a local act requiring something to be done – or not done – in a specified area. They are accompanied by some sanction or penalty for their non-observance. If validly made, byelaws have the force of Law within the areas to

shall think fit". By virtue of such right, ABP made the ABP Southampton Harbour Byelaws 2003 (2003 Byelaws). These contain specific provisions dealing with the navigation of vessels, mooring and management of vessels and managing goods and road and rail traffic within the Port of Southampton as defined under section 5 of the Southampton Harbour Act 1887.

which they apply [145]. Byelaws must be within the scope of the harbour authority's byelaw-making powers. They are used to regulate activities in the harbour, reflecting local circumstances and enabling the operation of the harbour to be conducted efficiently and safely [146].

Legal instrument	Type	Remit	Issuing body	Regulator	Notes
Harbours, Docks and Piers Clauses Act 1847	Act of Parliament	England, Northern Ireland and Wales	UK Parliament	N/A	Establishes the right for port authorities to make byelaws "as they shall think fit for all or any" of purposes set out in the Act (including for the regulation of the use of the harbour, dock and pier). Contains provisions around the discharge of cargoes and removal of goods and the protection of the harbour, dock, and pier from hazardous substances
Southampton Harbour Act 1887	Act of Parliament	Southampton	UK Parliament	N/A	Extends and amends previous Acts relating to the Southampton Harbour, including with regards to vesting duties for the management of the port and harbour of Southampton and of the Southampton pier in the Southampton Harbour Board. Defines the boundaries of the Port of Southampton under section 5.
Harbours Act 1964	Act of Parliament	All UK ports	UK Parliament	N/A	Defines a harbour as any natural or artificial harbour, any port, haven, estuary, tidal or other river or inland waterway navigated by sea-going ships. It also includes docks and wharves. The powers and duties for the management and running of a harbour are conferred to Statutory Harbour Authorities and are set out in local Acts of Parliament or a Harbour Order under the Act.
British Transport Docks Act 1972	Act of Parliament	All UK ports	UK Parliament	N/A	Incorporates the right for port authorities to make byelaws in respect of their activities. Places statutory responsibility on the harbour master to ensure navigation and safety within the harbour limits.
Health and Safety at Work etc. Act 1974	Act of Parliament	Onshore (including UK harbour authorities) and (since 2013) offshore.	UK Parliament	N/A	The primary legislation covering occupational H&S in the UK. It sets out the general duties which: (1) employers have towards employees and members of the public; (2) employees have to themselves and to each other; and (3) certain self-employed have towards themselves and others. Established the HSE which has been entrusted with the enforcement of H&S legislation via the Health and Safety (Enforcing Authority) Regulations 1998

Health and Safety (Enforcing Authority) Regulations 1998	Statutory Instrument	Activities listed in the Regulations' Schedules taking place in "any premises" in the UK	UK Parliament	Local Authorities and the HSE	Allocate the responsibility for the enforcement of legislation governing occupational H&S in the UK between Local Authorities and the HSE (depending on the activity in question). Although not listed in the Regulations, dock premises are allocated in their entirety to HSE. However, 'dock premises' are defined as 'any dock, wharf, quay, jetty or other place at which ships load or unload goods or embark or disembark passengers, together with neighbouring land or water which is used or occupied, or intended to be used or occupied, for those or incidental activities, and any part of a ship when used for those or incidental activities' [140]
Transport Act 1981	Act of Parliament	All UK ports	UK Parliament	N/A	Replaced the British Transport Docks Board by the Associated British Ports (ABP)
Ports Act 1991	Act of Parliament	All UK ports	UK Parliament	N/A	Enabled the privatisation of ports in the UK by granting port authorities the power to form a company whose objects include the acquisition of property, rights and liabilities and the assumption of functions of the authority
The Workplace (Health, Safety and Welfare) Regulations 1992	Statutory instrument	All UK ports; the "workplace" (defined as "any premises or part of premises which are not domestic premises and are made available to any person as a place of work"	Parliamentary Under Secretary of State, Department of Employment	LAs or the HSE, in accordance with the Health and Safety (Enforcing Authority) Regulations 1998	Impose requirements with respect to the H&S and welfare of persons in a "workplace".
Workplace health, safety and welfare Workplace (Health, Safety and Welfare) Regulations 1992	Code of Practice	All UK ports	HSE	N/A	Aims to help employers understand the regulatory requirements under the Workplace (Health, Safety and Welfare) Regulations 1992 on issues such as ventilation, temperature, lighting, cleanliness, room dimensions, workstations and seating, floor conditions and falls or falling objects

The Management of Health and Safety at Work Regulations 1999	Statutory instrument	All UK ports; the Regulations' scope of application is very broad with the only exception to "employment business" (defined as a business which supplies persons who are employed in it to work for and under the control of other persons in any capacity) being sea-going ships in respect to "normal *ship-board* activities" (emphasis added)	Parliamentary Under Secretary of State, Department of the Environment, Transport and the Regions	LAs or the HSE, in accordance with the Health and Safety (Enforcing Authority) Regulations 1998	These require an employer to make a suitable and sufficient assessment of the risk that the installation could present and to identify suitable preventative measures on the basis of defined general principles of prevention; they also require the employer to appoint one or more competent persons to assist the employer in complying with the Law
Managing health and safety in Dockwork (2002)	Guidance	SHAs; dock companies/operators; berth/terminal operators; storage/warehousing and freight forwarding operators	HSE	N/A	The Approved Code of Practice and guidance for the Docks Regulations 1988 and the Health and Safety at Work Act 1974. Aims to clarify legal duties and responsibilities for employers in the docks industry
The Control of Substances Hazardous to Health Regulations 2002	Statutory instrument	All UK ports	Secretary of State for the Department for Work and Pensions	HSE	Impose duties on employers to protect employees and other persons who may be exposed to substances hazardous to health and also impose certain duties on employees concerning their own protection from such exposure
ABP Southampton Harbour Byelaws 2003	Byelaw	Port of Southampton	ABP	N/A	Contain specific provisions dealing with the navigation of vessels, mooring and management of vessels and managing goods and road and rail traffic within the Port of Southampton (as defined under section 5 of the Southampton Harbour Act 1887)
Ports Good Governance Guidance (2018)	Guidance	All UK SHAs, but is also relevant to all organisations that own or manage harbour and port facilities	DfT	N/A	Focuses on the governance aspects of ports. From this angle, it contains specific sections which summarise key elements of an SHAs' safety responsibilities (drawing on existing guidance such as the PMSC) and what they entail for 'duty holders'

Guidance on Bulk Liquids (in ports) 2018	Guidance	All UK SHAs	HSE/Port Skills and Safety	N/A	Guidance for companies operating in the UK ports industry with responsibility for the safe design, construction, operation, management and maintenance of ports and terminal facilities and management of port and terminal activities. It addresses the loading, unloading and handling of bulk liquids in ports. It includes site design, operational planning safety equipment specific to liquids, management of hoses and transfer equipment as well as controlling spills and ensuring environmental protection. It does not cover landside storage of bulk liquids
The Port of Southampton Harbour Revision Order 20 (2020)	Statutory instrument	Port of Southampton	MMO	N/A	Amends the Southampton Harbour Act 1887 to clarify the definition of Port. Updates the regulatory powers of Associated British Ports at the Port of Southampton and confers additional powers on its harbour master at the Port to make directions regulating use of the Port and makes new provisions concerning the publications and enforcement of such directions
The Control of Major Accident Hazards Regulations 2015	Statutory instrument	Apply to establishments, as defined in regulation 2(1), where dangerous substances are present or are likely to be present in quantities equal to or exceeding the quantities specified in the Regulations.	Secretary of State for Work and Pensions	Except for a nuclear establishment, the HSE and the EA acting jointly (in England), the HSE and the Natural Resources Body for Wales (in Wales), and the HSE and Scottish Environment Protection Agency acting jointly (in Scotland)	Impose requirements on "operators" with respect to the control of major accident hazards involving dangerous substances, including: (a) taking all necessary measures to prevent major accidents and to limit their consequences for human health and the environment; (b) demonstrating to the competent authority that it has taken all measures necessary as specified in the Regulations (c) preparing and retaining in writing a major accident prevention policy containing specified information and to revise it in specified circumstances

Dangerous Goods in Harbour Area Regulations 2016	Statutory instrument	All UK ports	Secretary of State for Work and Pensions	Except for sites regulated by the Office for Nuclear Regulation (nuclear establishments), the HSE	Contain a set of safety provisions aimed at safeguarding ports against major accidents involving dangerous goods when they transit through ports, harbours and harbour areas. The purpose of the Regulations is to put in place certain specific measures to reduce the risk of a serious incident occurring.
Port Marine Safety Code (2016)	Guidance	All UK ports	DfT/MCA	MCA	Establishes a national standard for every aspect of port marine safety and aims to enhance safety for those who use or work in ports, their ships, passengers and the environment.
A Guide to Good Practice on Port Marine Operations (2018)	Guidance	All UK ports	DfT/MCA	MCA	Supplements the PMSC and contains useful information and more detailed guidance on several issues relevant to the management of ports and other marine facilities.
Environmental Protection Act 1990	Act of Parliament	Commercial, industrial, and any other activities (including storage) within UK ports which "are capable" of causing environmental pollution through the release/discharge of harmful substances into, *inter alia*, water	Secretary of State for Environment, Food and Rural Affairs	The EA or local authorities (pursuant to section 1(7)) in England, or the Scottish Environment Protection Agency in Scotland	Aims to prevent or minimise pollution of the environment due to the release of substances into any environmental medium (section 4(2)). Makes provision for the improved control of pollution to the air, water and land by regulating the management of waste and the control of emissions, and imposes a duty of care on those who produce, carry, keep, treat, dispose of or import controlled waste.
Bulk transfer of dangerous liquids and gases between ship and shore (1999)	Guidance	All UK ports	HSE	HSE for shore-side operations; MCA for ship-side operations	Contains guidance on practical measures to protect shore staff and ships' crews and others who might be affected by liquid bulk transfer operations in ports. It provides information on the fire, explosion, toxic and environmental hazards associated with the bulk transfer of dangerous liquids and gases between ship and shore, and sets out practical measures to prevent and minimise them (*e.g.* with regards to construction/design, operation and maintenance of equipment).

The Pollution Prevention and Control (England and Wales) Regulations 2000	Statutory Instrument	UK ports where activities listed in the regulations are undertaken, including gasification, liquefaction and refining activities and the loading, unloading or other handling of, the storage of, or the physical, chemical or thermal treatment of substances. The regulations do not apply in Scotland where the equivalent Pollution Prevention and Control (Scotland) Regulations 2000 apply.	Secretary of State for Environment, Food and Rural Affairs in the United Kingdom	The EA (England) or the competent local authority	Prevent and control pollution from various industrial activities by implementing an integrated approach to environmental permitting which requires operators of industrial installations to control the release of substances ("emissions") to air, water and land and develop plans for waste management, energy efficiency and accident prevention.
The Environmental Permitting (England and Wales) Regulations 2016	Statutory Instrument	UK ports where activities listed in the regulations are undertaken, including gasification, liquefaction and refining activities and the loading, unloading or other handling of, the storage of, or the physical, chemical or thermal treatment of substances. The regulations do not apply in Scotland where the equivalent The Environmental Authorisations (Scotland) Regulations 2018 apply.	Secretary of State for Environment, Food and Rural Affairs in the United Kingdom	The EA (England), Natural Resources Body (Wales), or the competent local authority	Streamline various environmental permitting regimes into a unified system which applies to various activities including industrial processes and waste management. The regulations require operators of facilities carrying out activities listed in its Schedules to obtain permits that detail conditions for controlling the release of substances ("emissions") to air, water and land, and to develop plans for waste management, for resource conservation, and for the protection of human health and the environment.
The Environment Act 2021	Act of Parliament	All UK ports	Secretary of State for Environment, Food and Rural Affairs in the United Kingdom	Office for Environmental Protection (OEP)	Establishes legally binding targets across environmental domains such as air and water quality and biodiversity. Improves environmental governance through the establishment of the OEP, with implications for the port sector.

Table 5. Summary of key legal instruments governing the health and safety and environmental protection aspects applicable in UK ports.

3.1.1 Health and safety

The H&S aspects of the handling of liquid CO_2 in the port of Southampton are underpinned by two principal pieces of legislation, namely, the HSWA and the Management of Health and Safety at Work Regulations (MHSWR). These establish a broader performance-based regulatory framework[93] within which duty holders are required to satisfy the regulator (the HSE) that appropriate measures have been taken to ensure the H&S and welfare of all involved in a port environment so far as is reasonably practicable. This is in line with the MCA's strategic aim to collaborate closely with the HSE on H&S aspects to ensure comparable levels of H&S for seafarers on merchant ships and fishing vessels as applies to workers ashore (see section 2.1.1 above). More specific legislation such as the 2003 Byelaws provide more detail on the respective duties of different actors within the Port of Southampton and therefore also merit consideration. Moreover, reference will be made in this section to the Dangerous Goods in Harbour Area Regulations 2016 (DGHAR) and the Control of Major Accident Hazards Regulations 2015 (COMAH), relevant for both H&S and environmental protection. The MSA95 contains some provisions conferring authority to SHAs to adopt H&S measures, but these are mostly with regards to providing aids to navigation and removing wrecks and abandoned vessels and will not be explored in this section. The MCA's Port Marine Safety Code (PMSC - November 2016) [147] and A Guide to Good Practice on Port Marine Operations (GPPMO - February 2018) [148] provide useful guidance to understand the complex legal framework applicable to ports in the UK and what it entails for various actors. They are endorsed by HMG, the devolved administrations and representatives from across the maritime sector. Although the Code is not mandatory, there is a strong expectation from regulating bodies that all harbour authorities will comply with them.

3.1.1.1 The Health and Safety culture[94] in UK ports

The H&S culture in UK ports is marked by an overarching responsibility for SHAs (or other organisations)[95] to satisfy the MCA that they have complied with the requirements of the PMSC through taking the necessary preventative and precautionary measures to eliminate risks or reduce them to the lowest possible level, so far as is reasonably practicable [147; 148]. As set out in the introduction of section 3.1, SHAs' respective powers, duties and geographical areas of jurisdiction set out in local Acts of Parliament or Harbour Orders have much in common but vary in detail.

SHAs must nominate a ''duty holder'' who is accountable for their compliance with the Code and their performance in ensuring safe marine operations. Often, the role of duty holder is performed by members of the management team or a board who are publicly accountable for marine safety under the Code (both collectively and individually). For example, the Director of Maritime and Compliance is the ABP Board member with responsibility for H&S matters within the ABP Group in the UK [149]. The SHA can also appoint officers to whom it delegates some powers. However, such delegations must be clear and must not obscure the accountability of the SHA and its duty holder. This could include appointing:

- Harbour master
- Chief executive
- Pilot
- Vessel Traffic Services (VTS) operator
- Tug crew

[93] See [35].
[94] Refer to footnote 42 and accompanying text above.
[95] Such as a marine terminal, jetty or berth operator, who may not have any statutory powers or duties but will need to consider the appropriate interpretation and applicability of duties incumbent upon SHAs under the Code and under common law (*i.e* duty of call to all harbour users).

- forums and committees that are in place to implement policies

3.1.1.1.1 Key health and safety requirements for SHAs

➔ Compliance with the PMSC

The appointed duty holder is responsible for ensuring that the SHA complies with the Code. The PMSC proposes behaviours and actions which duty holders can adopt to satisfy its duties. These include being aware of the organisation's powers and duties related to marine safety, ensuring that a suitable marine safety management system (MSMS) which has been adopted using formal safety assessment techniques is in place, appointing a "suitable" designated person to monitor and report the effectiveness of the MSMS and provide independent advice on matters of marine safety, and reporting compliance with the Code to the MCA every 3 years. The PMSC details that harbour masters' responsibility can include developing and implementing emergency plans and procedures, for regulating dangerous goods in transit on ships and for counter-pollution and waste disposal plans [147].

➔ Appointing a "designated person"

Each SHA must appoint an individual as the "designated person" to provide independent assurance directly to the duty holder that the MSMS is working effectively. These designated persons perform internal-audit functions, and their main responsibility is to evaluate the effectiveness of the MSMS in ensuring compliance with the Code through assessment and audit.

➔ Adopting measures to secure marine safety

This is primarily achieved through ABP Southampton's development and maintenance of an effective MSMS. The PMSC provides general principles to guide SHAs' satisfaction of this duty:

1. Powers, policies, plans and procedures should be based on a formal assessment of hazards and risks. This assessment should take account of risks arising out of the handling and/or storage of new commodities in bulk in ports (*e.g.* CO_2, Hydrogen).
2. The MSMS should be in place to ensure that all risks are controlled – the more severe ones must either be eliminated or reduced to the lowest possible level, so far as is reasonably practicable. It should also document and capture any custom and practices which may have become the standard approach to various port marine operations.
3. All parties involved in the safety of navigation must be competent and qualified in accordance with a minimum national standard.
4. [SHAs] should monitor, review and audit the MSMS on a regular basis.
5. [SHAs] should publish plans and an assessment of their performance in meeting their obligations at least once every three years.

The GPPMO further added that the key elements of successful MSMS include the adoption of effective safety policies which set a clear direction for the organisation to follow and having an effective management structure and arrangements in place for delivering the policy [148]. This includes policies to regulate the safe arrival, departure and movement within the harbour of all vessels, protecting the general public from dangers arising from marine activities within the harbour, and preventing acts or omissions that may cause personal injury to employees or others [147]. The GPPMO highlights that organisations must also learn from experiences and apply lessons where applicable, thus tying in a continuous cycle for effective safety management over time [148]. Moreover, the guidance adds that SHAs should commit to a safety policy to manage the relevant assets of the authority safely and efficiently and to ensure that staff are properly trained for emergencies and contingencies [148]. Other elements which should be included in the MSMS include confirming the roles and responsibilities of key personnel at the organisation and outlining present procedures for marine

safety within the harbour or facility [147]. Annex B of the GPPMO provides an example of a comprehensive MSMS contents list.

With regards to formal risk assessments, it is worth noting that they provide the basis for decision-making around the deployment of means to eliminate risks or, failing that, to reduce risks as low as reasonably practicable (ALAP chosen level of protection) [148]. This involves three stages:

1. identifying hazards and analysing risks;
2. assessing those risks against an appropriate objective criteria/standard of acceptability, without being influenced by the financial position of the authority;
3. where appropriate consider a cost-benefit assessment of risk-reduction measures [147]

The PMSC also adds that the guiding principle should be that "the greater the risk, the more likely it is that it is reasonable to go [through] the expense, trouble and invention to reduce it". Thus, it proposed a "hierarchy of risk control principles" which SHAs could adopt to satisfy their duties:

a. minimise risks – by suitable systems of working
b. combat risks – by taking protective measures to prevent risk; and
c. eliminate risks – by avoiding a hazardous procedure, or substituting a less dangerous one.

➔ General duties and powers *vs.* specific duties and powers

The PMSC and GGPMO distinguish between *general* duties and powers and *specific* duties and powers that have been identified for SHAs and are relevant to port marine safety. The former category imposes broad responsibilities on duty holders in respect of set "areas" inspired by existing laws and regulations, whereas the latter is concerned with specific duties and powers which relate to port safety and usually apply to SHAs. It is expected that duty holders should ensure that SHAs discharge their responsibilities with regards to both sets of duties [147;148]. With regards to general duties and powers, this includes:

- Safe and efficient port marine operations
- Open port duty
- Conservancy duty
- Environmental duty
- Civil contingencies duty
- Harbour authority powers
- Revising duties and powers

To illustrate, the general duty of safe and efficient port marine operations requires that SHAs take "reasonable care", that all who may choose to navigate in it may do so without danger to their lives or property so long as the harbour/facility is open for public use, that the safe use of the harbour/facility is conserved and promoted, that loss and injury through the SHA's negligence is prevented, and that the necessary action is taken to maintain and preserver the harbour/facility for safe use. Another relevant duty for the purposes of this study is the civil contingencies duty which is aimed at ensuring civil protection in the event of an emergency that threatens serious damage to human welfare (*e.g.* in our scenario, risk of asphyxiation due to the release of large amounts of CO_2 into the atmosphere). It is governed by the framework provided under the Civil Contingencies Act 2004 pursuant to which SHAs are classified as category 2 ''cooperating bodies''. Accordingly, they will be "involved" in the associated planning work, and "heavily involved" in responding to incidents that affect their sector – in which instances they are responsible for cooperating and sharing relevant

information with category 1 (emergency services and local authorities) and other category 2 responders [147].

With regards to specific duties and powers, the duty holder should also be aware of other specific duties and powers which are relevant to port safety, and usually applicable to SHAs including with regards to dangerous vessels and dangerous substances which must be effectively managed [147;148]. A good example are the powers recognised to the harbour master pursuant to The Port of Southampton Harbour Revision Order 2020 which is discussed below.

3.1.1.1.2 Compliance and Enforcement

In line with the performance-based regulation of health and safety aspects in UK ports whereby SHAs own the responsibility of satisfying the regulators (MCA and, as detailed in section 5.1.1.2 below, the HSE) that they have adhered to duties incumbent upon them under the existing legislative and regulatory framework, SHAs must *demonstrate* compliance with the PMSC. The GGPPMO offers guidance in this regard by providing that compliance with the standards set by the PMSC is achieved "in stages":

- Reviewing and being aware of existing powers based on local and national legislation;
- Confirming compliance with the duties and powers under existing legislation;
- Ensuring that a considered assessment of risks and the means of reducing them are in place;
- Operating and maintaining an MSMS based on risk assessment to ensure there is proper control over vessel movement;
- Using appropriate standards of qualification and training for all those involved in safety management and execution of relevant services;
- Establishing a robust procedure for auditing performance against the policies and procedures that the SHA has adopted to comply with the Code;
- Monitoring the standard achieved using appropriate measures and publishing the results.

Byelaws and directions adopted by the harbour master to manage identified marine risks must be backed by an appropriate policy on enforcement. SHAs must ensure that all policies and procedures are properly and effectively enforced and that these are supported by adequate resources [147]. Moreover, every three years, the duty holder should sign a statement describing the SHA's compliance with the Code. This statement should be sent to the MCA on a periodic basis. The MCA undertakes at least eight PMSC health check visits yearly, in various SHAs across the UK [147]. In compliance with these requirements, ABP Southampton has published the following documents (in their latest available versions at the time of drafting of this report):

1. Port Marine Safety Code Marine Safety Plan 2020-2023 (April 2020) [150]
2. Marine Policy (v 6.0) (April 2024; review date April 2025) [151]
3. Statement of ABP's Approach to Marine Enforcement (December 2020) [152]
4. Port Marine Safety Code, Annual Performance Review - Year ending 31st December 2021 (April 2022) [153]
5. Health & Safety policy statement (January 2022) [154]
6. Port of Southampton – Master Plan 2009-2030 (2010) [155]

3.1.1.2 The legal and regulatory framework governing the handling and storage of dangerous goods in UK ports

The H&S aspects of the handling and storage of dangerous goods in UK ports are primarily governed by the DGHAR and the COMAH. The powers of duly appointed harbour masters to direct vessels within a port environment might also have some relevance to this section of the report. Other merchant

shipping legislation and guidance documents apply to relevant aspects which will not be addressed, such as the ship-to-ship transfer of liquid dangerous substances in bulk[96] and the packaging and labelling of dangerous goods.

3.1.1.2.1 The Dangerous Goods in Harbour Area Regulations 2016

The DGHAR, which came into force on 1 October 2016, replaced the Dangerous Substances in Harbour Areas Regulations 1987 (DSHAR) together with its associated Approved Code of Practice.[97] These aim to safeguard against major accidents involving dangerous goods as they transit through ports, harbours and harbour areas through providing for specific measures to reduce risks of occurrence of serious accidents. The HSE's Approved Code of Practice L155 (ACP L155) provides practical advice on how to comply with the DGHAR [159]. One of the key changes between the DSHAR and the DGHAR is the replacement of the DSHAR's definition of "dangerous substances" by "dangerous goods" based on the latest applicable international standards, namely the IMO's IMDG Code. As detailed in section 2.1.1 above, liquified CO_2 is included in Class 2.2 "non-flammable, non-toxic gases" in the IMDG Code, and therefore falls within the remit of the DGHAR.[98] "Operator" is defined under the DGHAR, in relation to any mode of transport or a berth other than by road, as "the person who has operational control of it for the time being". As detailed in section 2.2.2.2, this will depend in a shipping context on the type of charterparty which the parties have contracted into. Under a voyage charterparty, the "operator" is likely to be the registered shipowner, whereas under a time charterparty, it is likely to be the charterer of the vessel. Regulation 5 lays out the locations and dangerous goods to which DGHAR apply. It provides that they apply "in Great Britain to – a) every harbour area;[99] b) premises or activities in any part of a harbour area in the territorial waters to which sections 1 to 59 of the 1974 Act apply under articles 6 (but only to the extent it relates to monobuoys)[100] and 11 of the Health and Safety at Work etc. Act (Application outside Great Britain) Order 2013 but not, except as provided in regulation 14, elsewhere". Commenting on this regulation, ACP L155 noted that "the boundary of Great Britain extends to those areas of the shoreline exposed at low tide". However, it acknowledged that some SHAs extend into territorial waters, but that in such instances the DGHAR only apply to premises and activities in relation to monobuoys, citing pipelines (that connect monobuoys to storage facilities within a harbour), and the loading, unloading, fuelling and provisioning of a vessel as examples [159].

A key requirement for operators under regulation 6 of the DGHAR is to give notice to the harbour master, the berth operator (where the goods are to be brought to a berth), and where relevant, to the harbour master of any abutting or overlapping harbour area, of any vessel before bringing any dangerous goods into the harbour area. Such notice must be given no less than 24 hours and no more than 6 months before the dangerous goods are brought into the harbour area. It must be in writing and must contain "sufficient information to assist a proper evaluation of the risk created by the goods

[96] Notably the Merchant Shipping (Ship-to-Ship Transfer) Regulations 2010 [156] and the MCA's MSN 1829 (M) [157], for ship-to-ship transfers; and The International Safety Guide for Oil and Tanker Terminals (ISGOTT), 6th Edition [158], for ship-to-shore transfer.

[97] These are the Approved Code of Practice on the Dangerous Substances in Harbour Areas Regulations 1987 (DSHAR) (COP18) and guidance document (HS(R)27).

[98] ACP L155 added that "[l]iquefied gases covered under the International Gas Carriers (IGC) Code will be in scope of the regulations as they will meet the criteria in the IMDG Code for Class 2 (Gases)".

[99] Regulation 2(1) defines "harbour area" as "any harbour, natural or artificial, and any port, haven, estuary, tidal or other river or inland waterway navigated by seagoing vessels" and includes "any monobuoy connected to one or more storage facilities in a harbour area and its monobuoy area".

[100] Regulation 2(1) defines "monobuoys" as "a mooring buoy at which dangerous goods may be loaded onto or unloaded from a vessel and which is connected to one or more storage facilities in a harbour area and includes any pipeline connecting to it".

to the health and safety of any person" (paragraph 4). Notice is not required in respect of vessels carrying non-explosive dangerous goods passing through the harbour area without unloading in that area, or of dangerous substances in a pipeline (paragraph 5). A harbour master duly appointed by a SHA generally has powers of direction to regulate when and how ships enter, depart from, and move within harbour waters, and for related purposes. This could include giving directions to prohibit the entry of any vessel into the harbour or requiring her removal therefrom, should the harbour master be satisfied that the condition of that vessel, or the nature or condition of its cargo, is such that its presence in the harbour might involve a "grave and imminent danger" to the safety of persons or property or risk that the potential sinking or foundering of the vessel in the harbour may "prevent or seriously prejudice" the use of the harbour by other vessels. Section 52 of the Harbours, Docks and Piers Clauses Act 1847 and regulation 7 of the DGHAR recognise these powers, and section 5 of The Port of Southampton Harbour Revision Order 2020 provided for additional power for the harbour master[101] to make directions for related purposes, including regulating the loading or discharging of cargo, fuel, water or ships' stores or the embarking or landing of persons.

Other key provisions under the DGHAR include the recognition under regulation 25 of the right for SHAs to make byelaws in respect of its harbour area prohibiting the entry or regulating the entry, carriage, handling or storage of dangerous goods; and the requirement under section 10 for SHAs to have in place an "effective emergency plan, before dangerous goods are permitted into the harbour area, for dealing with emergencies which may arise and which involve, affect or could affect dangerous goods that are brought into or are handled in the harbour area".[102]

As the SHAs for the Port of Southampton, ABP Southampton has the responsibility for enforcing Parts II and III of the DGHAR in the Harbour Area against persons other than itself [160]. It produced for this purpose guidance to assist masters, shipowners, agents and transport operators in preparing the information required by the harbour master, for example through requiring them to complete a checklist of information in Accordance with Schedule II of the Regulations before entering the Southampton Pilotage Area (see Figure 6) [161].

[101] As appointed by ABP at the Port and includes any deputies or assistants of the harbour master.
[102] This plan should be developed in consultation with the emergency services and any other relevant bodies, and requires the coordination of other plans which might be required under other pieces of legislation, such as the Civil Contingencies Act 2004 and the Management of Health and Safety at Work Regulations 1999.

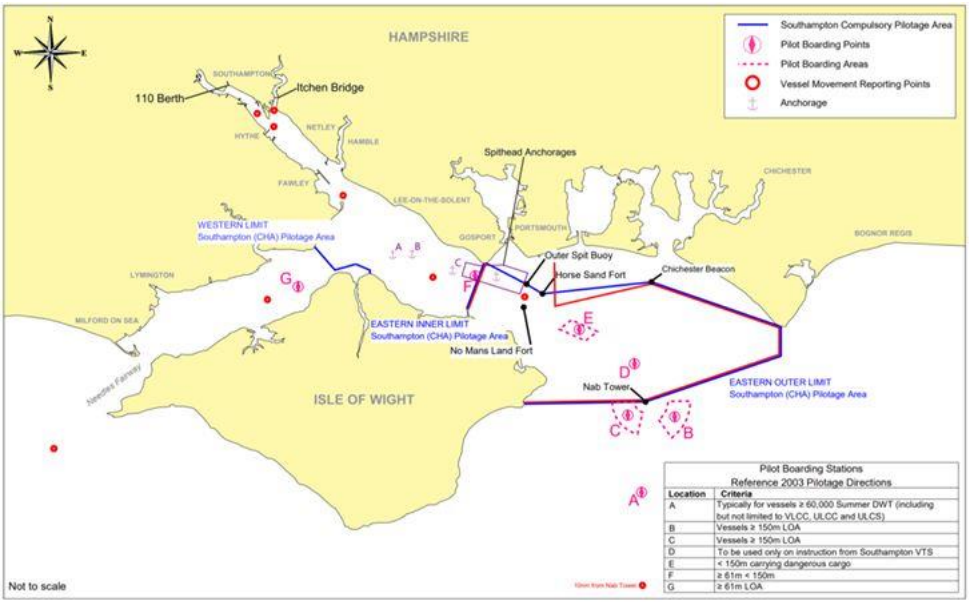

Figure 6. Geographical Limits of ABP Southampton Pilotage Area and Pilot Boarding Places (reproduced from [161])

3.1.1.1.1 The Control of Major Accident Hazards Regulations 2015

In contrast to the DGHAR, the COMAH are concerned with the regulation of the risk of "major accidents"[103] occurring in establishments in the UK due to the *storage* of dangerous substances therein rather than to their *transit* through such establishments. Regulation 2(1) of the COMAH defines "storage" as "the presence of a quantity of dangerous substances for the purposes of warehousing, depositing in safe custody or keeping in stock" and "establishment" as "the whole location under the control of an operator where a dangerous substance is present in one or more installations, including common or related infrastructures or activities, *in a quantity equal to or in excess of the quantity listed in the entry for that substance* [in Schedule 1]" (emphasis added). Therefore, the question of whether an establishment falls within the scope of application of the Regulations depends upon the *type* and *quantity* of substance(s) stored therein. When applicable, the Regulations impose a duty on operators[104] of establishments, where dangerous substances are present or are likely to be present in quantities equal to or exceeding the quantities specified in Schedule 1, to take all measures necessary to prevent major accidents and to limit their consequences for human health and the environment and to demonstrate to the HSE that they have taken all measures necessary pursuant to the Regulations. This applies for example with regards to flammable gases in excess of 10 tonnes, oxidising gases in excess of 50 tonnes, or Hydrogen in excess of 5 tonnes. The storage of these substances in quantities in excess of their respective limits in UK ports would therefore qualify the latter as "establishments" falling within the scope of the Regulations. "Dangerous substances" are however defined with reference to Schedule 1 of the Regulations (COMAH, regulation 2(1)), which do not include CO_2 in any form - neither by falling within a listed category of dangerous substances (Schedule 1 Part 1) nor as a named dangerous substance (Schedule 1 Part 2). Therefore, on the face of it, the storage of CO_2 falls outside the remit of the Regulations, including in UK ports, which entails that duties imposed on operators do not extend to the risks associated therewith.

[103] Defined as "an occurrence such as a major emission, fire, or explosion resulting from uncontrolled developments in the course of the operation of any establishment to which these Regulations apply, and leading to serious danger to human health or the environment (whether immediate or delayed) inside or outside the establishment, and involving one or more dangerous substances", regulation 2(1) of the COMAH.

[104] Defined as "the person who is in control of the operation of an establishment […], regulation 2(1) of the COMAH.

However, paragraph 5 of Part 3 of the COMAH envisages the scenario whereby a potentially dangerous substance is not covered by Schedule 1, specifying that this could include "waste". It notes that when such substances are present (or are likely to be present) in an establishment and possess (or are likely to possess), under the conditions found at the establishment, "equivalent properties [to those listed in the Schedule] in terms of major accident potential", they must be provisionally assigned to the most analogous category or named dangerous substance falling within the scope of these Regulations. As CCS activities are upscaled in the UK, it is expected that larger quantities of CO_2 will need to be temporarily stored in UK ports if shipping is going to be utilised as a mode of transport. As discussed in section 2.1.2.1, CO_2 poses some risks to health and to the environment which suggests that it might be sensible for it to be added as a new substance in Schedule 1 to avoid confusion around whether the regulation of CO_2 storage activities in UK ports falls under the scope of the COMAH. In any case, as discussed in the following sections, the EDR still impose some duties of prevention on the operators of risk-creating activities. However, in contrast to the COMHA, these are not concerned with managing the risk of *harm to human health* and are instead focused on the prevention and remediation of *environmental pollution*.

3.1.2 Environmental protection

The regulatory framework for occupational H&S in ports naturally has some implications for environmental protection. The PMSC, the DGHAR and the COMAH present good examples of how, through the prevention of major hazards in ports, not only is the H&S of workers and of the general public being safeguarded, but potential damage to the environment as a result of shipping and storage accidents is also prevented. Environmental protection is more specifically achieved through an established regulatory regime for environmental permitting which apply to installations where activities which can be harmful to the environment are undertaken. If applicable to CO_2 storage activities in UK ports, existing regulations would impose specific requirements on operators, which include the development of plans for waste management, accident prevention, and the protection of human health and of the environment. The HSE has also produced guidance aimed at those involved in transporting "dangerous liquids and gases" between ship and shore, which could be relevant for operations involving the transfer of liquified CO_2 at the loading/unloading port [162]. With an emphasis on achieving acceptable standards for H&S, the guidance sets out practical measures to assist those "directly responsible" for transfer operations with assessing the risks associated with their activities and with adopting measures to control them. Part of the guidance is concerned with the operation and maintenance of equipment used in transfer operations, which exemplifies instances where cooperation between the ship's master and harbour master is needed – *e.g.* with regards to controlling safe mooring operations, and adopting precautionary measures during cargo transfer.

The key environmental permitting regulations which could apply to CCS activities in UK ports are the EPR[105] and the Pollution Prevention and Control (England and Wales) Regulations 2000 [163] [PPC].[106] The regulations were made by the Secretary of State for Food Environment and Rural Affairs following consultation with the EA, in exercise of the powers conferred by section 2 of the Pollution Prevention and Control Act 1999 [164]. They aim to achieve "a high level of protection of the environment taken as a whole" by ensuring that operators of risk-creating activities adopt adequate measures to prevent or reduce emissions[107] into the air, water and land (regulation 8(2) and (3), PPC). Under both

[105] See [125]. The EPR's Scottish equivalent are the (Environmental Authorisations (Scotland) Regulations 2018 for Scotland).
[106] The PPC's Scottish equivalent are the Pollution Prevention and Control (Scotland) Regulations 2000.
[107] "Emission" under the regulations refers to "the direct or indirect release of substances, vibrations, heat or noise" from regulated facilities into the air, water, or land (regulation 2, EPR; regulation 2, PPC).

regulations "pollution" also refers to the detrimental effects which such emissions have on human health and damage to material property, including "hindering human senses"; and "pollutant" is defined as "any substance liable to cause pollution" (regulation 2, EPR; regulation 2, PPC). "Hazardous substance" is also defined under the EPR as "any substance or group of substances that are toxic, persistent and liable to bio-accumulate, or that give rise to an equivalent level of concern" (section 4(1), Schedule 22, EPR). The COSHH classes CO_2 as a "substance hazardous to health" and EH40/2005 set the CO_2 workplace exposure limits for occupational H&S. A coherent application of H&S and environmental protection regulations in the UK would therefore indicate that CO_2 falls within the definitions for "hazardous substance" and "pollutant" under the EPR and the PPC. But a deeper examination of the latter's provisions paints a much more complex picture. Ultimately, the question of the applicability of the regulations to CO_2 storage activities as part of CCS will determine whether specific measures are required from operators to prevent environmental pollution associated with those activities due to the release of CO_2.

The environmental permitting regulations apply to a wide range of industrial processes, waste management operations and polluting activities. They apply primarily to installations where activities listed in the regulations' Schedules are undertaken (paragraph 1(1), Part 1, Schedule 1, EPR; regulation 2(1)(iv), PPC – these are also referred to as "regulated facilities"). Although, the EPR also apply to activities not specifically listed in its Schedules if they meet certain thresholds or criteria (*e.g.* water discharge activities, discussed below). Pursuant to Part 2 of the EPR and Part II of the PPC, operators[108] of activities falling within the scope of the regulations must obtain an environmental permit prior to operating the facilities in which they are undertaken and must for that purpose satisfy the competent authority of the conditions contained in those Parts. Importantly, the EPR also impose this requirement on those *operating* facilities where water discharge or groundwater activities are undertaken, which fall within the scope of the definition of "regulated facility" (regulation 7, regulation 8(1) and (4) and regulation 12(1)(a), EPR), or those who *cause or knowingly permit* such activities (regulation 12(1)(b), EPR). This entails that, unless the water discharge or groundwater activity in question is an "exempt facility" (pursuant to regulation 5, EPR), those engaged in it are subject to the permit requirements even when they are not operators in the meaning prescribed under regulation 7 of the EPR (regulation 12(2), EPR). This arguably includes CO_2 shippers when passing through ports given that:

1. "Water discharge activity" is defined under Schedule 21 as "the discharge or entry to […] coastal waters or relevant territorial waters" of, *inter alia*, "noxious or polluting matter" or "waste matter".
2. "Pollution"[109] and "pollutant" are broadly defined under the EPR as described above, and arguably include CO_2.
3. The reference to Council Directive 2008/98/EC on waste [165] [the Waste Framework Directive] to define "waste" in "waste matter" (paragraph 2, Schedule 21, EPR) as "any substance or object which the holder discards or intends or is required to discard".

[108] Defined in relation to having "control" over the operation of regulated facilities (regulation 7, EPR; regulation 2(1), PPC).

[109] "Pollution" is specifically defined in respect of water discharge activities as "the direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may (a) be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems; (b) result in damage to material property; pr (c) impair or interfere with amenities or other legitimate uses of the environment.

With regards to 3. above, the argument is that whilst CO_2 in its gaseous form is usually emitted as a by-product which climate change legislation aims to mitigate and is explicitly excluded from the Waste Framework Directive's definition of "waste",[110] it may be considered as a product of certain industrial processes such as CCS which involve its capture and liquefaction. In such instances, the liquified CO_2 is *intended for disposal* and would not have any intrinsic value or utility for further use, which would bring it within the scope of the Waste Framework Directive's definition of "waste".

The conditions for environmental permits include the adoption of measures to control emissions, prevent pollution, and mitigate potential environmental impacts associated with regulated facilities (under the EPR and the PPC) or with causing/knowingly permitting water discharge and groundwater activities (under the EPR). The specific conditions of environmental permits are set out by the regulator pursuant to paragraph 2(1), Part 1, Schedule 5 of the EPR, and regulation 11 of the PPC. For example, Part B1 of EA's environmental permit form for standard facilities under the EPR requires applicants to have "an effective" written environmental management system in place which satisfies the regulator that risks of pollution are identified and reduced [166]. Similarly, regulation 11 of the PPC is subjected to the general principles provided for under paragraph (2) thereof, which requires that regulated facilities are operated in such a way that "(a) all the appropriate preventative measures are taken against pollution, in particular through application of the best available techniques; and (b) no significant pollution is caused". Moreover, Part 3 of the EPR and Part III of the PPC both provide for the power of the competent authority to enforce the regulations by serving a notice on permit holders who have contravened or are likely to contravene any condition of their permit. The EPR also recognise the power of the competent authority to take action to prevent pollution or remedy it and then have recourse against the operator of the regulated facilities to recover the costs (regulation 57, EPR). In England, the competent authority under the EPR and PPC is either the EA or the local authority (as defined under regulation 6 of the EPR and regulation 8 of the PPC), depending on the description and class of the facility being regulated [167].

As highlighted in section 2.2.2.2 above, the capture of CO_2 streams is an activity which is provided for in Part 2 of Schedule 1 of the EPR, which would bring the installation where it is performed within the scope of the regulations (section 6.10, Chapter 6, Part 2, Schedule 1, EPR). Interestingly, section 6.10 specifies that such capture of CO_2 must be "from an installation" and "for the purpose of geological storage". Whilst the CCS scenario being examined in this report satisfies the second of these conditions, it is worth expanding on the first to explain the relationship between CO_2 capture and other activities provided for under the EPR. In this regard, it must be noted that "installation" is defined under Schedule 1 of the EPR as "a stationary technical unit where one or more activities are carried on […]" (paragraph 1, Schedule 1, EPR). Therefore, the CO_2 capture activity described in section 6.10 would bring the capture facility where it is undertaken within the scope of the EPR so long as it is concerned with the capture of CO_2 streams from an installation where one or more of the activities listed in Part 2 of Schedule 1 of the EPR (*e.g.* energy activities; the production and processing of metals; chemical activities) are undertaken. While it's less common for ports themselves to have CO_2 capture facilities, there are instances where such facilities may be located within ports in the UK, particularly in industrial port areas with heavy manufacturing or processing activities. The port of Immingham is a good example of that, with several heavy industries and industrial activities taking place within its area - including oil refining and chemical manufacturing - and projects like HumberZero being expected to enable the capture of CO_2 emissions from such processes. However, it is not a requirement pursuant to section 6.10 for the CO_2 capture and the activity undertaken on the installation from which the CO_2

[110] Article 2.1(a) of the Waste Framework Directive excludes "gaseous effluents emitted into the atmosphere" from its scope of application.

streams are captured to be carried out on the same site. The SHA in question would be a "regulated facility" even when the CO_2 capture facility within its boundaries is engaged in capturing streams from regulated facilities falling outside the limits of the port. In contrast to the EPR, the PPC do not include CO_2 capture in the activities it lists in Schedule 1 thereof.

It must also be noted that both the EPR and the PPC also apply to "directly associated activities", which refers to operations that (1) have a technical connection with activities listed in the regulations' Schedules; (2) are carried out on the same site as the facility in question; *and* (3) present a risk to the environment (section 1, Part 1, Schedule 1, EPR; section 1(e), and section 2(1), Part 1, Schedule 4, PPC). Where capture plants are located within the boundaries of a SHA, the liquefaction, storage, handling, and loading/unloading activities associated with the capture of CO_2 could constitute "directly associated activities" if they are carried out "on the same site" as the capture plant, thus bringing them under the scope of the regulations as activities which operators must obtain a permit for and prevent or minimise pollution from.

Whilst the EPR and the PPC apply to gasification, *liquefaction* and refining activities (section 1.2, Chapter 5, Part 2, Schedule 1 , EPR; section 1.2, Chapter 1, Part 1, Schedule 1, PPC) and to the storage, loading, unloading and handling activities associated with them (section 1.2 (e), Chapter 5, Part 2, Schedule 1, EPR; section 1.2(h), Chapter 1, Part 1, Schedule 1, PPC), these liquefaction activities covered under the regulations do to apply to CO_2 and are rather restricted to coal, other fuels and carbonaceous materials (section 1.2 (c), (e) and (g), Chapter 5, Part 2, Schedule 1, EPR; section 1.2 (h) and (j), Chapter 1, Part 1, Schedule 1, PPC). However, the liquefaction of CO_2 and its storage might be regulated under the EPR and the PPC under other provisions, which will be discussed in the following paragraphs.

The regulation of CO_2 storage as a waste management activity

The provisions under the EPR and PPC which govern waste operations could apply to the regulation of CO_2 storage activities as part of CCS within ports in the UK. Foremost, this depends on whether CO_2 is considered a "waste" under the regulations. But the qualification of it as "hazardous" or "non-hazardous" also determines the specific requirements of the regime governing such activities. The definition of "disposal" under the regulations is also worth unpacking. In this regard, reference is made under the EPR and the PPC to other legislation which apply more specifically to waste management in the UK. The most relevant of those is the EU's Waste Framework Directive, although reference is also made to repealed legislation which could be helpful for the interpretation of the EPR and PPC's waste management provisions. The analysis of whether these provisions apply to CO_2 storage in ports is complicated by the reference in different parts of the regulations to different legislation to define "waste", "hazardous" and "non-hazardous". For example, under the EPR, "hazardous waste" is defined with reference to the Hazardous Waste (England and Wales) Regulations 2005 and the Hazardous Waste (Wales) Regulations 2005 (regulation 2(1), EPR), whereas the definition under the Waste Framework Directive applies with regards to activities falling within Chapter 5 of Part 2 of Schedule 1 or Schedule 13 of the regulations (regulation 2(7), EPR). Moreover, the EPR and the PPC deal with different waste management approaches. For example, Chapter 5 of Part 2 of Schedule 1 of the EPR deals with the incineration and co-incineration of waste (section 5.1), the disposal of waste by landfill (section 5.2), and the temporary or underground storage of hazardous waste (section 5.6); whereas Chapter 5 of Part 1 of Schedule 1 of the PPC deals with the disposal of waste by incineration (section 5.1), by landfill (section 5.2) and by ways other than by incarnation or landfill (sections 5.3). It is therefore important to refer to the relevant provisions of the EPR and the PPC and the appropriate supporting legislation when examining whether and how do the regulations apply to the temporary storage of CO_2 in UK ports.

The definition of "waste" and "disposal" under the PPC

"Waste" is not defined under the PPC, but "hazardous waste" is defined according to Article 1(4) of Directive 91/689/EEC [168] (paragraph 1, section 5.3, Part 1, Schedule 1, PPC) as those featured in a list drawn up according to a procedure laid out in Directive 75/442/EEC and having "one or more of the properties listed in Annex III". "Non-hazardous waste" arguably refers to waste which does not fall within the Article 1(4) definition.[111] Although not referred to by the PPC, Directive 91/689/EEC also refers to Directive 75/442/EEC to define "waste" as "any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard" (Article 1(3), Directive 91/689/EEC; and Article 1(a), Directive 75/442/EEC). Both European Directives were superseded by the Waste Framework Directive, which adopts a broader definition of "waste" which does not tie it to categories listed in its Annexes. According to the latter, "waste" means "*any substance or object* which the holder discards or intends or is required to discard" (emphasis added; Article 3(1), Waste Framework Directive). This definition entails that the classification of CO_2 as a waste depends on its intended use, but also on it being possessed by the "holder", who is defined as "the producer of the waste or the natural or legal person who is in possession of it" (Article 1(c), Directive 75/442/EEC; Article 3.6, Waste Framework Directive). As discussed above, a distinction must be drawn here between scenarios where CO_2 in its gaseous form is merely a by-product of industrial activities, and scenarios where it is a product of industrial processes such as CCS, where the CO2 is processed and stored with an ultimate intention to dispose of it permanently. This distinction is also reflected in Article 2 of the Waste Framework Directive, which excludes "gaseous effluents emitted into the atmosphere" from its scope (Article 2(a), Waste Framework Directive). This categorisation of CO_2 has important implications on its regulation under different primary and secondary legislation in line with adopted environmental and climate change policies in the UK. It is argued that an interpretation of "waste" which is consistent with the Waste Framework Directive brings CO_2 within the scope of the section 5.3, Part 1, Schedule 1 of the PPC, which is concerned with pollution control and environmental protection rather than mitigating climate change.

Section 5.3, Part 1, Schedule 1 of the PPC applies to the disposal of waste other than by incineration or landfill and includes within the scope of the regulations installations where "hazardous" and "non-hazardous" waste is disposed of when their daily capacities exceed specified limits. The installation needs to have the capacity to receive more than 10 tonnes per day for hazardous waste, and more than 50 tonnes per day for non-hazardous wastes.

"Disposal" in relation to hazardous waste is defined as "any of the operations described in Annex IIA to the Council Directive 75/442/EEC on waste" (paragraph 1, section 5.3, Part 1, Schedule 1 of the PPC). The latter lists disposal operations which it subjects to the requirement of preventing harm to human health and to the environment. Amongst those operations the Annex includes D7 "release into seas/oceans including sea-bed insertion" and D15 "storage pending any of the operations numbered D1 to D14 (excluding temporary storage, pending collection, on the site where it is produced)". Therefore, subject to liquified CO_2 being legally construed as a "hazardous waste", the temporary storage thereof in ports with capacity of more than 10 tonnes per day ahead of subsequent storage in offshore geological formations is an activity which brings the ports in question within the scope of the requirements under the PPC. However, a reading which emphasises on the exception in operation D15 might suggest that this does not include the scenario where the CO_2 is "produced" on the site

[111] This is consistent with the Waste Framework Directive's definition of "non-hazardous waste". See Article 3(2a) of the Waste Framework Directive.

where it is temporarily stored pending collection.[112] This arguably applies to the scenario where the CO_2 is liquified within the port and temporarily stored pending its collection by ships.

But in any case, this scenario might be covered by another operation described in Annex IIA which might be relevant for the regulation of CO2 storage activities in ports as part of CCS, namely operation D9, "physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures *which are discarded by means of any of the operations numbered D1 to D12*" (emphasis added). Given that the methods employed for CO_2 capture (*e.g.* absorption, adsorption, membrane separation, cryogenic separation) and that the compression and cooling processes involved in CO_2 liquefaction aim to manipulate its physical and chemical properties, they arguably constitute "physico-chemical" treatments of CO_2 in its gaseous form. In the CCS scenario examined in this report, the liquified CO_2 is then "the final compound" intended to be injected under the seabed, which fits within the description of operation D7 (thereby satisfying the condition under D9). However, the disposal operation described in D9 still needs to concern a "hazardous waste" for it to bring the facility where it is conducted within the scope of the PPC. Considering the definitions of "waste" and "holder" discussed above, it is argued that captured CO_2 does not fit within the definition of "waste", whereas liquified CO_2 which has already been captured does. Although the former type of CO_2 is intended to be discarded of, it is regarded as a by-product of industrial processes and is not in the possession of the "holder" prior to it being captured; whereas the latter type would have already undergone a process of which it is a product, is in possession of the capture facility or liquefaction facility operator and is intended to be discarded permanently. This brings CO_2 liquefaction installations with a capacity of more than 10 tonnes per day within the scope of the PPC if the CO_2 is construed as "hazardous", but not CO_2 capture installations. However, the capture of CO_2 and the storage of liquified CO_2 can still constitute "directly associated" activities under the PPC if they are undertaken within the same installation. Where CO_2 is disposed of via "physico-chemical" treatment at liquefaction installations with a capacity of more than 10 tonnes per day which are located within the boundaries of a port, such associated temporary storage activities within the port would also fall within the scope of the PPC. And the PPC do not provide for any specific tonnage threshold to be crossed for such associated storage activities. Rather, the threshold applies to the main [disposal] activity being regulated.

"Disposal" is not directly defined in relation to "non-hazardous waste". But reference is made under the PPC to the same Annex in Directive 75/442/EEC to specify types of non-hazardous waste operations which are governed by the regulations. This suggests that, due to its less risky nature, disposal in relation to non-hazardous waste is defined as those specific operations whereas other disposal operations, such as D15, are only regulated if the waste in question is "hazardous". One of two operations which the PPC refers to in relation to non-hazardous waste is D9 described above (Part A(1)(c), section 5.3, Part 1, Schedule 1 of the PPC). This brings ports where CO_2 liquefaction and associated activities, including storage, with a capacity of more than 50 tonnes per day within the scope of the PPC, even if CO_2 is not considered "hazardous".

The different conditions for the application of the PPC's provisions governing hazardous and non-hazardous waste disposal activities other than by incineration and landfill (section 5.3, Part 1, Schedule 1 of the PPC) to CO_2 storage in UK ports as part of CCS are summarised in Figure 7 below. It illustrates that such CO_2 storage activities can fall within the scope of the PPC, imposing requirements on the

[112] An argument is made to the contrary in the developments below, based on an analysis under the Waste Framework Directive.

operators of UK ports where they are undertaken even where CO_2 is not construed as a "hazardous" waste.

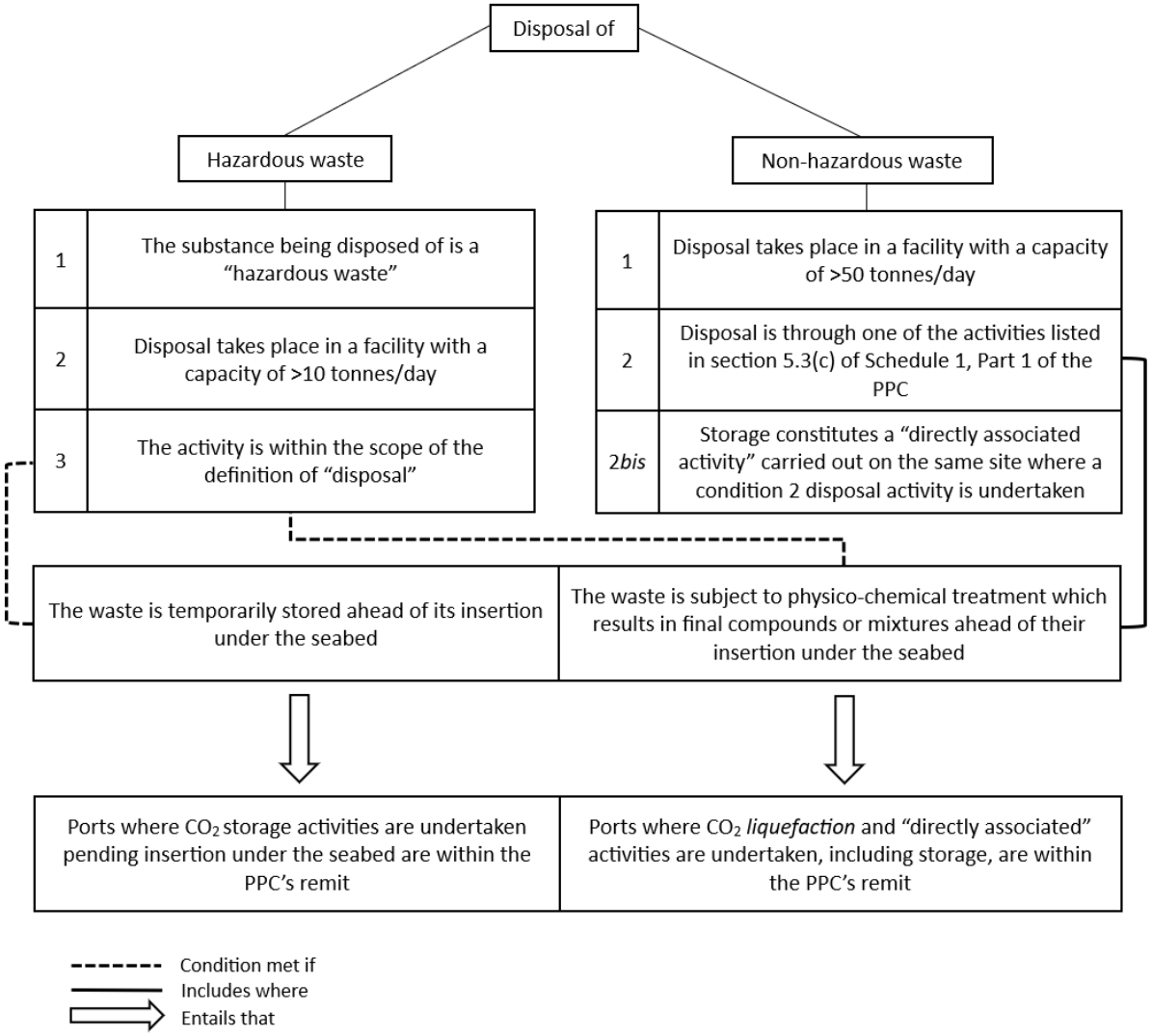

Figure 7. The conditions for the application of the PPC's provisions governing waste disposal activities other than by incineration and landfill to CO_2 storage activities as part of CCS in UK ports, considering the PPC's *exclusion* of gaseous effluents emitted into the atmosphere from its definition of "waste".

The definition of "waste" and "disposal" under the EPR

The EPR also regulate installations where waste disposal activities take place and impose distinct regimes in relation to hazardous and non-hazardous waste. "Disposal" is defined under the EPR in Schedule 9, which applies in relation to "every waste operation" (paragraph 1, Schedule 9, EPR), by referring to the Waste Framework Directive. The latter defines "disposal" as "any operation which is not recovery […]" and refers to a list of operations which constitute "disposal" in Annex I. The listed operations mirror those contained in Annex IIA to the Directive 75/442/EEC which the PPC refers to. However, the Waste Framework Directive, specifies that the list is not exhaustive, thereby adopting a broader definition to disposal operations which might fall within its scope. "Recovery" is defined under the Waste Framework Directive as "any operation the principal result of which is waste serving a useful purpose […]". This excludes the scenario involving liquified CO_2 which is being considered in this report, where it is intended to be discarded permanently through injecting it under the seabed. Considering that the Waste Framework Directive superseded Directive 75/442/EEC, it is suggested

that the provisions of the PPC making reference to the latter are interpreted consistently with the former. This position also supports the consistent application of the EPR and the PPC in the UK, which overlap in their scope of application with regards to the management of waste disposal activities.

Another notable difference between the Waste Framework Directive and Directive 75/442/EEC is the footnote added to disposal operation D15 in Annex I, which clarifies that "temporary storage" means "preliminary storage" and refers to Article 3(10) for further clarification. According to Article 3(10), "temporary storage" means the process of gathering the waste in question and preliminarily sorting/storing it "for the purposes of transport to a waste treatment facility". As discussed above, one interpretation of the disposal operation described in paragraph D15 of Annex IIA to Directive 75/442/EEC is that operations where the CO_2 in question has been liquified in a facility outside of a port, and then temporarily stored within the port before being collected for its eventual release under the seabed (operation D7 in the Annex) would fall outside of the scope of the PPC. However, the Waste Framework Directive reading of the same operation suggests that this scenario does not fall within the exception to D15, given that the temporary storage of the CO_2 would be ahead of its transport to either another temporary storage in another port, or for it to be injected under the seabed.

Regulation 2(1) of the EPR explicitly defines "waste" in relation to Chapter 5 of Part 2 of Schedule 1 thereof, which governs waste management activities, by referring to Article 3(1) of the Waste Framework Directive and the exclusions under Article 2(1)(d) of that Directive (concerned with radioactive waste). It is interesting that the EPR does not directly refer to the other exclusions under Article 2(1) of the Waste Framework Directive, including exclusion (a) "gaseous effluents emitted into the atmosphere", which applies to CO_2 emissions from industrial processes. This can be explained by the fact that this definition of waste under the EPR also applies in relation to Schedules 13 to 15, 17 and 19 thereof. Schedule 15 is concerned with large combustion plants and is a transposition of the Industrial Emissions Directive [169] into UK law which aims to lower emissions from industrial production through an integrated approach and commits [EU] Member to control and reduce the impact of industrial emissions on the environment. Therefore, applying exclusion (a) under the Waste Framework Directive to the definition of "waste" under the EPR in its current form would bar it from being applied to Schedule 15 of the regulations. This interpretation is supported by the fact that waste is defined under the EPR "in any case" other than in relation to Chapter 5 of Part 2 of Schedule 1 and Schedules 13 to 15, 17 and 19 as any waste within the meaning of Article 3(1) of the Waste Framework Directive which is not excluded from its scope by Article 2(1), (2), or (3) of the Directive. This suggests that the specific mention of the exclusion under Article 2(1)(d) of the Waste Framework Directive in relation to waste management activities intends to adopt a broader definition for "waste" under the EPR than under the Directive. This creates a split in the definition of "waste" under the PPC and the EPR particularly with regards to the interpretation of whether it includes "gaseous effluents emitted into the atmosphere" (exclusion (a), Article 2(1), Waste Framework Directive), which leads to discrepancy in their scope of application to regulate installations where CO_2 capture, CO_2 liquefaction, and activities directly associated with these processes are undertaken in the UK.

Sections 5.3 and 5.4 of Part 2 of Schedule 1 of the EPR deal respectively with the disposal of hazardous and non-hazardous waste by including them in the list of activities which bring installations where they are run within the scope of the regulations. Whilst the provisions under these sections might be relevant for CO_2 storage activities in ports in the UK, section 5.6 of the same Part deals specifically with the temporary storage of hazardous waste. The combined reading of these sections results in two regimes applicable to the storage of CO_2 as a hazardous waste, and a regime for its storage as a non-hazardous waste.

Section 5.3 covers the disposal of hazardous waste with a capacity exceeding 10 tonnes per day which "involves" one or more of the activities it lists. "Involves" is interpreted to mean that the disposal is conducted at least in part via one or more of the listed activities. This entails that "disposal" is interpreted more narrowly under the EPR in relation to *hazardous waste* than it is defined under the Waste Framework Directive which also refers to other activities that are covered by other provisions under the EPR. Activity (ii) in the section, "physico-chemical treatment", is relevant for CCS activities given that it encompasses both CO_2 capture and CO_2 liquefaction processes. It entails that it is a requirement that the capture or liquefaction of CO_2 is the mechanism through which it is disposed of with a capacity exceeding 10 tonnes per day for the installation where the activity is taking place to be brought within the scope of the EPR. However, for the section to apply to these CCS activities, the substance undergoing the physico-chemical treatment would still need to be regarded as a "waste", let alone a hazardous one. Given that, unlike under the PPC, the definition of "waste" under the EPR does not exclude gaseous effluents emitted into the atmosphere, the CO_2 being disposed of through its capture as a gaseous by-product of industrial processes and the captured CO_2 undergoing liquefaction *both* fall within the scope of section 5.3 of the regulations should it also be considered hazardous.[113] Pursuant to paragraph 1(2) of Part 1 of Schedule 1 of the EPR, the temporary storage of the captured or liquefied CO_2 would constitute an activity which is directly associated with its physico-chemical treatment where it is carried out on the same site (assuming that the two other conditions under the paragraph are met, namely, that the two activities in question are technically connected, and that the directly associate activity [storage] carries an environmental risk). However, in contrast to the regime under section 5.6 of Part 2 of Schedule 1 of the EPR (discussed below), such storage does not need to precede the disposal activity which is covered by the regulations (namely, the capture or liquefaction of hazardous waste with a capacity exceeding 10 tonnes per day), and there are no specific thresholds which need to be crossed for it to fall within the scope of the regulations (the threshold rather applies to the disposal activity in question). As discussed above, the situation is different under section 5.3 of Chapter 5 of Part 1 of Schedule 1 of the PPC which, due to its narrower definition of "waste", applies to ports where CO_2 liquefaction and directly associated activities are undertaken (including temporary storage), but not to facilities where CO_2 capture is the main activity being undertaken.

In contrast, section 5.6 brings within the scope of the EPR installations where hazardous waste is temporarily stored with a total capacity exceeding 50 tonnes when such storage is "pending any of the activities listed in sections 5.1 to 5.3 […]". Section 5.1 and 5.2 are not relevant for this report, as they deal respectively with the incineration of waste and the disposal of waste by landfill. And, as highlighted above, section 5.3 is concerned with the disposal of hazardous waste, but only through one of the activities it lists. Compared to the regime under section 5.3 and paragraph 1(2) of Part 1 of Schedule 1 of the EPR, the temporary storage of the hazardous waste under section 5.6 must (1) be in excess of 50 tonnes, and (2) precede the disposal activity in question.

The relevant section 5.3 activity for CCS purposes is the physico-chemical treatment of the hazardous waste, which, when applied to CO_2 encompasses both its capture and its liquefaction. The EPR apply to the disposal of CO_2 through both processes, but this does not entail that they also apply to its temporary storage pending such disposal pursuant to section 5.6. Importantly, unlike the Waste Framework Directive which lists it in its Annex I (operation D7), section 5.3 does not include the

[113] This is also consistent with the fact that section 6.10, Chapter 6, Part 2, of Schedule 1 of the EPR specifically lists the capture of CO_2 streams from installations for the purposes of geological storage in Schedule 1 thereof as an activity which would bring the installation where it is undertaken within the scope of the regulations, whereas the PPC do not.

disposal of wastes via sea-bed insertion in its list of activities. Therefore, the temporary storage of liquified CO_2 ahead of its disposal in offshore geological storage would not constitute an activity bringing the installation where it is conducted under the scope of the EPR. Moreover, within a CCS context, any storage of CO_2 related to industrial processes is not practically possible prior to its capture. Thus, the temporary storage of CO_2 ahead of its capture is not a realistic scenario which can be regulated under section 5.6. However, the section applies to the temporary storage of >50 tonnes of captured CO_2 pending its disposal via liquefaction, bringing ports where this temporary storage activity is undertaken within the scope of the EPR if the CO_2 is considered hazardous.

Lastly, section 5.4 of Part 2 of Schedule 1 of the EPR describes the non-hazardous waste disposal activities which bring installations where they are conducted with a capacity of more than 50 tonnes per day within the scope of the regulations. The section can be relevant for the storage of the non-hazardous waste regulated thereunder if it meets the requirements for it to constitute a directly associated activity pursuant to paragraph 1(2) of Part 1 of Schedule 1 of the EPR, including being carried out "on the same site". One of the disposal activities listed under section 5.4 is through "physico-chemical treatment" (paragraph a(ii), section 5.4), which, as discussed above, encompasses both capture and liquefaction processes. And given that the definition of "waste" under the EPR is wide enough to include CO_2 as a by-product from industrial processes, its capture and its liquefaction *both* constitute activities through which it could be disposed of under section 5.4. Therefore, based on the section 5.4 regime, UK ports would fall within the scope of the EPR and its requirements, notably with regards to the duties incumbent upon the SHAs operating them, where CO_2 capture *and/or* liquefaction activities and directly associated storage activities are undertaken within them. No capacity threshold applies to directly associated storage activities, and they do not need to precede the disposal of the CO_2 in question (unlike the regime under section 5.6), but the disposal activity(ies) should be in excess of 50 tonnes per day, compared to 10 tonnes per day if the CO_2 is considered "hazardous".

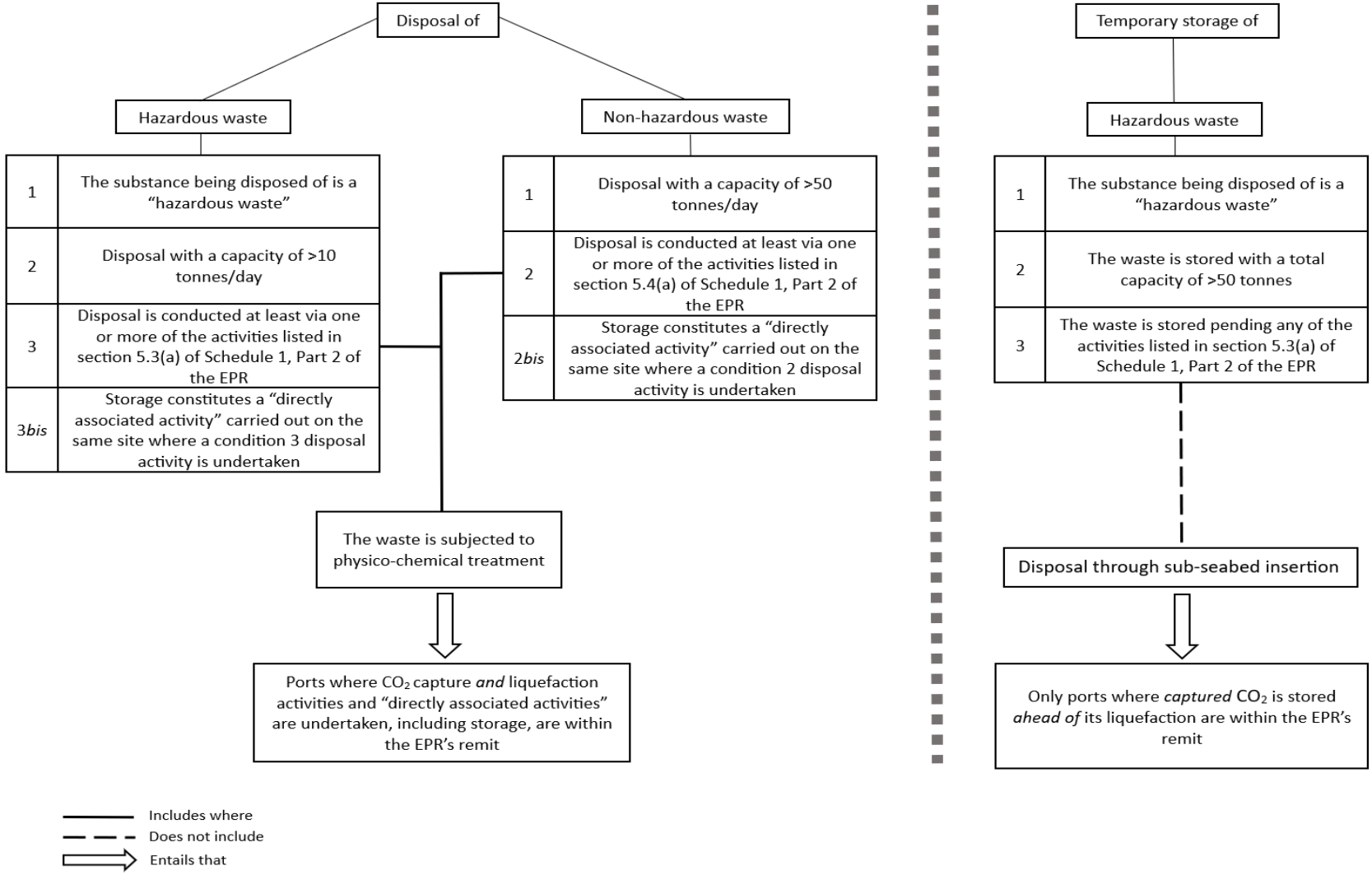

Figure 8. The conditions for the application of the EPR's waste management provisions to CO_2 storage activities as part of CCS in UK ports, considering the EPR's *inclusion* of gaseous effluents emitted into the atmosphere in its definition of "waste"

Table 6 below demonstrates how the different conditions for the regulation of waste disposal and temporary storage activities under the PPC and EPR (detailed in Figures 7 and 8) lead to discrepancies when applied to CCS activities in UK ports. The varying conditions, coupled with a mismatch in the definition of "waste" and "disposal", lead to confusion about the environmental permitting requirements incumbent upon the operators of activities constituting the different components of the CCS process in ports (*i.e.* capture, liquefaction, and temporary storage). Most notably, this includes satisfying the regulator - the EA - that risks of pollution from their activities are identified and reduced through the adoption of effective environmental management systems.

For example, CO_2 storage which is "directly associated" with liquefaction activities in UK ports with a capacity of more than 50 tonnes/day are subject to environmental permitting requirements pursuant to section 5.3(c), Part 1, Schedule 1 of the PPC *and* section 5.4, Part 2, Schedule 1 of the EPR. But only the regime under the latter governs storage associated with CO_2 *capture* activities in UK ports which are not regulated under the PPC due to a narrower definition of "waste". Moreover, if CO_2 is considered a "hazardous" waste in accordance with the regulations (which is discussed in detail below), the environmental permitting requirements would be triggered for storage activities in ports with a capacity of as little as more than 10 tonnes/day (section 5.3, Part 2, Schedule 1, EPR).

Furthermore, there are at least two other regimes governing the storage of CO_2 as part of CCS in UK ports, if it meets the criteria for being "hazardous" - namely, (1) the EPR's regime governing temporary storage of hazardous wastes (section 5.6, Part 2, Schedule 1); and (2) the PPC's regime governing hazardous waste disposal activities, including via temporary storage ahead of insertion under the seabed (section 5.3(a), Part 1, Schedule 1).

Divergence amongst the regimes governing hazardous waste activities include the fact that the EPR's section 5.6 regime is conditioned upon the port where the waste in question is stored to exceed a *total capacity of 50 tonnes*, whereas the EPR's section 5.3 and the PPC's section 5.3(a) regimes are conditioned upon the port in question having the capacity to store *10 tonnes of CO_2 per day*. Another key distinction is the fact that the former is primarily concerned with *temporary storage* activities pending disposal through one or more of the activities listed in section 5.3, Part 2, Schedule 1 of the EPR, whereas the latter are primarily concerned with *disposal* activities, which, in the case of the PPC's section 5.3(a) regime is performed through storage activities pending insertion under the seabed; and in the case of the EPR's section 5.3 regime, could also bring "directly associated" storage activities within the scope of the regulations.

Moreover, applying specifically to non-hazardous waste, section 5.4, Part 2, Schedule 1 of the EPR also regulates storage activities when the conditions for them to be considered as "directly associated" to CO_2 capture and liquefaction activities undertaken within UK ports are met. As a result, the EPR and the PPC establish two overarching regimes governing CO_2 storage activities as part of CCS in UK ports irrespective of their hazardous or non-hazardous nature – *i.e.*, as "temporary storage" (highlighted in pink in Table 6) or as storage which is "directly associated" to an activity falling within the scope of the regulations (highlighted in green in Table 6). Nonetheless, due to the discrepancy in the PPC and EPR around the activities which fall within the scope of their definition of "disposal" – specifically the fact that, unlike under section 5.3(a) of the PPC, the EPR's section 5.3 regime omits "seabed insertion" from the list of such activities – the PPC and EPR's sections governing the temporary storage of CO_2 apply to different stages of the CCS process. Specifically, the PPC's section 5.3(a) regime applies to storage ahead of injection under the seabed, whereas the EPR's section 5.3 regime only applies to the storage of captured CO_2 ahead of its liquefaction. Moreover, unlike temporary storage, "directly associated" storage is not subject to the disposal capacity threshold stipulated in the regulations' sections governing the main activity in question. Nonetheless, such "directly associated" activities are

only brought within scope where *all* the conditions for the regulation of the main disposal activity are met, including the hazardous/non-hazardous nature of the CO_2 in question and whether the activity encompasses CO_2 capture *and* liquefaction, and where the conditions for it to be considered a "directly associated activity" are also satisfied.

Waste management regulatory framework applicable to CO_2 storage as part of CCS in UK ports						
Pollution Prevention Control Regulations regime			Environmental Permitting Regulations regime			
Definition of "waste" in relation to waste management activities	Disposal of hazardous waste - regime under section 5.3(a), Part 1, Schedule 1	Disposal of non-hazardous waste - regime under section 5.3(c), Part 1, Schedule 1	Definition of "waste" in relation to waste management activities	Disposal of hazardous waste - regime under section 5.3, Part 2, Schedule 1	Disposal of non-hazardous waste - regime under section 5.4, Part 2, Schedule 1	Temporary storage of hazardous waste - regime under section 5.6, Part 2, Schedule 1
- Conditioned upon the "holder" of the waste discarding it or intending/being required to discard it. - Excludes gaseous effluents emitted into the atmosphere	Governs CO_2 storage activities in ports with a capacity of >10 tonnes/day pending insertion under the seabed	Governs CO_2 liquefaction activities undertaken in ports with a capacity of >50 tonnes/day, including storage as a "directly associated" activity	- Conditioned upon the "holder" of the waste discarding it or intending/being required to discard it. - Does not exclude gaseous effluents emitted into the atmosphere	Governs CO_2 capture *and* liquefaction activities in ports with a capacity of >10 tonnes/day, including storage as a "directly associated" activity	Governs CO2 capture *and* liquefaction activities in ports with a capacity of >50 tonnes/day, including storage as a "directly associated" activity	Governs CO_2 storage in ports with a total capacity of >50 tonnes ahead of its liquefaction

Table 6. The inconsistent regulation of CCS activities in UK ports under the PPC and EPR waste management regimes.

Is CO2 a "hazardous" waste?

"Hazardous waste" under the EPR and PPC refers to "waste which displays any of the characteristics listed in Annex III to the Waste Framework Directive" (regulation 2(1) and (7), EPR; paragraph 1, section 5.3, Part 1, Schedule 1, PPC, which refers to Council Directive 91/689/EEC which was superseded by the Waste Framework Directive). If the waste in question does not display any of the characteristics – so-called "hazardous properties" – listed therein, it is deemed to be non-hazardous (regulation 2, EPR; article 3.2a, Waste Framework Directive). Some properties which render a waste "hazardous" under Annex III are clearly not relevant for CO_2 in its gaseous or liquefied form, such as HP 1 "explosive", HP2 "oxidising", and HP3 "flammable". But other health properties such as HP4 "irritant — skin irritation and eye damage" and HP6 "acute toxicity", and environmental properties such as HP14 "ecotoxic" merit deeper examination. However, it must be noted that the assessment of the hazardous nature of the substance in question under UK law depends on the context within which it is examined. In that regard, a distinction should be made from H&S regulations in the UK, notably the HSWA, which is not directly applicable in the context of environmental permitting and protection.[114] Instead, reference should be made to European Regulation (EC) No 1272/2008 on

[114] Under UK H&S regulation, CO_2 is considered a "substance hazardous to health" [91].

classification, labelling and packaging of substances and mixtures (CLP) [170], which remains in force in the UK today [171]. The CLP aims to ensure a high level of protection for human health and the environment, as well as to facilitate the free movement of substances and mixtures within the EU by harmonising the classification, labelling, and packaging of chemicals. To achieve this, it typically classifies substances by their hazardous properties, which include physical hazards, health hazards, and environmental hazards (Parts 2, 3, and 4, Annex I, CLP).

It is important to note one preliminary point before analysing the CLP framework and its implications on the qualification of CO_2 under the EPR and PPC in the UK. The responsibility for identifying hazards and deciding on their classification under the CLP lies primarily with the manufacturers, importers, or downstream users of the substance in question (recital (16), CLP; article 4, CLP). However, competent authorities play a supervisory role in overseeing compliance with the CLP and may conduct audits, inspections, or enforcement actions to ensure that substances are classified correctly and in accordance with regulatory requirements. In this regard, the CLP calls for the cooperation between suppliers in an industry sector through the sharing of data and expertise when classifying substances and requires them to document the basis on which classification decisions were made and make them available to the competent authorities (paragraph 1.1.0, Annex I, CLP). The authority responsible for the enforcement of the CLP in the UK is the HSE as part of its mandate to regulate workplace H&S under the HSWA, including the handling of hazardous substances [171].[115]

The classification of substances under the CLP is based on the criteria set out therein in relation to each of the hazardous properties it considers. This includes their classification based on their "skin corrosion/irritation" properties, which can be determinant in the characterisation of liquified CO_2 as hazardous by HP4 under the Waste Framework Directive. HP4 refers to "waste which on application can cause skin irritation or damage to the eye", a risk which liquefied CO_2 presents due to its storage at very low temperatures and under pressure, which can cause rapid cooling upon contact with the skin. Frostbites and cold burns can be caused by this rapid cooling, especially if the skin is exposed to the liquefied CO_2 for an extended period. A waste is considered to present this property under the Waste Framework Directive when it is classified by one of the hazard classes and category codes and hazard statement codes which the Directive refers to, *and* its relevant concentration limit is exceeded or equalled. The potentially relevant hazard class and category codes and hazard statement code for liquefied CO_2 which the Directive refers to are, respectively, skin irritation category 2 and H315; and it needs to be present with concentration levels exceeding or equal to 20% for it to be hazardous by HP4. To determine whether liquified CO_2 is classified by theses hazard classes/category codes and hazard statement codes, reference should be made to the CLP. According to paragraph 3.2.1.1 of Part 3 of Annex I of the latter, skin irritation means "the production of reversible damage to the skin following the application of a test substance for up to 4 hours". The CLP provides for the reliance on animal testing and human data to determine whether the substance in question should be placed in skin irritation category 2 which, pursuant to Table 3.2.5 of Part 3 of Annex I of the CLP corresponds to Hazard Statement H315 (causes skin irritation). In this regard, table 3.2.2 of Part 3 of Annex I of the CLP lists three criteria to be relied upon to determine whether a substance falls within the category. The "major criterion" for the irritant category according to paragraph 3.2.2.7.1, Part 3, Annex I, of the CLP is that "at least 2 of 3 tested animals have a mean score of ≥ 2,3 - ≤ 4,0".

Another example is the Waste Framework Directive's HP6, according to which waste which "can cause acute toxic effects […] following inhalation exposure" can be deemed hazardous under the EPR and

[115] The HSWA establishes a performance-based approach to the regulation of occupational H&S risks by imposing a duty on employers to ensure the H&S of workers and members of the public, "so far as is reasonably practicable".

the PPC. This depends on the concentration levels of the substances contained in the waste in question exceeding specified thresholds based on their acute toxic hazard class and category code and hazard statement code, where applicable. Therefore, the question of whether CO_2 is attributed an acute toxic hazard class/category and hazard statement code when being handled under UK law becomes an important step in the evaluation of whether it can be hazardous by HP6 under the Waste Framework Directive. This is determined by reference to the CLP's classification process. In this regard, the CLP provides that "acute toxicity" means "those adverse effects occurring following oral or dermal administration of a single dose of a substance or a mixture, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours". It specifies the criteria to be relied upon to class a given substance as acutely toxic considering different routes of exposure (*i.e.* oral toxicity, dermal toxicity, and inhalation toxicity). Accordingly, substances are classified into four acute toxicity hazard categories (1 to 4, where Category 1 is the most toxic and Category 4 is the least toxic) based on their applicable acute toxicity values. These are experimentally determined and expressed either as approximate median lethal dose (LD_{50}) (in relation to oral and/or dermal toxicity) or median lethal concentration (LC_{50}) (in relation to inhalation toxicity) values,[116] or as acute toxicity estimates (ATE) [172]. For example, if LC_{50} is less than 100 parts per million per volume (ppmV), then the gaseous substance in question would fall in acute toxicity hazard category 1 (most toxic); whereas if it is between 2,500 ppmV and 20,000 ppmV, then the substance would fall in acute toxicity hazard category 4 (least toxic). It is advanced that if LC_{50} is more than 20,000 ppmV in the example under examination, then the substance in question would not be regarded as presenting an acute toxicity hazard and would therefore not be attributed an acute toxic hazard class/category.[117] For the application of the classification to mixtures, the CLP provides that "it is necessary to obtain or derive information that allows the criteria to be applied" (paragraph 3.1.3.1, Annex I, CLP). It then details the procedure to be followed in different scenarios involving mixtures, namely, where acute toxicity data are available for the complete mixture (paragraphs 3.1.3.4 and 3.1.3.5, Annex I, CLP); and the classification of mixtures based on ingredients of the mixture (paragraph 3.1.3.6, Annex I, CLP). In the latter scenario, the CLP offers classification guidance where data is available for all the ingredients involved (paragraph 3.1.3.6.1), and where data are not available for all components (3.1.3.6.2).

Practically, within a CCS context, the latter example is relevant for the assessment of whether the disposal of CO_2 in its *gaseous* state via its capture, and the directly associated storage thereof in a UK port prior to liquefaction falls under the scope of the EPR sections concerned with the regulation of either hazardous or non-hazardous waste (the EPR regimes under section 5.3 and 5.4, highlighted in Table 6). This is a determinant factor under the EPR of the thresholds for triggering the environmental permitting and protection requirements incumbent upon SHAs operating ports where such activities are undertaken. In the CCS scenario examined in this report, CO_2 is captured from flue gas emissions produced by combustion processes (*e.g.,* power plants, refineries) at point source. The emissions will include other gases such as nitrogen oxides (NOx) and sulfur dioxide (SO_2), as well as particular matter, all of which can present adverse effects on human health and the environment. Typically, therefore, the concentration of CO_2 in these emissions is around 10% to 15% by volume, compared to making up only about 0.04% of the atmosphere. And, while the goal at this stage of the process is to capture a significant portion of the CO_2 present in the flue gas emissions employing technologies such as absorption, adsorption, or membrane separation, the release of these other pollutants into the atmosphere is also minimized. Depending on the specific requirements and logistics of the CCS project

[116] These values represent the dose or concentration of a substance that is lethal to 50% of the test animals exposed to it.
[117] This entails that the substance in question would not be regarded as hazardous for the purposes of the Waste Framework Directive, and consequently the EPR and the PPC.

in question, the captured CO_2 can be stored in its gaseous state with these other pollutants in capacities up to several thousand cubic meters before being processed to remove impurities and compressed to reduce its volume and facilitate its subsequent transport. In such scenarios, the mixture of gaseous CO_2 and other pollutants would need to be classified following the procedures mentioned above instead of relying on experiments run on gaseous CO_2 alone. If this results in the substance being placed in one of the categories provided for under the CLP, the mixture would be regarded as hazardous by HP6 under the Waste Framework Directive for the purposes of the interpretation of the EPR, given that it will constitute the entirety of the waste in question, and therefore the concentration thresholds of the substances contained in the waste provided for in the Directive would be met. This is despite the explicit exclusion of gaseous effluents emitted into the atmosphere from the scope of the Waste Framework Directive pursuant to Article 2.1(a) thereof considering that they are not excluded from the scope of the EPR.

Regarding the assessment of whether CO_2 can be characterised as a hazardous waste by HP14 under the Waste Framework Directive, reference should be made to its classification as a substance presenting acute or chronic aquatic toxicity properties under the CLP. HP14 regards as "ecotoxic" waste which "presents or may present immediate or delayed risks for one or more sectors of the environment". It brings within the scope of this definition waste which contains one or more substances falling under the aquatic acute toxicity category or one of the aquatic chronic toxicity categories under the CLP when the sum of their concentrations exceeds thresholds specified in the Waste Framework Directive. The classification of substances under these categories relies on acute aquatic toxicity data for the aquatic acute toxicity category, and on two sources of information, namely acute aquatic toxicity data and environmental fate data for the chronic toxicity categories. Amongst the chronic toxicity categories, the CLP introduced a "safety net" classification which applies when there are "some grounds for concern" but the data available is not sufficient to allow a classification under one of the other categories. In all these scenarios, the data needed to apply the classifications set out in the CLP relies upon scientific experiments run on taxa which is generally considered as being representative of aquatic fauna and flora for the purposes of hazard identification, namely fish, crustacea, and algae/aquatic plant [172].

Practically however, the purpose for which manufacturers, importers, and downstream users classify a given substance will influence the settings within which the experiments provided for in the CLP to apply the classification criteria for different hazard classes will be conducted.[118] In this respect, CO_2 has been typically classified for the purpose of its transportation and storage in relatively small quantities, rather than for its processing, handling, transport, and storage in the quantities anticipated in large-scale CCS activities. Thus, with regards to applying the CLP's criteria for assessing its acute inhalation toxicity hazards, gaseous CO_2 is typically tested at its harmless normal atmospheric concentrations, rather than as part of a mixture which can include pollutants presenting acute toxicity properties. And with regards to assessing its aquatic toxicity, tests are typically conducted using aqueous solutions of the test substance, which may not accurately represent the conditions under which liquefied CO_2 would be released into aquatic environments in a CCS scenario.[119] In fact, CO_2 is

[118] For example, in relation to acute toxicity, those detailed under paragraph 1.1.1, Part 1, Annex I, of the CLP; and paragraph 3.1.2, Part 3, Annex I, of the CLP.

[119] Liquefied CO_2 is usually pressurised at low temperatures. Its release into an aquatic environment would result in rapid phase change and the formation of bubbles - dynamic conditions which may not be easily replicated in a typical aquatic toxicity test. In fact, Recital 33 of the CLP explicitly acknowledges that "the application of the criteria for the different hazard classes to information is not always straightforward and simple" and requires that those responsible with classifying substances should "apply weight of evidence determinations involving expert judgement to arrive at *adequate results*" (emphasis added).

commonly classified under the CLP based on its *physical* hazard properties when it comes to its transport and storage in smaller quantities (rather than its *health* or *environmental* hazard properties). Accordingly, it is classified pursuant to paragraph 2.5 of Annex I to the CLP as a "compressed gas", a "liquefied gas", a "refrigerated liquified gas", or a "dissolved gas", and its hazard statement is usually either H280 (contains gas under pressure, may explode if heated) or H281 (contains refrigerated gas; may cause cryogenic burns or injury) [173; 174; 175]. This is in contrast with hazard statements for substances which are categorised as acutely toxic if inhaled which the Waste Framework Directive refers to, namely: H330 (Fatal if inhaled), H331 (Toxic if inhaled), and H332 (Harmful if inhaled); or for substances which are categorised as hazardous to the aquatic environment, namely H400 (Very toxic to aquatic life), H410 (Very toxic to aquatic life with long lasting effects), H411 (Toxic to aquatic life with long lasting effects), H412 (Harmful to aquatic life with long lasting effects), or H413 (May cause long lasting harmful effects to aquatic life).

In order to avoid the underestimation of the potential hazards involving CO_2 as it passes through the CCS stages and undergoes phase changes, it is essential that it is not classified based on its intrinsic properties in "normal" conditions. Regulating authorities should ensure that classification is based on tests conducted in suitable settings which allow for an accurate estimation of the risks it poses to health and to the environment in conditions which practically arise in a CCS context. For example, the classification of CO_2 for the specific applications involved in CCS must consider factors such as its pressure, temperature, concentration, and potential interactions with other substances. Internationally recognised guidelines such as those produced by the Organization for Economic Co-operation and Development (OECD), or the European Chemicals Agency (ECHA) provide detailed procedures for conducting the tests provided for under the CLP and outline the specific parameters to be measured [172]. However, the practical usefulness of these tools will be limited by the perception which those responsible for classifying substances and the regulating authorities will have about the risks they can pose at the different stages of a CCS project.

Ultimately, the data relied upon to classify CO_2 under the PLC will have implications on determining whether it presents the hazard properties referred to in Annex III of the Waste Framework Directive which are relied upon to qualify a substance as hazardous for the purposes of the regulation of waste management activities under the EPR and the PPC. If the tests lead to an underestimation of its hazard properties and it is not characterised as hazardous, higher thresholds would apply for triggering permitting and environmental protection duties for port operators running waste management activities involving large quantities of CO_2 in its gaseous or liquified states within a CCS context in the UK (see Table 6). Conducting the tests and experiments under the CLP in suitable settings might result in producing data which, once applied to the criteria it sets out for the classification of substances, would lead to CO_2 being attributed hazard classes/category codes and hazard statement codes referred to in Annex III of the Waste Framework Directive. According to the latter, the qualification of a substance as hazardous by one of the properties it lists will depend on the level of concentration of the substance in the waste in question. Given that CO_2 in its different states either as a stand-alone substance or as part of a mixture will constitute the entirety of the waste being considered, the concentration thresholds provided for under the Waste Framework Directive are likely to be met, and the waste will be considered hazardous for the purposes of the EPR and the PPC.

It is also noteworthy that Annex III of the Waste Framework Directive refers to physical properties which do not appropriately consider the health hazards posed by processing and storage activities involving large quantities of CO_2 in UK ports, which are commonly situated in highly populated areas. As alluded to above, Annex III only refers to the following physical properties which are not applicable to CO_2, namely, HP 1 "explosive", HP 2 "oxidising", HP 3 "flammable". In addition, the criteria relied

upon for the classification of gases under pressure under the CLP are not reflected in any of the hazard property categories under Annex III of the Waste Framework Directive and are therefore deemed to be irrelevant for the qualification of a substance as hazardous.[120] This entails that, even when large quantities of CO_2 are kept in large quantities and at high concentration levels around densely populated areas, higher thresholds will apply to trigger the EPR and the PPC's environmental protection and permitting duties based on their regulation of waste management activities in the UK. And although CO_2 is not hazardous in the same way as certain chemicals which pose a health hazard due to their acute toxicity properties, authorities might want to consider it as such due to its potential to cause major population casualties through the displacement of oxygen and asphyxiation. One way to ensure this is to add a new "waste capable of displacing oxygen and causing asphyxiation" property under Annex III of the Waste Framework Directive and subjecting wastes that are deemed hazardous by it to a high concentration threshold of gases that fall under one of the categories of "gases under pressure" under the CLP. This will trigger the application of the EPR and PPC's waste management provisions to CCS activities based on the [lower] thresholds for activities involving *hazardous* waste without unintentionally creating additional requirements for manufacturers, importers, and downstream users of gases under pressure in other scenarios.

Recommendations

The application of existing environmental permitting regulations to CO_2 storage activities as part of CCS within UK ports is dubious. Under certain conditions (see Table 6), several regimes under the PPC and the EPR can govern activities constituting different components of the CCS process (*i.e.* CO_2 capture, liquefaction, and temporary storage; see Table 7 below). This creates a complex regulatory landscape for stakeholders to navigate to ensure they are consistently fulfilling the legal requirements incumbent upon them by virtue of several regimes when they operate CCS activities within ports. It also ultimately leads to applying varying environmental protection standards with regards to the processing and handling of CO_2 as it passes through the CCS stages and undergoes phase changes.

<table>
<tr><th>CCS stage</th><th colspan="4">Potentially applicable regimes under the EPR and the PPC</th></tr>
<tr><td>CO_2 capture</td><td colspan="2">Disposal of hazardous waste (EPR) - section 5.3, Part 2, Schedule 1</td><td>Disposal of non-hazardous waste (EPR) - section 5.4, Part 2, Schedule 1</td><td>Carbon capture and storage (EPR) - Section 6.10, Part 2, Schedule 1</td></tr>
<tr><td>CO_2 liquefaction</td><td>Disposal of non-hazardous waste (PPC) - section 5.3(c), Part 1, Schedule 1</td><td>Disposal of hazardous waste (PPC) - section 5.3(a), Part 1, Schedule 1</td><td>Disposal of hazardous waste (EPR) - section 5.3, Part 2, Schedule 1</td><td>Disposal of non-hazardous waste (EPR) - section 5.4, Part 2, Schedule 1</td></tr>
<tr><td>CO_2 temporary storage</td><td colspan="2">Disposal of hazardous waste (PPC) - section 5.3(a), Part 1, Schedule 1</td><td colspan="2">Temporary storage of hazardous waste (EPR) - section 5.6, Part 2, Schedule 1</td></tr>
</table>

Water discharge activities regime (EPR) - Schedule 21

The regimes also govern "directly associated activities"

Table 7. The regimes under the EPR and the PPC which can govern the different components of the CCS process.

[120] The CLP places gases under pressure under the following categories according to their physical state when packaged: compressed gas, liquefied gas, refrigerated liquefied gas, and dissolved gas.

Regardless of the uncertainty created by the potential for multiple regimes to simultaneously govern CO_2 storage activities as part of CCS in UK ports, recognising that the respective conditions for their application are met in specific circumstances is not straightforward. Stakeholders operating port-based CCS activities will need to ascertain whether the PPC and EPR's relevant provisions can be interpreted to regulate their activities, which will depend on several factors as illustrated in Figures 7 and 8. Without official guidance from the competent authorities, there is a significant risk of misinterpreting the regulations or not applying them at all. This could result in their inconsistent application by various stakeholders and, potentially, an underestimation of the health and environmental risks associated with large-scale CO_2 storage activities in UK ports. For example, with regards to the regulations' waste management provisions, the definition of "waste" must consistently apply across regulations, CO_2 must be construed as a "hazardous waste" when examined in a CCS context, and there must be an alignment in what constitutes a "waste disposal activity".

Expressly including CO_2 capture, liquefaction and storage activities in the list of activities which bring installations where they are performed within the scope of the regulations is recommended to avoid confusion about whether they govern different components of the CCS process in UK ports. This can be achieved through expanding the provision under section 6.10, Part 2, Schedule 1, of the EPR[121] to CO_2 liquefaction and temporary storage activities. It would also simultaneously ensure that the same conditions for triggering the regulatory requirements incumbent upon port operators, including environmental protection duties, would apply in respect of *any* of those activities. For example, in contrast with the application of the PPC and EPR's waste management provisions to CCS activities in UK ports, such approach would circumvent the question of applying differing standards depending on whether CO_2 in its different states is regarded as hazardous or non-hazardous, or whether CO_2 storage activities are "directly associated" with waste disposal activities which fall within the scope of the regulations. Moreover, the proposed EPR provision must also be added in Part 1, Schedule 1 of the PPC to ensure consistency in the application of the regulations.[122]

3.1.3 Liability for environmental damage

The key instrument governing the liability for environmental harm caused by CO_2 storage activities within UK ports are the EDR. Such liability can nevertheless be limited pursuant to the MSA95 which is also discussed in this section.

The EDR regime has been detailed in section 2.2.2 of this report and is summarised here. The Regulations constitute a public liability instrument: they apply to State claims (through the competent authority) for damage caused to land, water, and to protected species/habitats, but do not cover civil liability claims brought by private entities/parties (who could request from the relevant competent authority to take action on their behalf). These Regulations aim to implement the polluter-pays principle by imposing on the operator of a potentially polluting activity the obligation to adopt measures to (1) prevent/halt environmental pollution, and (2) to remediate environmental damage caused by its activity by restoring the affected environment to its "baseline" condition. The liability of operators is strict under the Regulations, but actions must be brought against them within five years

[121] Which in its current form only applies to the capture of CO_2 from an installation for the purposes of geological storage.
[122] As illustrated in Table 7, CO_2 capture activities are not regulated under the PPC, whereas multiple regimes under the PPC and the EPR have the potential to govern CO_2 liquefaction and storage activities.

from the date of the completion of the measures to which the proceedings relate,[123] or the identification of the operator liable to carry out the measures (whichever is later).

The "operator" is defined under the EDR (regulation 2(1)) as "the person who operates or controls an activity, including the holder of a permit or authorisation relating to that activity, or the person registering or notifying an activity for the purposes of any enactment". As mentioned in section 3.1 above, ABP is the SHA for the port of Southampton. One of the services offered by ABP Southampton is indeed the handling and storage of "a range of liquid bulks", which arguably could in the future include large quantities of CO_2 [176]. Therefore, ABP will be potentially liable to adopt the preventative and "primary", "complementary" and "compensatory" remediation measures, defined in Schedule 3 of the EDR, in respect of storage activities within the Southampton Harbour area.

The EDR regime applies to environmental damage caused by activities listed in Schedule 2 (EDR, regulation 5) to a protected species or natural habitats, surface water or groundwater, marine waters, and land (EDR, regulation 4). Regulation 4(5) EDR defines "environmental damage to marine waters" as "damage to marine waters such that their environmental status is significantly adversely affected", and "marine waters" is defined with reference to article 3.1(a) of Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for Community action in the field of marine environmental policy [121] (EDR, regulation 2(1)):

> "(a) waters, the seabed and subsoil on the seaward side of the baseline from which the extent of territorial waters is measured extending to the outmost reach of the area where a Member State has and/or exercises jurisdictional rights, in accordance with the UNCLOS, with the exception of waters adjacent to the countries and territories mentioned in Annex II to the Treaty and the French Overseas Departments and Collectivities; and
>
> (b) coastal waters as defined by Directive 2000/60/EC, their seabed and their subsoil, in so far as particular aspects of the environmental status of the marine environment are not already addressed through that Directive or other Community legislation".[124]

Schedule 2 activities include the "[m]anufacture, use, *storage*, processing, filling, release into the environment and onsite transport of:

a) dangerous substances as defined in article 2(2) of Council Directive 67/548/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous substances;
b) hazardous substances as defined in Article 3 of Regulation (EC) No. 1272/2008 of the European Parliament and of the Council on classification, labelling and packaging of substances and mixtures
c) […]" (emphasis added).

"Dangerous goods" are defined under article 2(2) of Council Directive 67/548/EEC [177][125] as substances which are:

"[…]

[123] If the proceedings brought against the operator are in respect of the recovery of costs incurred by a third party due to the adoption of measures to halt environmental pollution or prevent the risk thereof which the operator was responsible for.
[124] Refer to the footnotes in section 2.2.2 above for more detail.
[125] Note that the Directive is no longer in force and is repealed by Regulations (EC) No 1272/2008 of the European Parliament and of the Council (L 353/1), but the EDR still makes reference to the repealed European Directive.

d) Toxic:
Substances and preparations which, if they are inhaled or taken internally or if they penetrate the skin, may involve serious, acute or chronic health risks and even death
e) Harmful:
Substances and preparations which, if they are inhaled or taken internally or if they penetrate the skin, may involve limited health risks."

Despite the H&S risks posed by the release of large quantities of CO_2, it is not clear whether it would qualify as a "dangerous substance" under Council Directive 67/548/EEC due to it being "toxic" or "harmful". As discussed in previous sections, it is *the capacity of CO_2 to displace oxygen* which creates the risk of asphyxiation for those in the vicinity of a major release thereof, rather than its inhalation.

However, "hazardous substances" are defined under the Waste Framework Directive as:

"A substance or a mixture fulfilling the criteria relating to physical hazards, health hazards or environmental hazards, laid down in Parts 2 to 5 of Annex I is hazardous and shall be classified in relation to the respective hazard classes provided for in that Annex.

[…]"

Pursuant to paragraph 2.5 of Annex I, gases which are "under pressure" are hazardous under the Waste Framework Directive. Paragraph 2.5.1.1 defines these gases as those "which are contained in a receptacle at a pressure of 200 kPa (gauge) or more, or which are liquefied or liquefied and refrigerated", and adds that "they comprise compressed gases, liquefied gases, dissolved gases and refrigerated liquefied gases". Paragraph 2.5.2 then lays down the criteria which need to be met for the substance in question to be classified in relation to one of these hazard classes.

In practice, as discussed in section 3.1.2 of this report, CO_2 is usually classified pursuant to these paragraphs of Annex I of the Directive and its hazard statement is usually either H280 (contains gas under pressure, may explode if heated) or H281 (contains refrigerated gas; may cause cryogenic burns or injury). This classification is influenced by the practice of transporting and storing CO_2 in relatively small quantities, but the criteria laid down in Table 2.5.1 of the Annex are arguably also met when it is stored as part of CCS.

Thus, liquified CO_2 is a "hazardous substance" under the Waste Framework Directive and the scenario whereby an accident related to the storage of CO_2 in the Southampton Harbour area is brought under the scope of the EDR regime. This entails that two main duties are imposed on ABP Southampton, namely:

(c) The duty of operators to adopt "all practicable steps to prevent […] damage" and to notify relevant details to the authorities. This duty is triggered as soon as it is established that their activity "causes an imminent threat of environmental damage, or an imminent threat of damage where there are reasonable grounds to believe that the damage will become environmental damage" (EDR, regulation 13(1)).
(d) The duty to remediate pursuant to Schedule 3 of the EDR. This duty is triggered as soon as the enforcing authority has established that the damage caused by the activity constitutes "environmental damage" in the meaning set under the Regulations (EDR, regulation 17) and has notified the operator about it pursuant to regulation 18.

Regulation 8 of the EDR provides for exemptions for their application. This includes situations where the environmental damage is caused by acts of terrorism, an exceptional natural phenomenon

(provided that the operator took "all reasonable precautions" to protect against the damage caused), activities the sole purpose of which is to protect against natural disasters, and incidents in respect of which liability or compensation falls within the scope of international conventions covering liability for oil pollution damage (EDR, regulation 8(3)). Thus, although liability under the EDR is strict, it is not absolute.

The competent authority for enforcing the EDR is defined with reference to regulations 10 or 11. Accordingly, the "enforcing authority" will be determined based on whether the regulated activity requires a permit or registration under the EPR [125]. In the affirmative regulation 10 of the EDR applies and the authority will in principle be identified according to the body which had the initial responsibility for granting the permit for the activity (EDR, regulation 10).[126] The EPR apply to "regulated facilities", which pursuant to regulation 8 include "installations", defined in Schedule 1, Part 1.1(1) as "a stationary technical unit where one or more activities are carried on". Schedule 1, Part 2 lists the activities covered by the regulations which can be carried out on such installations and include "gasification, liquefaction and refining activities". However, the loading, unloading, handling or storage activities in question apply specifically to (a) crude oil and (b) stabilised crude petroleum. Another listed activity is "carbon capture and storage", but it is only envisaged in respect of the *capture* of CO_2 streams from an installation for the purposes of geological storage (Schedule 1, Part 2, section 6.10). This raises doubts about whether the storage of CO_2 is in scope and suggests that regulation 11 of the EDR is applicable. The latter provides that in such instances (where the activity in question is not covered by the EPR), the Regulations are to be enforced in accordance with the provisions in the table in Schedule 2A. Accordingly, the Regulations are enforced with regards to damage to land by the local authority, with regards to damage to marine waters up to 12 nautical miles from the Baseline in England by the MMO, and with regards to damage to marine waters beyond 12 nautical miles from (a) the baselines in England, or (b) the baselines in Northern Ireland, by the Secretary of State for Environment, Food and Rural Affairs. On the other hand, the EA is the enforcing authority with regards to damage to "a protected species or natural habitat or a site of special scientific interest on any other part of the continental shelf or in the sea up to the limit of the exclusive economic zone" (see Table 3).

ABP Southampton's potential liability in relation to damage caused by CO_2 storage activities within the Southampton Harbour area is nonetheless limited pursuant to the MSA95. Section 191 of the latter specifically limits liability incurred by "a harbour authority, a conservancy authority and the owners of any dock or canal" in respect to "any loss or damage caused to any *ship*, or to any goods, merchandise or other things whatsoever *on board any ship*" (emphasis added). Therefore, unlike the limitation of liability for shipping operators, SHAs can only limit their liability in respect to damage to the ship and/or her cargo whilst on board the ship, not in respect of loss of life or personal injury or property damage beyond the ship. Such limitation shall be determined "by reference to the tonnage of the largest United Kingdom ship which, at the time of the loss or damage is, or within the preceding five years has been, within the area over which the authority or person discharges any functions" and by applying to that ship the method of calculation specified in article 6.1(b) of the LLMC read together with paragraph 5(1) and (2) of Part II of that Schedule 7 of the MSA95.

[126] In the case of CO_2 capture under the EPR, it is the EA. If the provision is expanded to include other CCS activities, then the EA will have the authority to enforce the EDR in respect of liability claims arising therefrom.

3.2 Geological storage of liquified CO2

The long-term geostorage of CO_2 in subterranean reservoirs such as depleted hydrocarbon fields or saline aquifers is an essential component of CCS projects. These storage activities can be undertaken on or offshore. For countries surrounding the North Sea, where there has been a >50-year history of oil and gas exploration and production and consequently numerous partially depleted hydrocarbon reservoirs, it is likely that that offshore formations will be the first CO_2 geostorage destinations developed [178]. This is despite the additional costs of working offshore and potential impacts on the marine environment.

From a UK-centric perspective, the main international conventions relevant to CO_2 storage in the marine environment are the:

- UNCLOS;
- London Convention and its 1996 Protocol; and
- OSPAR.

None of these conventions contemplated the possibility of using CCS as a GHG mitigation measure when they were adopted [179] and some of their provisions are incompatible with CCS operations in marine spaces, as noted in early reports [24]. This has led to uncertainties hindering the development of large-scale offshore CCS activities and required amendments of those conventions to be addressed. These amendments are unpacked in the following sub-sections.

3.2.1 UNCLOS

UNCLOS recognises the sovereignty of coastal States over storage activities as part of CCS when they occur in those States' internal waters, their territorial sea (article 2), exclusive economic zone (EEZ; article 56), continental shelf (article 77) or any archipelagic waters as relevant. This gives those States the authority to regulate all aspects of these activities pursuant to their right to exercise such sovereignty over natural resources falling under their jurisdiction. This right is *exclusive* in that if the coastal State does not explore its EEZ or the continental shelf or exploit their natural resources, "no one may undertake these activities without the express consent of the coastal State".[127] Thus, despite coastal States falling short from having "full sovereignty", the Convention affords coastal States the necessary authority to permit and regulate CCS activities in these maritime zones [179].

Analysing article 56(1)(a) of UNCLOS which explicitly recognises coastal States' sovereign rights pertaining to the exploration and exploitation of natural resources of "the waters superjacent to the seabed and of the seabed and its subsoil", Bankes [179] argued that this includes injection of new substances into the subsoil (as distinct from production from the subsoil) given that "the pore space of the subsoil is itself as much a resource as are the hydrocarbon or other contents of pore space".[128] Article 56(1)(b)(i) further added the right for coastal States to "establish and use" artificial islands and installations and structures within their EEZ. Pursuant to article 60, the right to establish and regulate such artificial islands and/or installations is exclusive to the coastal State when these activities take place within its EEZ. This right also applies *mutatis mutandis* when they take place on the continental shelf (article 80).

The aforementioned rights are only qualified by the duty of coastal States to have "due regard to the rights and duties of other States" while exercising their jurisdiction over their EEZ/continental shelf (UNCLOS, article 56(2)). The *Chagos Arbitration* Award provided some clarity on the "due regard" test

[127] UNCLOS, articles 56 and 77.2.
[128] With regards to the continental shelf, article 81 provided for the exclusive right for coastal States to "to authorize and regulate drilling […]for all purposes."

in article 56(2). It provided that "the extent of the regard required by the Convention will depend upon the nature of the rights held by [the other State], their importance, the extent of the anticipated impairment, the nature and importance of the activities contemplated by the [coastal State], and the availability of alternative approaches. In the majority of cases, this assessment will necessarily involve at least some consultation with the rights-holding State" [180]. Another noteworthy limitation of the rights conferred to coastal States in the regulation of CCS activities in their EEZ/continental shelf is their duty to ensure that the exercise of those rights does not "infringe or result in any unjustifiable interference with navigation and other rights and freedoms of other States as provided for in this Convention" (also commonly referred to as "the right for innocent passage" - UNCLOS, article 78.2).

Other key UNCLOS provisions relevant for the storage component of the CCS value chain are those relating to the obligations and responsibilities of coastal States with regards to the environmental protection of the marine environment, and the Convention's approach to dumping [181]. In this regard, article 56(1)(b)(iii) recognised the right for coastal States to adopt measures to protect and preserve the marine environment within their EEZ, whilst articles 192-194 balance the exclusive right of States to explore and exploit resources within their jurisdiction with a general obligation to protect and preserve the natural environment;[129] and article 208.1 deals specifically with pollution from *seabed activities* subject to national jurisdiction. This requires coastal States to adopt laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with [such activities] and from artificial islands, installations and structures under their jurisdiction. According to article 208.3, these "shall be no less effective than international rules, standards and recommended practices and procedures".[130] Article 210 requires States to "adopt laws and regulations [and other measures as may be necessary] to prevent, reduce and control pollution of the marine environment by *dumping*" (emphasis added). Article 210.3 provides that such laws and regulations shall ensure that permitting requirements are in place for dumping at sea. Paragraph 5 adds that "[d]umping within the territorial sea and the exclusive economic zone or onto the continental shelf shall not be carried out without the express prior approval of the coastal State, which has the right to permit, regulate and control such dumping after due consideration of the matter with other States which by reason of their geographical situation may be adversely affected thereby."

With regards to the enforcement of laws and regulations adopted with respect to the regulation of pollution by dumping, article 216 provides that this is the responsibility of:

- The coastal State – with regards to dumping within its territorial sea or its EEZ or onto its continental shelf;
- The flag State – with regards to vessels flying its flag or vessels or aircraft of its registry;

[129] Article 194.3 requires that States take measures which deal with "all sources of pollution of the marine environment", including those that are designed to minimise as much as possible the "the release of toxic, harmful or noxious substances, especially those which are persistent, from land-based sources, from or through the atmosphere or *by dumping*" (emphasis added).

[130] "Pollution to the marine environment" is defined under article 1.(4) as "the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities". "Dumping" is defined as "(i) any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea; (ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea". This definition, and the limitations thereof, have been transposed into the London Convention discussed below.

- Any other State – with regards to acts of loading of wastes or other matter occurring within its territory or at its off-shore terminals.

Moreover, where there are "reasonable grounds" to believe that planned CCS activities under their jurisdiction may cause "substantial pollution of or significant and harmful changes to the marine environment", coastal States are also under a requirement to conduct an environmental impact assessment (UNCLOS, article 206). Risks of carbon leakage are covered in article 195 which provides that in carrying out their obligations to prevent, reduce and control pollution of the marine environment and to protect and preserve it, States are further required not to transfer, directly or indirectly, damage or hazards from one area to another or to transform one type of pollution into another.

The IEA recommended that the development of an effective regulatory system where no overlap and confusion exist between various stakeholders is key for accelerating the deployment of CCS, increasing public acceptance, and levelling-up the playing field for CCS relative to other mitigation options [181]. It called for additional guidance to advance CO_2 storage incentives, including through the participation in emissions trading schemes, recognising that additional work is needed to advance CCS in this context.[131] In particular, the report highlighted the need to develop environmental baselines, monitoring, reporting and verification guidelines, and to address leakage.

3.2.2 The London Convention and its Protocol

The text of the Convention does not make any reference to the seabed, which could suggest that it does not apply to sub-seabed storage activities. However, the Convention will arguably need to be consistently interpreted with its Protocol (discussed below) which incorporates sub-seabed activities in its definition of "sea" under article 1, paragraph 7.[132]

*3.2.2.1 **The London Convention***

As discussed in section 2.1.2.2 above, the London Convention places an absolute prohibition upon the dumping of wastes or other matter listed in Annex I and requires a prior special permit to be obtained for dumping those listed in Annex II. A prior general permit issued in accordance with Annex III is needed for all other substances for them to be dumped (article IV). The discussion above concluded that CO_2 is not included in Annex I or Annex II, which entails that it can be dumped under the Convention, provided that a general permit is obtained pursuant to Annex III. The latter lists the provisions to be considered by Contracting States while establishing the criteria governing the issuing of permits for the dumping of matter at sea.

The Convention defines "dumping" as "any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures" (article III, paragraph 1 (a)). However, it provides for two scenarios where such disposal falls outside the definition of "dumping", and therefore is not prohibited under the Convention (article III, paragraph 1 (b)):

a) "[t]he disposal at sea of wastes or other matter incidental to, or derived from *the normal operations* of vessels, aircraft, platforms or other man-made structures at sea and their equipment […]" (emphasis added), and
b) "[the] placement of matter for a purpose *other than the mere disposal thereof*, provided that such placement is not contrary to the aims of [the] Convention" (emphasis added).

[131] In particular, the IEA report highlighted the need to develop baselines, monitoring, reporting and verification guidelines, and to address leakage [181].
[132] As argued by the UK Government, see [182].

Accordingly, depending on whether CO_2 storage activities are included in the "normal operations" of platforms, and whether the injection of CO_2 under the seabed for the purposes of enhanced oil recovery or as a climate mitigation measure are interpreted as going beyond "the mere disposal" thereof, the geological storage of CO_2 may still fall outside the scope of the Convention (and the need for permitting in accordance with Annex III).

Interestingly, the first exception under article III, paragraph 1 (b) does not apply to the disposal at sea of wastes or other matter transported by or to vessels, aircraft, platforms or other man-made structures at sea, "operating for the purpose of disposal of such matter […]". Thus, the Convention prohibits the dumping of CO_2 from ships transporting it to offshore structures for subsequent injection under the seabed, and subjects it to the permitting regime under Annex III.

3.2.2.2 The London Protocol

As discussed in section 2.1.2.2, the London Protocol, which entered into force on 24 March 2006 and supersedes the London Conventions for the States party to it (including the UK), introduced a more stringent approach to the regulation of dumping of wastes at sea: it prohibits all dumping of any wastes or other matter except for those listed on a 'reverse list' in Annex 1 (article 4.1) which require a permit that must be issued in accordance with Annex 2 (article 4.2). The latter includes a requirement to carry out a "waste prevention audit" to identify the types, amounts and relative hazard of the wastes generated, and an assessment of the feasibility of waste reduction techniques, including scoping opportunities for waste prevention at source (Annex 2, paragraphs 2 and 3). Paragraph 5 of the Annex establishes a hierarchy of waste management options which applications to dump wastes shall demonstrate the consideration of. These are as follows:

1. re-use;
2. off-site recycling;
3. destruction of hazardous constituents;
4. treatment to reduce or remove the hazardous constituents; and
5. disposal on land, into air and in water.[133]

The question of whether offshore CCS falls within the definition of "dumping" and whether it should be permitted was deliberated amongst the parties to the OSPAR Convention (discussed below) and the London Convention-Protocol framework. Following the Protocol's entry into force and various legal and technical reviews, Australia, co-sponsored by France, Norway and the UK, submitted a proposal to amend Annex 1 in order to allow the storage of CO_2 in sub-seabed geological formations, which was adopted at the first meeting of the Contracting Parties to the London Protocol in November 2006 (and entered into force on 10 February 2007) [183]. The category of matter added to the Annex consisted of "carbon dioxide streams from carbon dioxide capture processes for sequestration". Sub-section 4 of the Annex details the circumstances under which CO_2 dumping is allowed, namely that:

1. Disposal is into a sub-seabed geological formation; *and*
2. They consist overwhelmingly of CO_2; *and*
3. No wastes or other matter are added for the purpose of disposing of those wastes or other matter.

This amendment provided a basis for the regulation of CO_2 sequestration in sub-seabed geological formations under the Protocol's permitting mechanism in accordance with the provisions of article 4 and Annex 2. The latter requires that permits are only issued once all "impact evaluations are

[133] Sub-seabed activities are included in the Protocol's definition of "sea" under article 1(7).

completed and the monitoring requirements are determined". This emphasises the importance of creating an adequate monitoring mechanism for CO_2 sequestration to ensure compliance with the terms of the Protocol. The Contracting Parties to the Protocol have thus adopted in 2007 the Specific Guidelines on Assessment of CO_2 Streams for Disposal into a Sub-Seabed Geological Formations (Specific Guidelines) [184], which provide the assessments and considerations required in issuing a permit.

In order to prevent Contracting States from circumventing the Protocol's dumping regime through exporting the material to be dumped to non-Contracting States, and in line with the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal [185], article 6 of the Protocol practically prohibited the transboundary movement of wastes and other matter by providing that: "Contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea" [32]. Analysing the provision, a 2011 IEA report highlighted that "wastes or other matter" is broadly defined under article 1 as "material and substance of any kind, form or description", whilst "export" is undefined [186]. Thus, in 2008 an IMO working group consisting of nine contracting States began to consider how the transboundary movement of CO_2 for storage in sub-seabed geological formations relates to article 6. The group considered that the term "export" would include any movement of CO_2 from a Contracting Party for the purposes of dumping at sea, irrespective of whether or not the receiving State is party to the London Protocol, but did not reach a conclusion on the scenario wherein CO_2 is shipped to international waters for dumping at sea.[134] Conversely, an Element Energy report noted that "the transboundary transportation of CO_2 for the purposes of storage *onshore*, or for utilisation, is not blocked by the London Protocol" (emphasis added) [32].

Ultimately, at the fourth meeting of the contracting parties to the London Protocol (26-30 October 2009), Norway submitted a proposed amendment to the London Protocol which culminated in the adoption of Resolution LP.3(4) on the Amendment to article 6 of the London Protocol [187]. The amendment added an additional paragraph (2) to article 6 as follows:

"2. Notwithstanding paragraph 1, the export of carbon dioxide streams for disposal in accordance with Annex 1 may occur, provided that an agreement or arrangement has been entered into by the countries concerned. Such an agreement or arrangement shall include:
2.1. confirmation and allocation of permitting responsibilities between the exporting and receiving countries, consistent with the provisions of this Protocol and other applicable international law; and
2.2. in the case of export to non-contracting parties, provisions at a minimum equivalent to those contained in this Protocol, including those relating to the issuance of permits and permit conditions for complying with the provisions of Annex 2, to ensure that the agreement or arrangement does not derogate from the obligations of contracting parties under this Protocol to protect and preserve the marine environment".

Following Resolution LP.3(4), the Contacting Parties revised the Specific Guidelines to take account of transboundary CCS activities (including export and migration) whereby it was decided that sub-seabed migration across national boundaries does not constitute export, and so was not prohibited by article 6, but was not covered by the Specific Guidelines. In 2012, the Special Guidelines were split into two documents covering technical and permitting responsibility issues: the revised Specific Guidelines

[134] The IEA report noted that an interpretation whereby this scenario falls under "export" is unlikely, given that the article 6 prohibition refers specifically to export "to other countries".

covering subsurface transboundary migration;[135] and Guidance on the implementation of article 6.2 on the export of CO_2 streams for disposal in sub-seabed geological formations for the purpose of sequestration.

With regards to the Guidance on the implementation of article 6.2., the Contracting Parties developed and adopted a new document at the annual meeting of the parties in 2013, in order to determine the responsibilities of Parties under an "agreement or arrangement" and the requirements of such agreements on those who wish to export CO_2, including to non-Parties, so as to ensure that the standard of requirements of the London Protocol on permitting CO_2 geological storage are maintained [188].

However, under article 21 of the Protocol, an amendment will enter into force for the Contracting Parties that have accepted it after two-thirds of the contracting parties have accepted the amendment. Moreover, if additional countries ratify the London Protocol, the number of contracting parties required for the amendment to enter into force will also increase. The 2011 IEA noted that "achieving this number of ratifications is a *significant challenge*" (emphasis added), and that, since 2009, only Norway had done so with it being "unclear whether any further contracting parties are considering ratification or taking action to ratify at this stage" [186].[136] The IEA report suspected that interest of Contracting States in CCS projects is "at an early stage" based on an analysis of their involvement in CCS initiatives. It also added that, out of the Contracting parties that are considering CCS and engaged in international CCS dialogue, "not all are interested in offshore CO_2 storage or transboundary movement of CO_2 for offshore storage, making ratification of the article 6 amendment a low priority". Moreover, it drew lessons from the OPSAR 2007 amendment experience (discussed below), which needed to be ratified by only 7 countries (as opposed to 27+ for the London Protocol) for it to enter into force but still took around four years. It concluded that, in the circumstances, "ratification of the 2009 amendment may not be an immediate priority", that "it is unlikely to enter into force unless a concerted, international effort is made towards ratification" and that "it is likely that article 6 will continue to present a barrier to transboundary CCS deployment in the foreseeable future, even though contracting parties have given a clear political signal that the London Protocol should not constitute such a barrier". The report went on to suggest potential options to address the issue which have been more recently presented and discussed at the 3rd Offshore CCS workshop in Norway in June 2018. The options suggested were:

a) To issue an interpretative resolution based on the general rules of interpretation[137]
b) Resolve to provisionally apply the 2009 amendment, until it is ratified
c) To enter into bilateral or multilateral agreements

[135] Therefore, permits can now be issued under the London Protocol for transboundary storage by London Protocol Parties. The revised Specific Guidelines also confirmed that where the sub-seabed geological formations could be used by more than one country or where there is potential for subsurface transboundary movement, then the responsibility for implementation of these guidelines is that of the Contracting Party where injection occurs.

[136] A more recent report noted that the export amendment had only been ratified by six out of the fifty-three parties, namely: Norway, the UK, the Netherlands, Iran, Finland and Estonia. See [188].

[137] The Element Energy report [32] cited literature (Henriksen, 2017) in support of this option, arguing for the application of '*overall logic*' to conclude that despite the transboundary movement of CO_2 for the purposes of dumping would be in conflict with the wording of article 6, it is in line with the overall aims and objectives of the London Protocol, most notably its calling for Contracting Parties to "harmonize their policies" to "individually and collectively protect and preserve the marine environment". According to this argument however, the export of CO_2 from a contracting State to a non-contracting State would not be permissible.

d) Agree to modify the operation of the relevant aspects of the London Protocol between specific contracting parties
e) Agree to suspend the operation of the relevant aspects of the London Protocol between specific contracting parties

In response to this barrier, and out of the aforementioned options, contracting Parties to the London Protocol ultimately adopted resolution LP.5(14) in 2019 to allow provisional application of the 2009 amendment to article 6 to allow the export of CO_2 for storage in sub-seabed geological formations in advance of its ratification.[138] The intention was also to encourage Parties to accept the 2009 amendment to article 6 and highlight the importance of this element of the 2006 amendments which could make CCS a viable climate change mitigation measure [189]. An IEAGHG Technical review in 2021 noted that the adopted resolution "removed the last significant international legal barrier to [CCS], and means that CO_2 can be transported across international borders to offshore storage" [188]. The IEAGHG noted that the rationale behind this option was "to allow states to give their consent to cross-border transport of CO_2 for the purpose of geological storage without being non-compliant with international commitments".

3.2.3 OSPAR Convention

The OSPAR Convention is regarded to be by far the most comprehensive and strict legal framework governing the marine environment.[139] It is a regional agreement aimed at protecting the waters of the North-East Atlantic and North Sea and is widely perceived as setting high environmental standards. Although not drafted specifically with CO_2 storage in mind, some of its provisions were interpreted as creating significant constraints on any offshore CO_2 storage activities. In 2004, the OSPAR Commission tried to develop an agreed position on whether placing CO_2 in the sea and the aquifers below the sea is consistent with the Convention, highlighting the legal uncertainty confronting potential offshore investors at the time [190].

The general obligation relating to the prevention and elimination of pollution in the maritime area[140] under the Convention is dealt with in the Annexes on land-based sources (Annex I), on dumping or incineration (Annex II) and on offshore sources (Annex III). After evaluating the provisions under each, a 2007 IEA report concluded that the Convention prohibits the deliberate disposal of wastes and other matter in the maritime area [181].However, it also added that "its legal framework which requires Parties to apply, inter alia, the precautionary principle and to define the use of 'best available techniques', emphasising the use of non-waste technology, and 'best environmental practice', meaning the application of the most appropriate combination of environmental control measures and strategies (article 2 and Appendix 1) may amongst other provisions of the Convention, contain a basis for Regulating CO_2 storage activity for the purpose of climate mitigation."

[138] This came as a result of Norway and the Netherlands exploring options to overcome barriers to cross-national collaboration on CO2 CCUS. The adopted measure is pursuant to article 25 of the Vienna Convention on the Law of the Treaties, according to which a treaty or a part thereof would be applied provisionally pending its entry into force if (a) the treaty itself so provides; or (b) the negotiating States have in some other manner so agreed. Therefore, provisional application of an amendment to the London Protocol could be based on an agreement between the negotiating States, according to the Vienna Convention, which provided the legal basis for provisional application of a treaty or part of a treaty in international law.
[139] The Convention requires States to take *all possible steps* to prevent and eliminate pollution of the maritime area as well as to take the necessary measures to protect the maritime area against the adverse effect of human activities (Art 2).
[140] The definition of the OSPAR maritime area includes the sea, the seabed and the subsoil of the marine waters within the geographical limits laid down in the Convention.

In 2007, amendments to OSPAR were adopted by its contracting Parties to allow for the conditional storage of CO_2 in sub-seabed geological formations [191]. These consisted of inserting new paragraphs to the Convention's Annexes allowing the issuing of permits for sub-seabed sequestration of CO_2 streams for storage, provided that the streams consisted 'overwhelmingly' of CO_2 and that no other wastes/materials were added for disposal. Moreover, the 2007 OSPAR amendment introduced a Framework for Risk Assessment and Management of CO_2 Streams in Geological Formations (FRAM) [192]. The Framework provides Parties with an 'iterative process' aimed at ensuring the continual improvement of risk management throughout the project's lifespan, and required that specific CO_2 guidelines are used when issuing permits for CCS activities to ensure that "carbon dioxide streams, which are stored in geological formations, are intended to be retained in these formations permanently and will not lead to significant adverse consequences for the marine environment, human health and other legitimate uses of the maritime area" [192].

3.2.4 The UK's approach to the regulation of offshore CO_2 storage as part of CCS

The UK's approach to CCS is underpinned by its aspiration to become a global leader in the technology. This presupposes a commitment from the UK Government to deploy CCS in the UK, coupled with efforts to foster collaboration internationally and continuous innovation through research and development (R&D). Primarily inspired by EU legislation, the UK enabled CO_2 storage activities in the UK Continental Shelf (UKCS) by regulating various aspects of the process.[141] Whilst the key focus is on achieving cost reductions to enable the deployment of CCS at scale during the 2030s, the following sections will unpack key licensing/permitting provisions for offshore CO_2 storage activities as set out in planning and environmental protection Regulations in the UK. This will highlight how the UK's licensing regime achieves a balance between facilitating the upscale of offshore CO_2 storage activities whilst protecting and preserving the marine environment in line with the UK's commitments under international law. It will unpack requirements incumbent upon developers of offshore storage projects and governmental authorities/agencies under different laws and regulations in the UK.

3.2.4.1 Permitting process

In 2009, the UK Government launched a consultation on its proposed offshore CCS licensing regime which was substantially based on the UK's petroleum licensing rules [194].[142] The Government published its response to the consultation report in August 2010 [196], where it laid out a two-tiered regulatory process for the offshore permitting process for CO_2 storage. In short, this process consists of requiring developers of offshore storage projects to apply for an interim permit or lease which allows for exploration activities for potential storage sites, even before applying for a permit which allows for actual injection and storage of CO_2.

The UK Energy Act 2008 [197] provides for a licensing regime that governs the offshore storage of CO_2 in the offshore area comprising both UK territorial sea and beyond,[143] designated as a gas importation and storage zone (GISZ) under section 1(5) of the Act. It forms part of the transposition into national law of EU Directive 2009/31/EC on the geological storage of carbon dioxide (CCS Directive). The Storage of Carbon Dioxide (Licensing etc.) Regulations 2010 (SI 2010/2221) (CO_2 Licensing Regulations) [198], which transpose many other requirements of the Directive, came into force on 1 October 2010.

[141] This includes for example investment in R&D to achieve cost reductions via technological breakthroughs, the implementation of economic tools such as Emission Trading Schemes, or the development of economic frameworks for transport and storage, power, and industrial carbon capture business models to ensure that the activity is sustainable. See generally [193].
[142] The safety and environmental capability licensee requirements are governed by the Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015 [195].
[143] This includes the EEZ and any other areas that may be specified by Order in Council.

The UK Energy Act 2016 [199] saw the licensing powers transfer from the Secretary of State for Business, Energy and Industrial Strategy to the Oil and Gas Authority (OGA) [200]. Since March 2022, the OGA became known as the North Sea Transition Authority (NSTA) [200]. In addition to oil and gas exploration in the UK, it regulates offshore CO_2 storage, approves and issues storage permits, and maintains the carbon storage public register. It is the licensing authority for offshore storage except within the territorial sea adjacent to Scotland, which Scottish ministers authorise. Under the UK's two-tiered system, in addition to applying for a Carbon Dioxide Storage License, developers must also obtain an Agreement for Lease (AfL) from The Crown Estate or the Scottish Crown Estate (the owners of the storage rights on the UKCS) (Energy Act 2008, section 4). The AfL is an exclusive, time-limited option over a lease for a specified area of the pore space in the seabed. The AfL allows the project to appraise a potential storage site prior to applying for a permit and while the permit is being issued. Once the project has been issued a permit, it will exercise the option provided by the AfL and be granted a lease to inject and store CO_2 in the specified area of the seabed. AfLs are limited in time to the period of construction, operation, closure and post closure monitoring of the project. The conditions for the lease are negotiated when the AfL is granted to allow the project to quickly secure the lease once it has a permit.

In support of such process, the IEA explained that "[p]rojects would often be unable to obtain a full CO_2 storage permit to cover the exploration as such permits usually will require a detailed understanding of the subsurface" [201]. AfLs provide exclusive time-limited options that enable developers to enter competitions for government funding assistance and to progress their CCS projects. The AfL also allows developers to undertake different activities in the pore space in which the CO_2 will be stored and specified areas of the seabed [201]. In this regard, the IEA noted that there will be a risk that, given that the area of the seabed covered by the Lease does not necessarily sit directly above the pore space, leases for CO_2 storage might overlap with leases granted for other purposes. In these instances, the report noted, overlapping licenses are managed by commercial arrangements between the relevant parties.

Schedule 1 of the CO_2 Licensing Regulations lists the requirements of storage sites which are authorised under a storage permit. It includes provisions for:

- The closure of storage site by the operator;
- The operator's post closure plan;
- Post closure operator obligations; and
- The extraction of stored CO_2.

Regulation 8 lays out what storage permits should contain. For example, it requires that:

- The operational requirements for CO_2 storage are specified (regulation 8(1)(c)), including requirements relating to the acceptance and injection of CO_2 (regulation 8(1)(d)).
- The permit contains the provisions provided for in Schedule 2 with regards to aspects such as monitoring plans (regulation 8(1)(g)), reporting (regulation 8(1)(h), and financial security (regulation 8(1)(m)).

Moreover, the Regulations make the facility operator responsible for:

- Ensuring that the conditions for storage are met;[144]
- Maintaining a register of the quantities and properties of the CO_2;[145]

[144] For example see Schedule 2 - 1.(4).
[145] See Schedule 2 – 1.(5).

- Monitoring the storage complex and injection facilities[146] on the basis of a monitoring plan[147] which has been approved by the Authority;[148]
- Reporting (including proving that the financial security requirements are in place);[149] and
- Notifying the Authority about leakage or irregularities.[150]

Financial security provisions in Schedule 2 require that the operator has a secured amount of funds sufficient to ensure that all obligations arising under the storage permit can be met (Schedule 2 – 7.(1)(a) and Schedule 2 – 7.(5)(a).

3.2.4.2 Environmental protection

3.2.4.2.1 Conservation of habitats

- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (Offshore Habitat Regulations) [202] set down the obligations for the assessment of the impact of offshore oil and gas activities (including gas and CO_2 unloading and storage activities) on habitats and species protected under Council Directive 2009/147/EC (the codified version of the Birds Directive) and Council Directive 92/43/EEC (the Habitats Directive).

- The Conservation of Habitats and Species Regulations 2017 [203] (Habitat Regulations; applicable within 12 nautical miles) and the Conservation of Offshore Marine Habitats and Species Regulations 2017 [204] (applicable between 12 nm out to 200 nm or the UK Continental Shelf) include provisions for the designation and protection of areas that host important habitats and species in the offshore marine area (referred to as "Special Areas of Conservation" for the protection of certain habitats and marine species, and "Special Protection Areas" for the protection of certain wild bird species). They also include provisions requiring competent authorities to take steps to preserve and re-establish a sufficient diversity and area of habitat for wild birds and impose a duty upon them to use all reasonable endeavours to avoid pollution or deterioration of wild bird habitat.

- The body responsible authority for developing, administering, and enforcing the offshore oil and gas environmental regulatory regime (including offshore gas unloading and storage and CO_2 storage) is the Offshore Petroleum Regulator for Environment & Decommissioning (OPRED) [205].

- Part 5 of the Habitat Regulations provides powers to issue licences for specific activities that could result in the injury or disturbance of European Protected Species ("EPS injury or disturbance licences") and the potential to issue wild birds licences (providing certain licensing tests are met). In other words, a license to authorise activities which would otherwise be unlawful under wildlife legislation as affecting a protected species.

- The MMO is responsible for wildlife licensing of activity in English and Northern Ireland offshore waters. Natural England is responsible for wildlife licensing in other parts of England. Outside of England, Natural Resources Wales licenses activity in Welsh waters, Scottish Natural Heritage and Marine Scotland (for seals) licenses activity in Scottish waters, and the

[146] Schedule 2 – 2(1).
[147] Schedule 2 – 2(4).
[148] Schedule 2 – 2(6).
[149] Schedule 2 – 3.
[150] Schedule 2 – 3 (6).

Department of Agriculture, Environment and Rural Affairs licenses activity in Northern Irish waters.

- In accordance with section 66 of Part 4 of the Marine and Coastal Access Act 2009 [206], the activities that may need a marine licence include: "To deposit *any substance* or object within the UK marine licensing area,[151] either in the sea or on or *under the sea bed*, from (a) any vehicle, vessel, aircraft or marine structure" (emphasis added); "To deposit *any substance* or object *anywhere in the sea or on or under the sea bed* from (a) a *British vessel, British aircraft or British marine structure* […]" (emphasis added).

3.2.4.2.2 Environmental Impact Assessment

The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (EIA Regulations) [207] transpose EU Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, as amended by EU Directive 2014/52/EU (EIA Directive) [208]. The Regulations apply to activities related to proposed offshore oil and gas exploration and production, gas unloading and storage, and storage of CO_2 (hereinafter referred to as "offshore projects").

The Regulations provide for the Secretary of State for DESNZ to consider the environmental impacts of proposed offshore projects when deciding whether to agree to the NSTA grant of consent for such projects (regulations 4; 4.(3); 5). As per regulation 8, where a project is subject to an environmental impact assessment (EIA), the developer must submit an environmental statement containing the information listed in Schedule 6. Alternatively, the developer may apply to the Secretary of State for an opinion on the scope and level of detail to be included in the environmental statement (regulation 9).

The Regulations categorise projects under three Schedules which has implications on the "screening direction" (the decision of whether or not an EIA is required): Schedule 1 projects require an EIA (regulation 5.(1)); developers of Schedule 2 projects must either apply to the Secretary of State to inform on the matter, or willingly decide to conduct an EIA (regulation 5.(2)); Schedule 3 Projects do not require an EIA when the Secretary of State considers that that the project is not likely to have a significant effect on the environment pursuant to regulation 7 (regulation 5.(3)); in addition, the Secretary of State can direct that projects be exempt from an EIA requirement as per regulations 17 and 18. The Secretary of State has the duty to coordinate conservation EIAs required under either regulation 5 of the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 [202] or regulation 28 of the Conservation of Offshore Marine Habitats and Species Regulations 2017 [203].

The following activities/projects are included in Schedule 1 of the EIA Regulations:

- Activities captured by section 17(2)(a) or (b) of the Energy Act 2008 (activities related to the geological storage of CO_2).
- Installations for the capture of CO_2 streams for the purposes of geological storage of CO_2 where – (a) the CO_2 is captured from an installation forming part of a project that falls under paragraph 1 of the EIA Regulations; or (b) the total yearly capture of CO_2 is 1.5 megatonnes or more.
- Pipelines with a diameter of more than 800 mm and a length of more than 40 km for the transport of oil, combustible gas or chemicals. Pipelines with a diameter of more than 800 mm

[151] Defined under section 42(1) of the Act and includes the UK territorial sea; the EEZ; and the UK Continental Shelf. It also includes the bed and subsoil of the sea within those areas.

and a length of more than 40 km for the transport of CO_2 streams for the purposes of geological storage of CO_2.

- The Regulations replace the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended) [209], except that the 1999 Regulations will continue to apply for some limited transitional provisions.

3.2.4.2.3 Strategic Environmental Assessment

- The Environmental Assessment of Plans and Programmes Regulations 2004 [210] set out the information to be included in the environmental report of Strategic Environmental Assessments (SEAs) in the UK. A SEA is the process of appraisal through which environmental protection and sustainable development are considered and factored into national and local decisions regarding Government (and other) plans and programmes. Activities include oil and gas licensing rounds and other offshore energy developments such as renewable energy generation and gas or CO_2 storage. In the UK, the requirements of the European Strategic Environmental Assessment Directive (Directive 2001/42/EC) [211] have been carried out since 1999 in accordance with its requirements.

- Offshore energy SEAs (OESEA, OESEA2, OESEA3) incorporated the entire UKCS (with the exception of Northern Ireland and Scottish territorial waters for renewable energy, and Scottish territorial waters for CO_2 transport and storage) for technologies including oil and gas exploration and production, gas storage and offloading including CO_2 transport and storage, and renewable energy (including wind, wave and tidal power). BEIS consulted on OESEA4 in March 2022, and the responses to the consultation were published in September 2022 [212].

- The OPRED is responsible for managing the assessment for offshore energy projects.

3.2.5 Transboundary CCS activities

The 2004 IEA report emphasised that the transboundary movement of CO_2 for CCS purposes may be needed given the fact that underground geological storages are "unlikely to coincide with CO_2 source locations" [24]. It supported this view by highlighting that most oil and gas reserves are located in the Middle East and Russia whereas the main industrial clusters (emission sources) are in "major population centres of OECD countries". It concluded therefore that: "the mismatch of sources and sink locations constitute a limitation for underground CO_2 storage in depleted oil and gas fields, *unless cost-effective inter-regional transportation systems are developed*" (emphasis added).

Given the projected volumes of CO_2 to be transported in the long run, the IEA report concluded that "the challenge of putting in place an appropriate transportation system for CO_2 should not be underestimated" [24]. Indeed, CO_2 storage sites are heterogeneously located across EU member States, and therefore, transportation networks linking CO_2 emission clusters with such sites are key for transboundary CCS projects. Highlighting that one of the key challenges for upscaling CCS activities is the integration of several separate activities into a full chain system, it was advanced that many legal issues remain unresolved in this space [101]. From an international perspective on transboundary CCS, three layers of energy law (international,[152] national[153] and local;[154] provide a

[152] Treaties and outputs from international organisations.
[153] National energy law and policy and finance availability.
[154] Local perspectives of individuals and communities.

framework for dealing with liability and other legal issued that may arise in a CCS project.[155] These layers combined create a structure for identifying the "key liability concerns" of project stakeholders in the EU context [101]. It was highlighted that, at international level, these concerns include (a) whether the UK has a "positive" international outlook and/or involvement in CCS and/or CO_2 transport; and (b) whether the UK has ratified the London Protocol amendment (article 6 in particular, which is the case). Moreover, complexities in value chain integration which are not faced in domestic projects arise in the context of transboundary CO_2 transport projects. For example, such projects require coordination between multiple Governments to align them with regards to risk sharing amongst private and public actors and governmental incentives for development [101].

[155] Authors referred to R. J. Heffron and K. Talus, "The development of energy law in the 21st century: a paradigm shift?"(2016) 9 Journal of World Energy Law and Business 189, to advance that changes at one of the three levels will "generally affect" issues at the other two levels.

Conclusions and recommendations

As part of its effort to support CCS deployment at scale, HMG's continues to develop a framework for the economic regulation of CO_2 T&S networks to ensure the continuity of T&S services in support of CCS in the UK. The framework, envisaged to be established under the Energy Bill, will allow T&S operators to receive revenues from their investments into T&S networks, but only applies to transportation by pipelines for geological storage operations. Recognising that it is "vital" for HMG's long-term net-zero objectives to ensure that T&S networks have the capacity to be able to accept CO_2 through NPT, HMG is now considering whether NPT should be accommodated into the T&S business model. Particularly, HMG continues to seek to achieve a better understanding of the role which NPT services could play in the UK's CCS plans, of the likely levels of competition between different modalities of transport in the provision of these services, and of the potential corresponding implications for economic licencing.

Within this context, this report adds to existing literature comparing the modalities of transporting CO_2 as part of CCS by examining the legal and regulatory framework governing the transport of CO_2 from port to port, taking the Solent Industrial cluster as an example. It did not examine the *private law* implications of the contractual relationships tying stakeholders in a traditional shipping context (*i.e.* shipowners, charterers, operators, insurers, cargo interest, *etc*.) given the assumption that the CO_2 shipping chain, including port infrastructure, is expected to be owned and operated by one entity (*e.g.* a joint venture). Instead, the report primarily focused on underlining the range of *public-law*-inspired duties incumbent upon CO_2 shipping stakeholders, the potential liabilities they could be exposed to by performing their activities, and on proposing action to address remaining barriers and simplify what is a highly complex regulatory landscape to navigate. It reviewed the main UK legislations and regulations and international conventions governing the occupational H&S and environmental liability aspects of CO_2 shipping and its temporary storage in ports, ahead of its subsequent transport via underwater pipelines for permanent storage in depleted oil and gas reservoirs or saline aquifers. Moreover, it provided an updated overview on recent developments surrounding offshore geological storage of CO_2 in the UK, which could bear indirect consequences on decisions to upscale CO_2 shipping as a modality of transportation to support CCS.

Section 2 unpacked the regulatory and liability regimes governing liquified CO_2 shipping in the UK. As part of the former, the legal framework applicable to occupational H&S and to environmental protection from liquified CO_2 shipping were explored (section 2.1). This analysis highlighted specific developments relating to CO_2 which fit within an already established regime which governs these aspects, most notably:

- The publication of EH40/2005, which includes CO_2 in its list of workplace exposure limits approved by HSE.
- The adoption of amendment 38-16 to the IMDG Code by the IMO's MSC, which added liquified CO_2 to Class 2.2 "non-flammable, non-toxic gases".
- The adoption of resolution MSC.370(93) which replaced the text of the IGC Code. Chapter 19 of the latter now includes CO_2 in "high purity" and in "reclaimed quality", thus bringing vessels engaged in transporting it under the scope of Chapter VII Part C of SOLAS.
- The adoption of the ISM Code in 1993, which was made mandatory via Chapter IX of SOLAS.

The framework for occupational H&S is mainly inspired by the transposition of international maritime conventions (*i.e.* the MLC and SOLAS) into national law, and the main enforcing authority is the MCA. It is also influenced by European Directives which were transposed into UK law pre-Brexit. Whilst the

MLC and EU-inspired UK Regulations directly address the H&S of seafarers, SOLAS is more concerned with the safety of the ship itself, which is intrinsically linked to the H&S of those on board. In addition, consideration of broader H&S legislation is common in the interpretation of the conventions' provisions by the MCA and the HSE, which set a common objective of achieving comparable levels of H&S for seafarers on merchant ships and fishing vessels as applies to workers ashore. In this regard, the HSWA establishes a performance-based approach to the regulation of occupational H&S risks by imposing a duty on employers to ensure the H&S of workers and members of the public, "so far as is reasonably practicable". This approach underpins the enforcement by the MCA of both the MLC and SOLAS.

Before the adoption of the MLC in 2006, the 1997 Regulations had transposed the EU Framework Directive into national law. The latter provided the general duties for "employer" *vis-à-vis* seafarers and other workers on board ships to ensure their health, safety and welfare at work. The main principle contained in these Regulations is that all safety measures should be based on an assessment of the risks involved in a particular task, and the H&S of workers is ensured "so far as is reasonably practicable" through the identification of the most effective measures to limit that risk. Of particular relevance to the transport of CO_2, the 1997 Regulations impose a duty on the employer to make the necessary arrangements to ensure safety and the absence of risk to health "in connection with the use, handling, stowage and transport of articles and substances". The Regulations also impose a duty upon seafarers to take reasonable care for their own occupational H&S and that of others, and to cooperate with their employer in this respect. These duties are complemented by the transposition of another EU Directive via the Chemical Agents Regulations which imposes a requirement for employers to control exposure of workers to substances that are hazardous to health in the air at the workplace. The latest published EH40 document, EH40/2005, includes CO_2 in Table 2 which lists the workplace exposure limits approved by the HSE. It set short-term and long-term workplace exposure limits which employers should control to 15,000 parts per million and 5,000 parts per million respectively. Irrespective of these limits, the Chemical Agents Regulations still require employers to determine whether any hazardous chemical agents are present at the workplace and to assess any risk to the H&S of workers arising from their presence in line with the general duties under the 1997 Regulations.

After its adoption in 2006, the MLC became widely regarded as the "seafarers' bill of rights" which comprehensively sets out seafarers' rights to decent working conditions. Following its ratification by the UK Government on 7 August 2013, the MCA launched a public consultation inviting views on amending the 1997 Regulations to give full effect to the MLC which culminated in the adoption of the 2014 MLC Amendment Regulations. The MCA's MGN 471(M) was published thereafter to clarify the differences between definitions under the MLC and the 2014 MLC Amendment Regulations. The MLC also required signatories to establish "an effective system" of inspection and certification for ships flying their flag and to ensure that ships flying their flags carry and maintain a "maritime labour certificate" and a "declaration of maritime labour compliance". These requirements are satisfied in the UK via the adoption of the Survey and Certification Regulations, and by the MCA's oversight over a system for the classification and certification of vessels in the UK.

The SOLAS Convention's main objective is to improve safety at sea by specifying minimum standards for the construction, equipment and operation of ships. It also provides the basis for port State control. The Convention in force today is generally referred to as "SOLAS, 1974, as amended". It includes provisions setting out general obligations, followed by an Annex divided into 14 Chapters which have been transposed into national law through corresponding Regulations. Chapter VII deals with dangerous goods both in bulk and in package forms, whereas Chapter IX contains provisions on the management for the safe operation of ships.

Chapter VII of SOLAS is comprehensive – this report focused on reviewing the provisions under Parts A and C thereof, relevant for the carriage of dangerous goods in in packaged form, and for the construction and equipment of ships carrying liquefied gases in bulk and gas carriers, respectively. Part A of Chapter VII established a general rule which prohibits the carriage of dangerous goods in packaged form unless carried out in accordance with the provisions contained therein. It also tied the definition of "dangerous goods" to the substances, materials and articles covered by the IMDG Code the application of which was made mandatory for the carriage of such goods by sea. During its 96th session, the MSC adopted amendment 38-16 to the IMDG Code which added liquified CO_2 to Class 2.2 "non-flammable, non-toxic gases" thus subjecting it to the requirements of the IMDG Code. Pure chemicals and dangerous goods transported in sufficient quantities are allocated individual UN Numbers. Refrigerated liquid CO_2 was allocated UN Number 2187. It is worth noting that liquified refrigerated CO_2 was not included in any of the three packaging groups which dangerous goods in most classes are subdivided into according to the degree of danger they present in transport. Chapter VII Part A is transposed into national law via the Dangerous Goods and Marine Pollutants Regulations, which apply to UK ships wherever they may be carrying dangerous goods in bulk or packaged form or marine pollutants in packaged form, and to other ships while they are within the UK waters. The Regulations impose a general duty on ship operators to ensure that, so far as is reasonably practicable, nothing in the manner in which goods are handled, stowed or carried on board ships is such as might create a significant risk to the health and safety of any person on board, and to provide information, instruction, training and supervision to all employees in connection with these activities. The MCA, which works closely with the HSE to ensure that H&S standards are complied with in harbours, is the competent authority with regulatory oversight over the carriage of dangerous goods and marine pollutants in the UK. It regularly publishes MSNs to provide guidance to relevant stakeholders around amendments to applicable international standards - the latest of such MSN, MSN 1906(M).

Part C of Chapter VII, transposed into the UK regulatory regime via the Gas Carriers Regulations, regulates the construction and equipment of ships carrying liquefied gases in bulk. It made mandatory the application of the IGC Code as it may be amended by the IMO and applies to "gas carriers", which are defined with reference to the products listed in Chapter 19 of the IGC Code. The implication for gas carriers falling within the scope of this Part is that they must comply with the technical requirements of the IGC Code, and surveying requirements under regulations 8 and 9 of Chapter I Part A of SOLAS. This includes surveying and certification requirements provided for in the IGC Code, which are subject to verification by the competent authorities of other Contracting parties when the ship in question is in their port. The latest amendment to the IGC Code was adopted through resolution MSC.370(93) (adopted on 22 May 2014), which replaced the "complete text" of the Code. It provided revised international standards for the design and construction of ships carrying liquefied gases in bulk constructed on or after 1 July 2016. Chapter 19 thereof includes CO_2 in "high purity" and in "reclaimed quality", thus bringing vessels engaged in transporting it under the scope of Chapter VII Part C of SOLAS. In accordance with the Gas Carriers Regulations, ships which have complied with the relevant requirements of the IGC Code shall be issued an "International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk" by the Secretary of State for Transport in the UK, and non-compliant ships shall be liable to detainment by the MCA, pursuant to section 95 of the MSA95.

Chapter IX of SOLAS makes mandatory the ISM Code which was adopted by the IMO in November 1993. The ISM Code's objective is to ensure safety at sea and to prevent human injury, loss of life and damage to the marine environment, which it achieves by requiring shipowners to establish to ensure compliance with rules and regulations related to the objectives of the Code. Via the development of SMSs, the safety management objectives of shipowners should assess all identified risks to their ships, personnel and the environment and establish appropriate safeguards to address them. The ISM

Regulations transposed Chapter IX part A into national law and provides that they apply to UK ships "wherever they may be", and to other ships while they are in UK water. The MCA is the UK competent authority which retains direct responsibility for the assessment and audit of UK shipping companies and ships against the ISM Code and publishes statutory guidance to support stakeholders, including surveyors, with complying with the requirements of the Code. Compliance with the shore-side aspects of SMSs is ensured through the issuing of DOC by MCA which evidences that the ISM Company's shore-side management structure meets the requirements of the ISM Code. Compliance with the ship-side aspects is ensured through the issuing of a SMC following a SMC audit.

The framework for the prevention of marine pollution from CO_2 shipping derives from two main IMO instruments: MARPOL 73/78 and the London Convention. More broadly, the OSPAR Convention, applicable in the North-East Atlantic and North Sea, embraces the precautionary principle and requires States to take *all possible steps* to prevent and eliminate pollution of the maritime area as well as to take the necessary measures to protect the maritime area against the adverse effect of human activities. These instruments were analysed in this report, which highlighted a potential confusion around whether and how the MARPOL 73/78 regime applies to the carriage of CO_2 by ships, and argued that recent amendments affecting the London Protocol do not hamper its mandate for the protection of the marine environment from CO_2 shipping activities.

Annex II of MARPOL 73/78 regulates the prevention of pollution by noxious liquid substances in bulk and therefore the question of whether it applies to the carriage of liquified CO_2 by sea was examined in this report. The general rule under the Annex is for the prohibition of the discharge into the sea of any effluent containing substances deemed to present a harm to the marine environment unless such discharge is made in compliance with the detailed conditions specified in it. It contains specific requirements with regards to the design, construction, equipment and operation of ships certified to carry noxious liquid substances in bulk identified in the IGC Code. Article 2(2) of MARPOL 73/78 adopts a broad definition of "harmful substances" as any substance which can create hazards to human health or to the environment if introduced into the sea. The definition also includes harmful substances which are included in each Annex or "provisionally identified" through relevant IMO circulars. "Discharge" was also broadly defined under the Convention as "any release howsoever caused from a ship and includes any escape, disposal, spilling, leaking, pumping, emitting or emptying". This report highlighted that CO_2 is not identified as a harmful substance in Annex II, nor in the definition of "noxious liquid substances" adopted in the Noxious Liquid Substances Regulations which transposed Annex II of MARPOL 73/38 into national law. The latter Regulations defined such substances in relation to chapters 17 or 18 of the IGC Code, which do not include liquified CO_2. Nonetheless, the report argued that liquified CO_2 still falls under the broader definition set out in the article 2(2) of MARPOL 73/78 due to the H&S and environmental pollution risk posed by its potential release into the marine environment. This entails that the general obligation of prevention of harm to the marine environment under article 1(1) of MARPOL 73/78 would be incumbent upon Contracting States which have to give effect to the obligation nationally. **Given the anticipated increase in the carriage of liquified CO_2 by sea in support of CCS activities globally, the report recommended that liquified CO_2 is added to the list of substances in chapter 17 and/or 18 of the IGC Code for the specific requirements under Annex II of MARPOL 73/78 and the Noxious Liquid Substances Regulations to become applicable to the carriage of liquified CO_2 by sea globally, and to settle any potential confusion around the application of the broader obligation of prevention of harm under article 1(1) of MARPOL 73/78. Moreover, as CO_2 is not categorised in accordance with regulation 6.1 of Annex II of MARPOL 73/78, the report noted that if the UK wants to engage in the international transport of liquified CO_2 by sea, an agreement on a provisional assessment for the proposed operation must be established with the**

Governments of the other concerned Parties to the MARPOL Convention, on the basis of the guidelines included in appendix I to Annex II of the Convention.

The London Convention defines "wastes and other matters" as "any material and substance of any kind, form or description", whereas "dumping" is defined as "any *deliberate* disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures" (emphasis added). The Convention was superseded by its 1996 Protocol, which maintained these definitions but introduced a more stringent approach to the regulation of dumping of wastes at sea by prohibiting all dumping of any wastes or other matter except for those listed on a 'reverse list' in Annex 1 which require a permit that must be issued in accordance with Annex 2. Annex 1 was amended in 2007 which resulted in a new category of matter being added to the Annex – "carbon dioxide streams from carbon dioxide capture processes for *sequestration*" (emphasis added), an amendment which was proposed to overcome regulatory barriers for the storage of CO_2 under the seabed as part of CCS. For transport purposes, this report highlighted that paragraph 1 of Annex 1 provides that the wastes or other matter it lists "may be considered for dumping *being mindful of the Objectives and General Obligations of this Protocol set out in articles 2 and 3*". It argued that the consideration of whether CO_2 can be dumped at sea during shipping operations should be in line with the general obligation imposed on contracting States to "take effective measures both individually and collectively to protect and preserve the marine environment from all sources of pollution, and to harmonise their policies in this regard" even in the absence of conclusive evidence to prove a causal relation between "inputs and their effects". **Given the risk potential associated with the release of CO_2 in the marine environment (discussed in the previous section), the report advanced that "effective measures" to prevent pollution from its carriage are incumbent upon shipping stakeholders in signatory States, and its "dumping" at sea for purposes other than sequestration remains prohibited under the London Protocol.**

Section 2.2 of the report focused on the liability regime governing liquified CO_2 shipping in the UK. It started by laying out overarching points for liability in the UK legal framework. This included an explainer of the polluter-pays principle and its relevance for environmental policymaking in the UK, an overview of environmental tort law in the UK (which can be relevant when liability aspects are not covered in laws and regulations), and remarks on the lack of understanding of the nature and extent of potential harm which leakage of liquified CO_2 from ships could cause. The second part of the section focused on unpacking the legislative framework governing the liability aspects of liquified CO_2 shipping in the UK, highlighting in particular the ELD/EDR regime, the LLMC, and the HNS Convention. The ELD's implementation into national Law and the LLMC are currently in force, whereas the 2010 HNS Convention is a regime which may become applicable in the future. The report noted that the framework established by these instruments is comprehensive, highlighting that liability thereunder is strict but limited, and that mandatory insurance to cover potential liabilities incurred is generally required. Following the addition of CO_2 to the IGC Code, the framework applies to its transport by road, rail, inland waterways, sea or air in the UK, but the enforcement of the regime is currently split across several bodies depending on the geographical location of the harm subject to the liability claim. Moreover, the liability of operators is limited differently under the EDR/LLMC and the HNS Convention regimes, which could lead to inconsistency in the regime governing different heads of claims in a shipping context once the HNS Convention enters into force.

The ELD, as transposed via the EDR implements the polluter-pays principle by imposing on the operator of a potentially polluting activity the obligation to adopt measures to (1) prevent/halt environmental pollution, and (2) to remediate environmental damage caused by its activity by re storing the affected environment to its "baseline" condition. The liability of operators is strict but the competent authority bringing action on behalf of injured parties should act within a period of five

years from the date of the completion of the measures to which the proceedings relate, *or* the identification of the operator liable to carry out the measures. The ELD/EDR regime applies to environmental damage caused by activities listed in Annex 2 of the ELR/Schedule 2 of the EDR, to a protected species or natural habitats, surface water or groundwater, marine waters, and land. Schedule 2 activities include "[t]ransport by road, rail, inland waterways, sea or air of dangerous goods or polluting goods", and goods that are classified in the IMDG Code and liquefied gases listed in Chapter 19 of the IGC Code fall within the definition of "dangerous goods". Given that liquified CO_2 is classified in the IMDG Code and included in Chapter 19 of the IGC Code, the scenario whereby an accident related to the carriage of CO_2 by sea is brought under the scope of the EDR/ELD regime. Pursuant to the Environmental Permitting Regulations, the EDR are enforced with regards to damage to land by the local authority, with regards to marine waters up to 12 nautical miles from the Baseline in England by the MMO, and with regards to damage to marine waters beyond 12 nautical miles from (a) the baselines in England, or (b) the baselines in Northern Ireland, by the Secretary of State for Environment, Food and Rural Affairs. On the other hand, the EA is the enforcing authority with regards to damage to "a protected species or natural habitat or a site of special scientific interest on any other part of the continental shelf or in the sea up to the limit of the exclusive economic zone". However, collaboration between regulatory bodies is common in instances triggering the application of the EDR.

The LLMC provides the basis for the limitation of liability of registered shipowners for maritime claims brought against them under the EDR or in tort. It has been transposed into national law via Schedule 7 of the MSA95. The LLMC applies to shipowners and to salvors and sets a very high threshold for barring them from limiting their liability for actions brought against them. The claims to which limitation could apply are listed in article 2, paragraph 1 of the Convention, which applies whatever the basis of liability may be and whether they are enforced by personal action against the owner or other person(s) or against the ship. These include claims relating to loss of life, personal injury, loss of/damage to property, as well as consequential losses provided that they occur either on board or in direct connection with the operation of the ship. Within a CCS context, such claims would arguably arise due to the characteristics of liquified CO_2 being transported and the risks it poses for H&S and for the ship, including during the loading/unloading operations in harbours. It must be noted, however, that wreck removal claims are in principle not subject to limitation, unlike claims based on cargo removal operations. The limits of liability are determined based on a tonnage-based system provided under the LLMC. The limitation regime provides for two limits of liability – one in respect of claims for loss of life or personal injury and the other in respect of any other claims (property damage). Moreover, the regime provides for a separate limit for loss of life and personal injury to passengers calculated based on the number of passengers which the ship is authorised to carry according to the ship's certificate. The shipowner/salvor's limitation of liability is invoked by the establishment of a limitation fund with the court or other competent authority in any State party where legal proceedings have been initiated for claims subject to limitation. However, practically, the shipowner of a ship flying the UK flag would be able to establish a limitation fund *before* substantive liability proceedings are initiated against them. In the scenario where the ship is arrested before a fund has been established, the shipowner would naturally have an interest in establishing it at the place of arrest.

The HNS Convention, which not yet in force, covers a variety of HNS including liquefied gases and is expected to replace the liability regime under the ELD/EDR with regards to the transport of dangerous goods/hazardous goods by ships. "Liquefied gases" are defined by reference to Chapter 19 of the IGC Code, which includes CO_2. The Convention channels liability to the "owner" of a "ship" in relation to "damage caused by any [HNS] *in connection with their carriage by sea on board the ship*" (emphasis added). Therefore, it could find application in a CCS context with regards to for example loss of life and personal injury on board as well as outside the ship caused by CO_2, or property damage outside

the ship caused by CO_2, but liability arising out of loading/unloading activities in ports would arguably still fall under the scope of the EDR. The regime that the HNS Convention will establish will also be based on strict but limited liability in respect of damage and injury arising in connection with the carriage of CO_2. It is characterised by a two-tier system of liability which claimants have access to: a first tier covered by the shipowner, and a second tier covered by the HNS Fund. With regard to the former, the extent of the liability is determined in relation to the size of the vessel; whereas claims made against the HNS Fund are capped to a limit unrelated to the size of the vessel. The UK has not yet adopted legislation which would enable the transposition of the HNS Convention into its legislative framework, and therefore **the report advanced that transposing instruments would adopt a broader scope than the HNS Convention for the limitation thereunder to cover liability arising out of loading/unloading activities and ensure consistency in the framework governing the liability aspects of CO_2 transport in support of CCS in the UK once the HNS enters into force.**

The legal and regulatory frameworks governing the temporary in-port storage of liquified CO_2 and its permanent storage in reservoirs under the seabed were then explored in section 3.1 and 3.2 respectively. The key legal instruments forming these frameworks were analysed, with an emphasis on identifying potential barriers therein and/or challenges in their enforcement and on providing an update on recent developments surrounding barriers which had been identified in past reports. The key challenges identified in relation to the in-port storage of CO_2 stem from an abundance of applicable regulations governing H&S, environmental protection and liability aspects of the activity in UK ports. In particular, the report highlighted that following the addition of liquified CO_2 to the IMDG Code, it falls within the remit of the DGHAR, but that the application of the COMAH to in-port CO_2 storage is debatable. With regards to environmental protection, the report presented a complex landscape for ascertaining the environmental permitting requirements incumbent upon port operators engaged in CO_2 storage activities as part of CCS. It also noted that the enforcement of liability aspects resulting from harm caused by the activity is split across multiple bodies which could lead to inconsistencies, and that SHAs can limit their liability in respect of potential liabilities incurred, but only in respect of damage to ships and/or their cargoes (as opposed to loss of life and/or property damage beyond the ship).

Section 3.1 unpacked the framework governing the H&S and environmental protection aspects of the handling of hazardous goods within a harbour environment and the regime governing the liability for environmental damage potentially caused by CO_2 storage in ports. In doing so, it primarily focused on the regime applicable in the port of Southampton, but referred to laws, regulations and guidance documents underpinning it where appropriate. It highlighted that the governance structure for ports in the UK is highly complex and marked by an abundance of laws, regulations and guidance documents which govern port management aspects, including the handling of hazardous goods within a port environment. This creates difficulties in understanding where roles and responsibilities for various management aspects in harbour areas lie, which the report attempted to clarify with regards to the storage of liquified CO_2. Moreover, different governmental authorities govern specific aspects within a port authority environment. Most notably, the MCA carries out the UK's "Port State" functions to implement provisions under international conventions which the UK had ratified (*e.g.* MARPOL; SOLAS); the MMO and its equivalents in Wales, Scotland and Northern Ireland have responsibility for protecting the marine environment; and the HSE has the overarching responsibility over H&S aspects in ports in the UK. However, compliance with the PMSC, developed to address the complexity of the applicable H&S framework in ports and widely recognised as establishing a national standard for every aspect of port marine safety in the UK, falls within the remit of the MCA.

The port of Southampton is managed by ABP, which by virtue of the Southampton Harbour Act, made the ABP Southampton Harbour Byelaws 2003 which contain specific provisions dealing with the navigation of vessels, mooring and management of vessels and managing goods and road and rail traffic within the Port of Southampton. However, the main pieces of legislation governing the H&S aspects of the handling of liquid CO_2 in the port of Southampton are the HSWA and the MHSWR. These establish a broader performance-based regulatory framework within which duty holders are required to satisfy the HSE that appropriate measures have been taken to ensure the H&S and welfare of all involved in a port environment so far as is reasonably practicable. The MCA's PMSC and GPPMO also provide useful guidance to understand the complex legal framework applicable to ports in the UK and what it entails for various actors. Importantly, they are endorsed by HMG, the devolved administrations and representatives from across the maritime sector, and although not mandatory, there is a strong expectation from regulating bodies that all harbour authorities will comply with them. As such, the H&S culture in UK ports is marked by an overarching responsibility for SHAs, via their nominated "duty holder", to satisfy the MCA that they have complied with the requirements of the PMSC through taking the necessary preventative and precautionary measures to eliminate risks or reduce them to the lowest possible level, so far as is reasonably practicable. In this regard, the Director of Maritime and Compliance is the ABP Board member with responsibility for H&S matters within the ABP Group in the UK, and they must ensure that a suitable MSMS which has been adopted using formal safety assessment techniques is in place. Moreover, a suitable person must be designated to monitor and report the effectiveness of the MSMS and provide independent advice on matters of marine safety, and reporting compliance with the Code to the MCA every 3 years. Harbour masters' responsibility can also include developing and implementing emergency plans and procedures, for regulating dangerous goods in transit on ships and for counter-pollution and waste disposal plans. The PMSC provides general principles to guide SHAs' satisfaction of the duty to develop and maintain an effective MSMS, including through providing guidelines for formal risk assessments, requiring SHAs to publish plans, adopt effective safety policies, and assess their performance in meeting their obligations at least once every three years. In compliance with these requirements, ABP Southampton has published several documents which have been reproduced in this report (see [150] to [155]).

In the context of this safety culture in UK Ports, the DGHAR and the COMAH are key regulations relevant for both H&S and environmental protection. The former are concerned with safeguarding against major accidents involving dangerous goods *as they transit through* ports, harbours and harbour areas through providing for specific measures to reduce risks of occurrence of serious accidents; whereas the latter are concerned with the regulation of the risk of "major accidents" occurring in establishments in the UK due to the *storage* of dangerous substances therein. The DGHAR's definition of "dangerous goods" is based on the latest applicable international standards, namely the IMO's IMDG Code. Given that liquified CO_2 is included in Class 2.2 "non-flammable, non-toxic gases" in the IMDG Code, it falls within the remit of the DGHAR. A key requirement for operators under the DGHAR is to give notice to the harbour master, the berth operator, and where relevant, to the harbour master of any abutting or overlapping harbour area, of any vessel before bringing any dangerous goods into the harbour area. Other key provisions under the DGHAR include the recognition of the right for SHAs to make byelaws in respect of its harbour area prohibiting the entry or regulating the entry, carriage, handling or storage of dangerous goods; and the requirement for SHAs to have in place an "effective emergency plan, before dangerous goods are permitted into the harbour area, for dealing with emergencies which may arise". Moreover, a harbour master duly appointed by a SHA generally has powers of direction to regulate when and how ships enter, depart from, and move within harbour waters, and for related purposes. As the SHAs for the Port of Southampton, ABP Southampton has the responsibility for enforcing the DGHAR in the Harbour Area

against persons other than itself. It produced for this purpose guidance to assist masters, shipowners, agents and transport operators in preparing the information required by the Harbour Master.

Under the COMAH, relevant for the *storage* of dangerous substances in UK establishments rather than to their *transit* through such establishments, the question of whether an establishment falls within the scope of application of the Regulations depends upon the *type* and *quantity* of substance(s) stored therein. When applicable, the Regulations impose a duty on operators of establishments, where dangerous substances are present or are likely to be present in quantities equal to or exceeding those specified by the Regulations, to take all measures necessary to prevent major accidents and to limit their consequences for human health and the environment and to demonstrate to the HSE that it has taken all measures necessary pursuant to the Regulations. Despite this clearly applying to flammable and oxidising gases and to Hydrogen, the Regulations do not neatly apply to liquified CO_2 which is not included in any form in Schedule 1 of the Regulations. This raises questions around whether the duties imposed on operators extend to the risks associated with the storage of CO_2 in ports. The Regulations however extend to substances not included in Schedule 1 should they present "equivalent properties [to those listed in the Schedule] in terms of major accident potential", in which case they must be provisionally assigned to the most analogous category or named dangerous substance falling within the scope of these Regulations. **Given that CO_2 poses some risks to health and to the environment and that it is expected to be stored in larger quantities in UK ports to enable the delivery of CCS plans, it is recommended for CO_2 to be added as a new substance in Schedule 1 of the Regulations to avoid confusion around whether the regulation of CO_2 storage activities in UK ports falls under the scope of the COMAH.** Nevertheless, it noted that the EDR still impose some duties of prevention on the operators of risk-creating activities in UK ports. However, in contrast to the COMHA, these are not concerned with managing the risk of *harm to human health* and are instead focused on the prevention and remediation of *environmental pollution*.

To assess whether existing environmental permitting regulations – *i.e* the PPC and the EPR – govern CO_2 storage activities as part of CCS in UK ports, the report examined the conditions for triggering the application of several regimes enshrined in the regulations which deal with the regulation of risk-creating activities in the UK. It primarily focused on examining the regulations' waste management provisions in this context and identified a risk for multiple regimes to simultaneously govern CO_2 storage activities as part of CCS. This creates a complex regulatory landscape for stakeholders to navigate which could result in applying varying environmental protection standards with regards to the processing and handling of CO_2 as it passes through the CCS stages and undergoes phase changes. To address this, **the report recommended that CO_2 capture, liquefaction and storage activities are expressly included in the list of activities which bring installations where they are performed within the scope of the regulations**. **It proposed that this can be achieved through expanding the provision under section 6.10, Part 2, Schedule 1, of the EPR**[156] **to include CO_2 liquefaction and temporary storage activities.** This would present the addition advantage of ensuring that the same conditions for triggering the regulatory requirements incumbent upon port operators, including environmental protection duties, would apply in respect of *any* of those activities.

With regards to liability from environmental harm potentially caused by CO_2 storage activities within ports, the EDR and the MSA95 provide the applicable framework in the UK. The EDR regime applies to environmental damage caused by activities listed in Schedule 2 to a protected species or natural habitats, surface water or groundwater, marine waters, and land. Schedule 2 activities include the

[156] Which in its current form only applies to the capture of CO_2 from an installation for the purposes of geological storage.

"[m]anufacture, use, *storage*, processing, filling, release into the environment and onsite transport of dangerous substances which are defined in part under article 2(2) of Council Directive 67/548/EEC, which includes broad definitions of "toxic" and "harmful" substances which encompass CO_2. This brings the scenario whereby an accident related to the storage of CO_2 in the Southampton Harbour area under the scope of the EDR regime and entails that operators are subject to the prevention and remediation duties they provide for. With regards to the enforcement of the EDR in relation to storage activities in ports, the "enforcing authority" will be determined based on whether the regulated activity requires a permit or registration under the Environmental Permitting (England and Wales) Regulations 2016. There is uncertainty around whether the *storage* of CO_2 is an activity for which a permit is granted by an authority, and therefore this report suggests that regulation 11 of the EDR is applicable. This results in a complex enforcement regime whereby the Regulations are enforced in line with the conclusions discussed in the paragraphs above.

ABP Southampton's potential liability in relation to damage caused by CO_2 storage activities within the Southampton Harbour area is nonetheless limited pursuant to the MSA95. The latter limits liability incurred by "a harbour authority, a conservancy authority and the owners of any dock or canal" in respect to "any loss or damage caused to any *ship*, or to any goods, merchandise or other things whatsoever *on board any ship*" (emphasis added). Therefore, unlike the limitation of liability for shipping operators, SHAs can only limit their liability in respect to damage to the ship and/or her cargo whilst on board the ship, not in respect of loss of life or personal injury or property damage beyond the ship.

Lastly, this report examined the legal and regulatory framework governing the geological storage of liquified CO_2 in the UK. Despite this element of the CCS chain falling outside of the scope of the scenario examined (from port-to-port), it was included in this report with the assumption that CO_2 storage provides the *raison d'être* for its transport as part of CCS, and that it would therefore have implications on the level of demand for the development of CO_2 shipping infrastructure within this context. Section 3.2 therefore explored the main international conventions relevant to CO_2 storage in the marine environment, namely: UNCLOS; the London Convention/Protocol; and OSPAR. It also presented an overview of the UK's approach to the regulation of offshore CO_2 storage as part of CCS. This examination provided an update on aspects which had been identified as key barriers for CCS activities in past reports (particularly in a transboundary context), and briefly unpacked some aspects of the permitting and environmental protection framework for offshore geological storage in the UK to highlight additional regulatory requirements incumbent upon CCS stakeholders and that regulatory oversight in their respect is split amongst multiple bodies.

UNCLOS recognises the sovereignty of coastal States over storage activities as part of CCS when they occur in those States' internal waters, their territorial sea, EEZ, continental shelf or any archipelagic waters as relevant. Such sovereignty is however not "full" – coastal States are subject to obligations and responsibilities pertaining to the environmental protection of the marine environment and more specifically to dumping activities under their jurisdiction. This includes the adoption of laws and regulations which ensure that permitting requirements are in place for dumping at sea. With regards to the enforcement of laws and regulations adopted with respect to the regulation of pollution by dumping, UNCLOS provides that this is the responsibility of the coastal State – with regards to dumping within its territorial sea or its EEZ or onto its continental shelf; the flag State – with regards to vessels flying its flag or vessels or aircraft of its registry; and other State – with regards to acts of loading of wastes or other matter occurring within its territory or at its off-shore terminals. Moreover, where there are "reasonable grounds" to believe that planned CCS activities under their jurisdiction may

cause “substantial pollution of or significant and harmful changes to the marine environment”, coastal States are also under a requirement to conduct an EIA.

The London Convention was superseded by the London Protocol when the latter entered into force in March 2006. Previously, the regime established by the London Convention placed an absolute prohibition upon the dumping of wastes or other matter listed in Annex I, required a prior special permit to be obtained for dumping those listed in Annex II, and prior general permit to be issued in accordance with Annex III for all other substances for them to be dumped. The London Protocol introduced a more stringent approach to the regulation of dumping of wastes at sea: it prohibits all dumping of any wastes or other matter except for those listed on a ‘reverse list’ in Annex 1 (article 4.1) which require a permit that must be issued in accordance with Annex 2 (article 4.2). The latter includes a requirement to carry out a “waste prevention audit” to identify the types, amounts and relative hazard of the wastes generated, and an assessment of the feasibility of waste reduction techniques, including scoping opportunities for waste prevention at source. The question of whether offshore CCS falls within the definition of “dumping” and whether it should be permitted under the Protocol was deliberated amongst the parties to the OSPAR Convention and the London Convention-Protocol framework. This led to an amendment which provided a basis for the regulation of CO_2 sequestration in sub-seabed geological formations: it added “carbon dioxide streams from carbon dioxide capture processes for sequestration” to Annex 1 and provided that dumping of this new category of matter is only permitted when it consists overwhelmingly of CO_2, is dumped into sub-seabed geological formations, and no wastes or other matter are added for the purpose of disposing of those wastes or other matter. Moreover, it required that permits are only issued once all “impact evaluations are completed and the monitoring requirements are determined”, which emphasises the importance of creating an adequate monitoring mechanism for CO_2 sequestration to ensure compliance with the terms of the Protocol. However, there were lingering concerns over the possibility of the transboundary transportation of CO_2 for the purposes of geological storage, due to the prohibition of the transboundary movement of wastes and other matter under article 6 of the Protocol. In this regard, a proposed amendment to the London Protocol was adopted via Resolution LP.3(4) on the Amendment to article 6 of the London Protocol. This led to the addition of an additional paragraph (2) which now allows for the export of CO_2 streams for disposal in accordance with Annex 1, “provided that an agreement or arrangement has been entered into by the countries concerned”. The amendment is nevertheless not in force due to the insufficiency of its ratification by signatory States. Thus, potential options to address the issue were presented and discussed at the 3rd Offshore CCS workshop in Norway in June 2018, out of which contracting Parties ultimately adopted resolution LP.5(14) in 2019 to allow provisional application of the 2009 amendment to article 6 to allow the export of CO_2 for storage in sub-seabed geological formations in advance of its ratification. Since then, the IEA interpreted this development as having “removed the last significant international legal barrier to [CCS], and means that CO_2 can be transported across international borders to offshore storage”.

Although the OSPAR Convention was not drafted specifically with CO_2 storage in mind, some of its provisions have been interpreted as creating significant constraints on any offshore CO_2 storage activities. This report examined the latest developments under the Convention, noting that amendments to OSPAR were adopted by its contracting Parties in 2007 to allow for the conditional storage of CO_2 in sub-seabed geological formations. These consisted of inserting new paragraphs to the Convention’s Annexes allowing the issuing of permits for sub-seabed sequestration of CO_2 streams for storage, and introducing a Framework for Risk Assessment and Management of CO_2 Streams in Geological Formations to provide Parties with an ‘iterative process’ aimed at ensuring the continual improvement of risk management throughout the lifespan of CCS projects.

With regards to the UK's approach to the regulation of offshore CO2 storage as part of CCS, the report examined the key licensing/permitting provisions for offshore CO_2 storage activities as set out in planning and environmental protection Regulations in the UK, which are primarily inspired by EU legislation. It noted a two-tiered regulatory process for the offshore permitting process for CO_2 storage in the UK which entails that developers of offshore storage projects are required to apply for an interim permit or lease which allows for exploration activities for potential storage sites (an AfL), even before applying for a permit which allows for actual injection and storage of CO_2. The licensing regime is governed by the Energy Act 2008 and is regulated through the CO_2 Licensing Regulations. The Regulations list the requirements of storage sites which are authorised under a storage permit and the details which such permits should include, and make the facility operator responsible for ensuring that the conditions for storage are met and maintained. The Energy Act 2016 transferred the licensing powers to what is now known as the NSTA which now regulates offshore CO_2 storage, approves and issues storage permits, and maintains the carbon storage public register. It is the licensing authority for offshore storage except within the territorial sea adjacent to Scotland, which Scottish ministers authorise.

The report then briefly examined the legal and regulatory framework governing environmental protection from offshore CCS activities in the UK. It focused mainly on the regimes applicable to the conservation of habitat, EIAs, and SEAs. With regards to the first, the report highlighted requirements for the assessment of the impact of offshore oil and gas activities on habitats and protected species and for the designation and protection of areas that host important habitats and species in the offshore marine area under applicable Regulations in the UK. It noted that the responsible authority for developing, administering, and enforcing the offshore oil and gas environmental regulatory regime (including offshore gas unloading and storage and CO_2 storage) is OPRED. However, it noted that the Habitat Regulations provide powers to issue licences for specific activities that could result in the injury or disturbance of European Protected Species and for the possibility to issue wild birds licences (providing certain licensing tests are met). In this regard, the Marine and Coastal Access Act 2009 established a broad framework for activities that may require marine licenses in the UK; the MMO is responsible for wildlife licensing of activity in English and Northern Ireland offshore waters, and Natural England is responsible for wildlife licensing in other parts of England; and, outside of England, Natural Resources Wales licenses activity in Welsh waters, Scottish Natural Heritage and Marine Scotland (for seals) licenses activity in Scottish waters, and the Department of Agriculture, Environment and Rural Affairs licenses activity in Northern Irish waters. In relation to EIAs, the report noted that the EIA Regulations apply to activities related to proposed offshore oil and gas exploration and production, gas unloading and storage, and storage of CO_2 in the UK. The Regulations are enforced through the requirement for the Secretary of State for DESNZ to consider the environmental impacts of proposed offshore projects when deciding whether to agree to the NSTA grant of consent for such projects. The Secretary of State must also coordinate conservation EIAs required under either other Regulations such as the Offshore Habitat Regulations or Habitat Regulations. Where a project is subject to an EIA, the developer must submit an environmental statement containing specific information listed in the EIA Regulations. Lastly, with regards to SEAs, the report referred to the Environmental Assessment of Plans and Programmes Regulations 2004 which set out the information to be included in the environmental report of SEAs in the UK. It noted that OPRED is responsible for managing the assessment for offshore energy projects and highlighted that that offshore energy SEAs OESEA, OESEA2, and OESEA3 have incorporated the entire UKCS (with the exception of Northern Ireland and Scottish territorial waters for renewable energy, and Scottish territorial waters for CO_2 transport and storage) for technologies including oil and gas exploration and production, gas storage and offloading including CO_2 transport and storage, and renewable energy (including wind, wave and

tidal power). Moreover, BEIS consulted on OESEA4 in March 2022, and the responses to the consultation were published in September 2022.

In light of the above and based on the assumption that the CO_2 shipping chain is expected to be owned and operated by one entity, the report argues that the regulatory landscape governing CCS in the UK, taking into account the specific requirements applicable to different components of the process, is laboursome and highly complex. Whilst OPRED is the primary authority for developing, administering, and enforcing the *offshore* oil and gas environmental regulatory regime in the UK, the MCA and the HSE have oversight of the ship side and shore-side aspects of the transport and in-port storage of CO_2 in the UK. However, other bodies have responsibility for the enforcement of more specific requirements which are relevant for CCS in the UK. **A simplification of the regulatory landscape can be achieved through bringing the responsibility over these specific requirements within the remit of the MCA/HSE or OPRED and facilitating cooperation between these bodies via forums such as the CCUS Council.**

Moreover, there is a risk of inconsistency in the enforcement of liability incurred by operators as a result of their CCS activities by different bodies which are determined depending on the geographical location of the harm caused and whether the activity in question is a licensed activity under the Environmental Permitting Regulations. The capture of CO_2 streams from an installation for the purposes of geological storage is a regulated activity under the latter, however the transport of liquified CO_2 and its in-port storage are not. This entails that the potential liability aspects relating to the capture element of the process would be enforced by the authority granting the license for the operator to undertake the activity, whereas those relating to the transport and in-port storage of CO_2 will be enforced by multiple authorities based on the geographical location of the harm caused. **Adding the loading/unloading of CO_2 in ports, its transport and its in-port storage to the list of activities in Schedule 1 of the Environmental Permitting Regulations and clarifying that the MCA and the HSE are the licensing authorities for these activities would help achieve higher levels of consistency in the enforcement of liability aspects resulting from port-to-port CCS activities in the UK. This would lead to higher certainty and better understanding of value chain risks faced by CCS project stakeholders which would enable a more informed comparison with other modalities for the transport of CO_2 as part of CCS in the UK.**

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