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Regulatory challenges to the implementation of carbon capture and geological storage within the European Union under EU and international law

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ABSTRACT

Carbon dioxide capture and storage (CCS) is a relatively new technology in the context of climate change mitigation strategies, and its legal and regulatory implications are not yet broadly understood. This paper takes a brief look at international environmental law principles relevant to CCS, identifies key environmental and safety risks associated with the technology, and highlights significant legal frameworks that pose challenges to the implementation of CCS within the EU under EU and international law. It then notes continuing regulatory gaps that will need to be addressed for large-scale CCS to take place. The paper concludes that the clear inclusion or exclusion of CCS activities from the range of relevant legal frameworks will increase transparency, provide regulatory certainty and ultimately facilitate CCS in appropriate contexts.

1. Introduction

Global warming is considered to be one of the most serious environmental problems of our time. Increasing concentrations of greenhouse gases in the atmosphere are contributing to increased global surface temperatures, sea level rise and increasingly severe extreme weather events. Increasing concentrations of carbon dioxide (CO_2) in the atmosphere a major greenhouse gas are also leading to increasing CO_2 concentrations in the ocean, increasing acidity and negatively impacting coral reefs and pelagic organisms, including key species of phytoplankton and zooplankton (OSPAR, 2006b).

Stabilization of greenhouse gas concentrations is essential to combat the risks posed by climate change. One option that has been identified to reduce emissions of CO_2 to the atmosphere is carbon dioxide capture and storage (CCS)—the capture and compression of CO_2 resulting from industrial processes, its transport to a storage location and its injection into a geological reservoir where it will remain isolated from the atmosphere for an extended period of time. However, this approach to an environmental challenge raises numerous environmental policy considerations of its own, not the least of which is whether the large-scale use of CCS is consistent with the existing EU and international law frameworks established to address climate change and environmental pollution more broadly.

In 2005, Ecofys and FIELD undertook a study on the impacts of EU and international law on the implementation of carbon

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dioxide capture and geological storage, funded by the European Commission. The study focused solely on geological storage and did not address the direct ocean disposal of carbon dioxide or possible uses of captured carbon dioxide. The resulting report (see Hendriks et al., 2005) first identified the main environmental and safety risks related to CCS. It then reviewed and analysed over 50 international conventions, regional conventions and EU Directives for their potential impacts on CCS activities in light of these risks. These included legal frameworks relating to waste management and transport, water pollution, marine pollution, climate change, transport, environmental impact assessments, access to information, public participation, access to justice, liability for transboundary impacts, nature conservation, siting with respect to accident hazards, and liability for environmental damage.

This paper draws from that study, noting subsequent international developments. It highlights international environmental law principles relevant to CCS, key environmental and safety risks associated with the technology, significant existing legal barriers to the implementation of CCS activities under EU and international law frameworks, and regulatory gaps that will need to be addressed in these frameworks for large-scale CCS to take place.

2. CCS and key international law principles

It is a general principle of international environmental law that nations (referred to as 'States' under international law) have the sovereign right to exploit their own resources, but also the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or damage to areas beyond the limits of their national jurisdiction (Sands, 2003). Each State has a responsibility to take measures to *prevent the occurrence* of transboundary environmental harm. Each State also has a responsibility to *redress damage* if and when transboundary harm occurs (Sands, 2003). Numerous international and EU legal frameworks reflect and apply these principles in the areas of air pollution, groundwater pollution, marine pollution, waste management, land and marine transportation of dangerous and hazardous substances, and natural resource protection (Sands, 2003).

CCS relates to these international law principles in two broad ways. First, industrial activities that generate carbon dioxide in the EU will have impacts beyond areas of national and EU jurisdiction. The UN Framework Convention on Climate Change, the Kyoto Protocol, and a number of EU Directives aim to reduce CO_2 emissions to prevent dangerous climate change. CCS offers a means to keep CO_2 emissions isolated from the atmosphere for an extended period of time—possibly hundreds or thousands of years. Carbon capture and storage thus represents a means to comply with international law principles by preventing transboundary harm from domestic activities.

Second, efforts undertaken to capture, transport and store carbon dioxide, to avoid transboundary harm, may themselves lead to damage to the environment in areas beyond the territorial limits of national jurisdiction. The degree and nature of this risk will largely depend upon the systems used to capture CO_2, the means used to transport CO_2, the routes used for this transport, and the location, reach and integrity of the geological storage sites selected for long-term storage. Where such environmental damage may result, there is a corresponding responsibility to consider both ways to minimize this possibility and ways to redress damage that may occur. Here it is useful to carefully consider how CCS is or is not consistent with the international law principle that States must not transfer damage or hazards, or transform one type of pollution into another,[1] as well with the polluter pays principle,[2] the precautionary principle,[3] and the principle of intergenerational equity.[4]

Table 1 – Relation between short-term and long-term risks and local and global risks for the CCS chain elements—capture, transport, injection and storage

	Short-term risks	Long-term risks
Local risks	Capture, transport, injection	Storage
Global risks		Storage

3. Environmental and safety risks

Environmental and safety risks related to CCS can be divided into two categories: (1) local risks, related to possible impacts of CO_2 releases on people, fauna, flora, soil and water systems; and (2) global risks, relating to the impact of possible CO_2 releases on the global climate, ocean acidification and biodiversity. Risks associated with capture, transport and injection of CO_2 are short-term local risks. Risks associated with storage are long-term risks which either manifest locally (e.g. accumulation in a cellar) or globally. An overview of these relationships is presented in Table 1.

Risks associated with CO_2 handling at capture sites and risks associated with onsite storage are well known. Various standards exist to assure safe and environmentally sound capture and storage operations. Although few studies have assessed the risks of CO_2 capture from engineered systems, at least one study, performed by DNV, has concluded that multiple fatality risks are very unlikely (Vendrig et al., 2003).

[1] See, e.g., UN Convention on the Law of the Sea, Article 195 ("taking measures to prevent, reduce and control pollution of the marine environment, States shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into another"); London Protocol Article 3.3 (Contracting Parties "shall act so as not to transfer, directly or indirectly, damage or likelihood of damage from one part of the environment to another or transform one type of pollution into another").

[2] See, e.g., London Protocol Article 15 (referencing the principles of international law regarding State responsibility for damage to the environment of other States or to any other area of the environment).

[3] See, e.g., London Protocol Article 3, UN Framework Convention on Climate Change (UNFCCC) Article 3.

[4] See, e.g., UNFCCC Article 3.

For transport by pipeline, the main risks are leakage and accidental release. The IPCC Guidelines (2006) provide an indicative average annual emission rate of 140 tonnes/100 km. CO_2 is a potential asphyxiant for humans and animals; as CO_2 is denser than air, it can accumulate to potentially dangerous concentrations in low-lying areas. The consequences of CO_2 accidents can be modeled and assessed on a site-specific basis using standard industry methods, taking into account local topography, meteorological conditions, population density and other local conditions. If impurities are included in the CO_2 being transported (such as H_2S), this could affect the potential impacts of a pipeline leak or rupture by altering the threshold for dangerous exposure. Where CO_2 is transported by ship, rather than by pipeline, risks include collision, foundering, stranding and fire. If CO_2 is released, its interaction with the sea will be complex. Hydrates and ice might form, and temperature differences would induce strong currents. Some gas would dissolve, increasing the sea's acidity, and some would be released to the atmosphere.

Risks associated with geological storage are of two broad kinds: (1) short-term risks, during injection of the CO_2; and (2) longer-term risks of CO_2 release during the period of storage. During injection, corrosion of casing and tubing or blocking of the wellbore pose the largest risks. During geological storage, CO_2 may escape through abandoned wells, escape through wellbore failure, escape by diffusion through caprock (e.g., along faults, or through upward migration due to buoyancy, or by chemical interaction with the caprock), or escape through dissolution in underground water flows that migrate away from the storage reservoir.

Regulatory frameworks may be needed to address both local and global risks, and short-term and long-term risks from CCS activities. EU and international legal frameworks are most relevant in addressing potential transboundary impacts resulting from these global and local risks, as well as risks from transboundary transport and risks from off-shore storage activities.

4. Legal barriers to carbon dioxide capture and storage

No single, clear international regulatory framework applies to carbon capture and storage activities undertaken for the purpose of greenhouse gas mitigation. Only a few frameworks even directly address CCS activities, and include them or exclude them from their scope (notably the UN Framework Convention on Climate Change, the Kyoto Protocol and the EU's Monitoring and Reporting Guidelines). However, despite the absence of an overarching framework for CCS, many individual international, regional and EU legal frameworks are potentially relevant to CCS activities and many definitions and prohibitions within these frameworks are sufficiently broad to encompass and regulate CO_2 capture and geological storage activities (see Hendriks et al., 2005).

Many of these legal frameworks use defined terms, such as 'pollution', 'land-based pollution', 'wastes', 'hazardous wastes', 'industrial wastes', 'liquid wastes', 'harmful substances', 'dangerous substances', 'dangerous activities', 'operator', 'ship', 'sea', 'dumping', 'disposal', 'placement' and 'storage' to define their scope and regulate specific activities. How these terms are understood in the context of each legal regime determines whether CCS activities are covered and prohibited, regulated, or excluded from regulation.

Some potentially relevant legal regimes use 'positive lists' to delineate the scope of their coverage. They may annex or reference lists of substances, groups of substances, characteristics of substances, or categories of covered activities. They may also refer to lists contained in other conventions, or to regionally or nationally determined lists. Other legal regimes use 'negative lists' to define their scope—with everything included unless it is expressly excluded from coverage. Positive and negative lists offer the flexibility to add or delete regulated substances or activities from coverage. Still other regimes define their scope and coverage by the risks that the handling, storage, shipment or accidental release of a particular substance may pose (for example, transboundary risks or substantial risks), or the risks that a particular activity may pose.

Where it is not clear whether a CCS activity falls within or outside the scope of a defined term, and thus inside or outside regulation, this creates regulatory uncertainty for entities undertaking or wishing to undertake CCS. A number of international, regional and EU frameworks present challenges for CO_2 capture and geologic storage in this regard. Some of the most prominent of these are the London Convention, the London Protocol, the OSPAR Convention, the EU Waste Directive, the EU Landfill Directive, the EU Water Framework Directive and the EU Liability Directive, which are discussed below.[5] Clarification of the applicability of these frameworks will be needed through amendments, policy guidance or the creation of a distinct legal regime for CCS, either inside or outside existing legal regimes.

4.1. *The 1972 London Convention*

The 1972 *London Convention*[6] is an international agreement between countries that aims to prevent the pollution of the sea by the dumping of waste. Under the London Convention, Contracting Parties pledge to 'individually and collectively promote the effective control of all sources of pollution of the marine environment, and pledge themselves especially to take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that 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'. Under Article XII, parties also pledge to promote, 'within the competent specialized agencies and other international bodies, measures to protect the marine environment against pollution caused by: (a) hydrocarbons, including oil and their wastes…'.

[5] Many other relevant international, regional and EU frameworks, including those relating to waste management and transport, marine pollution, transportation, transport and liability, environmental impact assessments, access to information, public participation and access to justice, water, liability for transboundary impacts, nature conservation, and siting are discussed at length in Hendriks et al. (2005).

[6] 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. The London Convention is a global convention, with 82 State Parties as of April 2006.

'Waste' is broadly defined to include 'material and substance of any kind, form or description'—a definition broad enough to encompass CO_2. 'Dumping' is defined as the 'deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms, or other man-made structures at sea'. The 'sea' is defined to include all marine waters other than the internal waters of State Parties. In 1990, the Parties to the London Convention agreed to phase out sea disposal of 'industrial wastes' by 1 January 1996, with 'industrial wastes' defined to include 'waste materials generated by manufacturing or processing operations' (Resolution LDC.43(13)). Exclusions from the prohibition against the dumping of industrial wastes do exist (e.g., for certain uncontaminated inert geological material, and uncontaminated organic materials), but CO_2 resulting from industrial processes does not clearly fall within any of the listed exclusions.

In 1997, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) conducted a study that noted that the dumping of both liquid and solid CO_2 is prohibited by both the London Convention and the 1996 London Protocol (Purdy and Macrory, 2004). In 1999, the Scientific Group to the London Convention concluded that fossil fuel derived CO_2 was an industrial waste.

Hence the London Convention prohibits the deliberate disposal of CO_2 directly into marine waters. The Convention does not, however, expressly address the sub-seabed, and its applicability to seabed injection may benefit from clarification in the context of CCS for countries that are not Parties to the London Protocol.

4.2. *The 1996 London Protocol*

The *1996 London Protocol* to the London Convention entered into force in March 2006, and had 30 Parties as of February 2006. The Protocol supersedes the London Convention for Parties to the Protocol who are also Convention Parties.[7] The London Protocol is notable because, when it was agreed, it specifically prohibited the dumping of wastes, including industrial wastes. Since that time, the Protocol has been amended to expressly allow CCS in certain circumstances.

The 1996 London Protocol differs in significant ways from the earlier London Convention. Under the Convention, dumping is *permitted*, except for materials that are on a banned list. Under the newer Protocol, dumping is *prohibited* except for materials on an approved list. The Protocol expressly prohibits the deliberate disposal (dumping) into the 'sea' of *all* wastes from vessels or manmade platforms. However, Annex 1 to the Protocol (as originally agreed in 1996), set out seven categories of wastes or other matter that 'may be considered for dumping': (1) dredged material; (2) sewage sludge; (3) fish waste, or material resulting from industrial fish processing operations; (4) vessels and platforms or other man-made structures at sea; (5) inert, inorganic geological material; (6) organic material of natural origin; and (7) bulky items primarily comprising iron, steel, concrete and similarly unharmful materials for which the concern is physical impact. CO_2 did not plainly fall within one of these listed waste categories.

Moreover, under the newer London Protocol, 'sea' is now defined more broadly to include the 'seabed and subsoil thereof', but does not include 'sub-seabed repositories accessed only by land.' Thus geologic storage by injection from vessels or manmade platforms at sea, directly into sub-seabed repositories (accessible by water) is prohibited. However, the London Protocol does not bring within its scope (and hence does not prohibit) geological storage of CO_2 by pipeline from a land-based source to a sub-seabed repository. This distinction is difficult to reconcile.

Recognizing the legal difficulty the London Protocol presented to some forms of geologic storage, Parties interested in CCS proposed amendments to expressly permit CCS activities. The United Kingdom, for example, proposed that Annex 1 to the Protocol be amended to add 'carbon dioxide streams arising from industrial fuel processes' as a new 'waste or other matter that may be considered for dumping' (LC/CM, 2006),[8] with the amendment limited to situations where the process of dumping consists of sequestration of the carbon dioxide into sub-seabed geological structures, and where the purpose of sequestration is to avoid the emission of those carbon dioxide streams to the atmosphere.

On 2 November 2006, at the First Meeting of the Contracting Parties to the London Protocol, the Parties adopted amendments to Annex 1 to include ''Carbon dioxide streams from carbon dioxide capture processes for sequestration''.[9] These streams may only be considered for dumping if: (1) disposal is into a sub-seabed geological formation; (2) they consist 'overwhelmingly' of carbon dioxide (they may contain incidental associated substances derived from the source material and the capture and sequestration processes used) and; (3) no wastes or other matter are added for the purpose of disposing of those wastes or other matter. These amendments came into force on 10 February 2007, 100 days after adoption.[10] Parties recognized that guidance on the means by which sub-seabed geological sequestration can be conducted in a manner that is safe for the marine environment over the short- and long-term should be developed as soon as possible. The Scientific Group of the London Protocol was requested to develop specific guidance on the application of Protocol Annex 2 to geological sequestration, with a view to adoption a the Second Meeting of the Contracting Parties in November 2007. Until then, Parties are to use best available guidance.[11]

Article 3 of the London Protocol imposes a general obligation on Parties, requiring that 'appropriate preventative measures are taken when there is reason to believe that

[7] London Protocol Article 23.

[8] Article 6 of the Protocol provides that 'countries shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea'. The UK also suggested that Article 6 also be amended to permit the export of CO_2 for sequestration under the seabed in another State Party to the Protocol, ''where the country of import has issued a permit for its sequestration'' (LC/CM, 2006).

[9] See IMO Briefing 43/2006 (8 November 2006); LC-LP.1/Circ.5 (27 November 2006) (Notification of amendments to Annex 1 to the London Protocol 1996).

[10] LC-LP.1/Circ.11 (16 February 2007) (Notification of entry into force of the ''CO_2 Sequestration'' amendments to Annex 1 to the London Protocol 1996).

[11] IMO Briefing 43/2006 (8 November 2006).

wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects.' Article 3 also emphasizes that Contracting Parties should ensure that the Protocol should not simply result in pollution being transferred from one part of the environment to another. Against this backdrop, CCS has been addressed within the London Protocol as part of a suite of measures to tackle the challenge of climate change and ocean acidification, including the need to further develop low carbon forms of energy; it is recognized as an important 'interim solution' and not a substitute for other measures to reduce carbon dioxide emissions.[12]

4.3. 1992 OSPAR Convention

The *OSPAR Convention*[13] is a regional agreement that regulates the deliberate dumping of pollutants into the North-East Atlantic Ocean maritime area. 'Maritime area' is broadly defined to include internal waters and territorial seas of the Parties, the sea beyond and adjacent to the territorial sea under the jurisdiction of the coastal state to the extent recognized by international law, and the high seas, including the bed of all those waters and its subsoil (Art. 1(a)).

Parties are under a general obligation to 'take all possible steps to prevent and eliminate pollution' and 'shall take 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.' The Convention has 16 Parties, including the European Commission on behalf of the European Community. Recent papers introduced within OSPAR have highlighted the effects on the marine environment of ocean acidification, resulting from elevated levels of CO_2 in the atmosphere (OSPAR, 2006a)[14] and suggested that the risks and effects of leakage of CO_2 stored in geological structures would have to be evaluated against the risk to the marine environment posed by elevated atmospheric levels of CO_2 (OSPAR, 2006b).

OSPAR uses different approaches for different sources of pollution (pollution from land-based sources, pollution by dumping, and pollution from off-shore sources—oil and gas activities). As a result, the same wastes, matter, or substances, with the same effects on the marine environment, may be regulated differently under different OSPAR Annexes depending upon how those wastes, matter or substances reach the marine environment.

Annex I *permits* the deliberate disposal under the seabed of 'pollution' from land-based sources, other than for the purpose of offshore activities (i.e., oil and gas activities). Here, best available technology and best environmental practice is required for point sources, as well as a system for monitoring and inspection for compliance with regulations or permits. Annex II, in contrast, *prohibits* the 'dumping' of CO_2 (as 'wastes or other matter') in the seabed and its subsoil from vessels and man-made structures at sea, though exceptions exist for 'placement' for certain purposes. Annex III then *prohibits* the dumping of wastes or other matter from offshore installations (oil and gas), but *allows* 'discharges or emissions' from these installations, and *allows* for certain 'placements' but only in the context of offshore activities.

OSPAR's Annexes thus create the potential for different treatment of CO_2 injection into geological storage sites reached by pipeline from land, by pipeline from vessels, by pipeline from manmade structures at sea that are not related to oil and gas extraction, and by pipeline from offshore installations that are related to oil and gas extraction. They also create the potential for different treatment of CO_2 that arises from offshore activities and that does not arise from offshore activities. In the context of CCS, these Annexes would benefit from an approach that addresses similar risks, purposes and wastes similarly, to increase regulatory certainty. With the amendment to Annex 1 of the London Protocol in November 2006, Parties to the London Protocol who are also Parties to OSPAR can be expected to push within OSPAR for a reflection of these November amendments.

4.4. UN Framework Convention on Climate Change

The *UN Framework Convention on Climate Change* (*UNFCCC*) requires a compilation of a national inventory of 'emissions by sources' and 'removals by sinks' of all greenhouse gases, using comparable methodologies agreed by the Parties. Parties must also report on national policies and measures and their impacts on emissions by sources and removals by sinks.

Recently, the IPCC completed its update of the 1996 Guidelines for National Greenhouse Gas Inventories. The new 2006 IPCC Guidelines include a chapter on the reporting of CCS activities. They provide guidance for estimating emissions from the additional fossil fuels used for CO_2 capture, compression, transport and injection of CO_2, with these emissions included and reported in national inventories where the energy is used in the appropriate stationary or mobile energy use categories. Fuel used by ships engaged in international transport are treated as international bunker fuels (not included in the national totals regulated under the Kyoto Protocol). Despite the new IPCC Guidelines, reporting may be challenging where leakage rates from storage sites are unknown, where geological storage sites combine CO_2 from a variety of installations or for a variety of purposes (e.g. disposal, storage, enhanced oil recovery), or where these sites extend beyond national borders. Emission factors for individual geological storage sites will need to be developed.

4.5. Kyoto Protocol

The *Kyoto Protocol* to the UNFCCC allows Annex B Parties to engage in emissions trading for the purpose of meeting their quantified emission limitation or reduction targets under Article 3. Parties may trade a variety of fungible units derived from Joint Implementation projects under Article 6, Clean

[12] LC-LP.1/Circ.5 (27 November 2006) (Notification of amendments to Annex 1 to the London Protocol 1996).

[13] 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic.

[14] According to these documents, high levels of carbon dioxide in the atmosphere are changing ocean carbon chemistry at a rate 100 times faster than at any time during the last 100,000 years (OSPAR, 2006a).

Development Mechanism projects under Article 12, or assigned amount units derived from Parties' Annex B targets.

The relationship of CO_2 capture and storage to present and future Kyoto commitments, and to emissions trading, requires further discussion—particularly if CCS is to be seriously considered for inclusion in the Clean Development Mechanism (CDM). CDM projects must contribute to real, measurable and long-term benefits related to the mitigation of climate change and generate reductions that contribute to sustainable development in host countries (Kyoto Protocol Article 12). It is the host country's prerogative to confirm whether a project assists it in achieving sustainable development.[15] However, due to the 'energy penalty' associated with CCS (additional energy required for CO_2 capture, transport and storage), the potential for escape from storage sites (fugitive emissions or leakage), and absence of strong regulatory frameworks in many developing countries, some consideration of the relative merit of CCS projects to accepted types of CDM mitigation options, such as renewable technologies, is warranted. From the perspective of the environmental integrity of the Kyoto Protocol (and its targets), it may be inappropriate to allow a tonne of emissions 'avoided' through CCS in a developing country (with associated uncertainties in baselines, seepage rates, energy penalties and fugitive emissions) to permit an additional tonne of emissions to the atmosphere in an Annex B Party—the anticipated result of issuance of a 'certified emission reduction' from a CDM project.

To explore some of these issues, at the First Meeting of the Parties to the Kyoto Protocol (COP/MOP 1), the Parties agreed to hold a workshop in May 2006 on considering CCS as CDM activities.[16] The Parties also requested the CDM Executive Board to consider proposed new methodologies for CCS activities and to make recommendations to the Parties on issues related to project boundary, leakage and permanence. The Second Meeting of the Parties to the Kyoto Protocol, in November 2006 (COP/MOP 2), considered the workshop report and CDM EB recommendations with a view to a decision on how to consider CCS as CDM project activities. COP/MOP 2 discussions were inconclusive, with the Parties recognizing 'that there remain a number of unresolved technical, methodological, legal and policy issues relating to carbon dioxide capture and storage activities under the clean development mechanism, including those noted in the report of the [CDM] Executive Board.'[17] The Parties initiated a process for collecting further input on a variety of issues, including:

(a) Long-term physical leakage (seepage) levels of risks and uncertainty;
(b) Project boundary issues (such as reservoirs in international waters, several projects using one reservoir) and projects involving more than one country (projects that cross national boundaries);
(c) Long-term responsibility for monitoring the reservoir and any remediation measures that may be necessary after the end of the crediting period;
(d) Long-term liability for storage sites;
(e) Accounting options for any long-term seepage from reservoirs;
(f) Criteria and steps for the selection of suitable storage sites with respect to the potential for release of greenhouse gases;
(g) Potential leakage paths and site characteristics and monitoring methodologies for physical leakage (seepage) from the storage site and related infrastructure for example, transportation;
(h) Operation of reservoirs (for example, well-sealing and abandonment procedures), dynamics of carbon dioxide distribution within the reservoir and remediation issues;
(i) Any other relevant matters, including environmental impacts.[18]

These inputs will be considered by the Parties at the Twenty-seventh meeting of the Subsidary Bodies, and COP/MOP 3 in 2007, with a view toward a decision at COP/MOP 4 in 2008.

4.6. *EU Frameworks*

No clear regulatory framework for CCS exists as yet within the EU, although a legislative proposal is expected in 2007. Instead, a number of existing frameworks are potentially problematic.

The EU Waste Framework Directive[19], for example contains a broad definition of 'waste' that excludes from its scope 'gaseous effluents emitted into the atmosphere.' CO_2 that is not 'emitted into the atmosphere' but instead captured prior to emission, and intended for disposal, would seem to fall within the Waste Framework Directive's regulatory scope. If captured CO_2 is regulated as 'waste', establishments or undertakings carrying out waste disposal or recovery operations related to CO_2 will require permits under Articles 9 and 10 of the Directive, with appropriate permitting conditions. The regulation of CO_2 as 'waste' under the Waste Framework Directive will impact the treatment of captured CO_2 under other Directives that rely on the definitions of waste under this Framework, among them the Landfill Directive.

The *EU Landfill Directive*[20] may be problematic for the geological storage of CO_2 because it imposes a total ban on the acceptance of liquid waste at landfills. CO_2 is most likely to be injected into geological cavities in dense phase.[21] In the United Kingdom, one Court of Appeals that has evaluated the disposal of liquid waste by injection into a borehole into sandstone and limestone strata 1000 m below sea level found that this activity constituted 'deposit into land' within the meaning of the Landfill Directive, and found the injection of liquid waste prohibited.[22] Hence the physical state in which CO_2 is

[15] See e.g., Report of the Conference, 2006, decision 1/CMP.2 (Further guidance relating to the clean development mechanism).
[16] Report of the Conference, 2005, decision 7/CMP.1 (Further guidance relating to the clean development mechanism).
[17] Report of the Conference, 2006, decision 1/CMP.2.
[18] Id.
[19] Council Directive 75/442/EEC of 15 July 1975 on waste, as amended by Directive 91/962/EEC of 23 December 1991.
[20] Council Directive 99/31/EC of 26 April 1999 on the landfill of waste.
[21] CO_2 normally will be injected in the liquid form (i.e. at temperatures under 31 °C). In most geological formations, CO_2 will be in the supercritical phase (i.e. at temperatures above 31 °C).
[22] Blackland Park Exploration Ltd. V. Environmental Agency, CCA (Civ. Div.) [2004].

'accepted' at a landfill and the physical state of CO_2 at injection are likely to impact its treatment under current legislative frameworks.

The *EU Water Framework Directive*[23] allows Member States to authorise the injection of 'water containing substances resulting from the operations for exploration and extraction of hydrocarbons ... into geological formations from which hydrocarbons or other substances have been extracted or into geological formations that are unsuitable for other purposes' (Art. 11(3)(j)). It also permits Member States to authorize injection of natural gas or liquefied petroleum gas (LPG) into geological formations which are permanently unsuitable for other purposes, or to inject natural gas or LPG for storage purposes in certain circumstances (Art. 11(3)(j)). However, the Water Framework Directive contains no explicit reference to CO_2. The relationship between the Landfill Directive and the Water Framework Directive requires consideration in the context of the timeframe for CO_2 'storage'—i.e., whether CCS involves storage or actual disposal.

The *EU Monitoring and Reporting Guidelines*[24] provide criteria for the monitoring and reporting of greenhouse gas emissions from listed activities. 'Emissions' are defined as the release of greenhouse gases into the atmosphere from sources in an installation. 'Installation' is then defined as a stationary technical unit 'and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution...'. It is not clear whether or under what circumstances the boundaries of an 'installation' could extend to related geological storage activities. The Monitoring Guidelines allow EU Member States to submit guidelines to the Commission for review and approval for reporting CCS. However, a difference in methodology between Member States could result in different methods of addressing and accounting for leakage from geological storage sites, and impact the cost of CCS in different locations.

The *EU Environmental Liability Directive*[25] places strict liability on 'operators' for the prevention and remediation of environmental damage to protected species, natural habitats, water or land resulting from a range of listed 'occupational activities'. These activities include the operation of installations with permits under the IPPC Directive,[26] waste management operations (including transport of waste, after-care of waste disposal sites, and operation of landfill sites), the discharge of pollutants into groundwater under the Water Framework Directive, and the transboundary shipment of wastes. Fault-based liability exists under the Environmental Liability Directive for damage to protected species and natural habitats resulting from non-listed occupational activities. Clarification is needed as to whether certain CCS activities fall within the listed occupational activities. Moreover, while the Directive covers damage to protected species and habitats, water and land, it does not satisfactorily address damage to the atmosphere resulting from leakage of carbon dioxide from geological storage sites, or liability for releases that impact upon commitments under the EU Emissions Allowance Trading Directive. To the extent that liability is excused where an emission or event is authorized by permit, appropriate permit conditions need to be designed to address CCS activities, and appropriate financial security considered for CCS activities and operators of geological storage sites.

5. Additional regulatory issues to be addressed

In addition to the issues identified above, a number of existing regulatory gaps must be addressed if carbon dioxide capture and storage is to proceed on a large scale.

- *The lack of information on the long-term impacts of geological CO_2 storage on the environment, on the storage effectiveness of particular sites, and on the potential human and environmental impacts of accidental releases from pipelines and individual storage sites*. The precautionary principle requires that conservative measures be taken where scientific knowledge is not complete. Substantial information will be needed to issue permits with appropriate permit conditions, and to determine that there is not infact 'a likelihood of significant environmental impacts' from CCS activities undertaken in particular locations.
- *The absence of criteria for monitoring and reporting captured and stored CO_2, and monitoring techniques to comply with these criteria*. Monitoring systems are needed to: (1) protect health and safety by confirming the integrity of geological reservoirs; (2) enhance public confidence; and (3) provide consistent data in support of accounting for greenhouse gas emissions.
- *The absence of an appropriate liability regime tailored to CCS*. Certain aspects of liability for environmental damage caused by the escape of CO_2 from the CCS chain can be addressed through the EU Environmental Liability Directive, with the clarification of listed 'occupational' activities. Similarly, certain aspects of transboundary harm can be addressed by existing international liability regimes and regulatory systems, with the extension or clarification of these frameworks for the bulk capture and transport of CO_2, depending on the scale contemplated and the risks posed as a result. However, a system for addressing climate liability will also be needed for the harm to the global environment from the leakage of CO_2 from the entire CCS chain where credit has been awarded under emissions trading schemes for avoided emissions. A system of long-term liability will also be needed to address long-term releases from geological storage sites, with consideration given to the identity of the responsible party, duration of liability, joint and several liability where multiple contributors are involved,

[23] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

[24] Commission Decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (2004/156/EC).

[25] Directive 2004/35/EC of the European Parliament and of the Council of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage.

[26] Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control.

limitations of liability, financial guarantees, and the possible transfer of responsibility from the private sector to the public sector at some stage.

- *Environmental impact assessments, access to environmental information by the public, and public participation in decision-making*. Many international conventions and EU Directives address these issues, including the Espoo (EIA) Convention, SEA Protocol, Aarhus Convention, EIA Directive and SEA Directive. Different activities, in different locations, with different risk thresholds, trigger the EIA process under different frameworks. Timing also varies, with some assessments and notifications to take place prior to the initiation of an activity, and others to take place after an activity is underway. These requirements raise a number of questions for policymakers to address in planning for large-scale CCS activities.
- *Economic incentives*. In a context of rising greenhouse gas emissions, where CCS is very costly and geological storage shown to be safe, a variety of economic incentives may be needed to encourage the uptake of CCS technology and to increase its cost-efficiency through large-scale application.

6. Conclusion

CCS is a relatively new technology in the climate change context, and many of its legal and regulatory implications are not yet broadly understood. Many international, regional and EU legal frameworks are relevant to CCS activities. However, only a few of these frameworks explicitly address CCS activities. The clear inclusion or exclusion of CCS activities from the range of relevant legal frameworks will increase transparency, provide regulatory certainty, and facilitate those CCS activities and methodologies that are agreed to be consistent with international and EU law. This is now underway within the London Protocol and OSPAR, but carbon capture and geological storage in other contexts will require further attention.

The adaptation of EU frameworks that are relevant to CCS may in some cases reflect a natural extension of these frameworks and the EU is expected to put forward a legislative proposal on CCS within the next year, which will significantly clarify the state of play. However, for certain international and regional conventions, the integration of CCS issues may be time consuming and challenging, and depend upon the political dynamics of each process. The extent of this challenge will be seen in the years to come.

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