Technical support for an enabling policy framework for carbon dioxide capture and geological storage

Task 2:
Discussion paper
Choices for regulating CO_2 capture and storage in the EU

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INDEX

1 Introduction

This paper presents a high level view of the key policy options for regulating CO_2 capture and storage(CCS) activities in the EU. It consists of:

- A brief introduction to the regulatory issues posed across a CCS activity, and the attendant regulatory needs;
- How components of these issues can be regulated through including CCS in the EU Emissions Trading Scheme (EU ETS), and what remains outside of the EU ETS i.e. what gaps then remain;
- What conferring other pieces of existing EU legislation could achieve in filling the gaps;
- What other pieces of EU legislation could be triggered if CO_2 is classified as waste/CO_2 injection classified as waste disposal, and does that provide additional benefits to EU ETS and other legislation;
- What gaps still persist within these frameworks, and;
- What are the options to consider going forward?

Annex B also outlines some suggested issues and amendments to existing EU legislation that will be required in order to clarify their scope, confer their provisions or remove them as potential barriers.

1.1 Impacts and risks to be managed for CCS

In terms of the risk presented by CCS, they can be broadly split between:

- The global risk - namely that the transported and stored CO_2 is re-emitted to the atmosphere, which would even be enhanced by the energy penalty, and
- Local environment, health and safety (EHS) risks - associated with the impacts and effects of CO_2 capture, transport and storage, including impacts of construction, materials consumption, and the risks posed by un-planned losses of containment (Table 1) – these may be augmented by the presence of certain toxic impurities in the captured CO_2.

Table 1 Environmental, health and safety impacts and risks related to CCS activities

Capture	Transport	Injection and Storage
1. Emissions of other pollutants to various media (such as SOx, NOx, solid waste and upstream impacts through greater fuel use, balanced against the environmental benefits of CO_2 capture); 2. Occupational and local environmental health and safety (EHS) risks posed by the presence of large volumes of pressurised CO_2 at capture plants; 3. Any other environmental concerns from construction and operation of the capture process, taking into consideration the use of best available technology as a potential means to minimise these risks;	1. Pipeline routing - pipeline construction and maintenance will have impacts on the environment and landscape; and, 2. Global risk - that the pipeline leaks and the captured CO_2 is re-emitted back to the atmosphere compromising the effectiveness of CCS as mitigation option; and, 3. Local EHS risk that any leaked CO_2 poses to the surrounding local populations and the environment (from asphyxiation of flora and fauna and acidifying effects on soil, surface and groundwaters).	1. Above ground installation siting, construction and technology employed, including the potential environmental impacts of storage site prospection (seismic etc.) 2. Global risk - that the stored CO_2 is re-emitted to the atmosphere, thus compromising the effectiveness of CCS as a mitigation option, which would even be enhanced by the energy penalty, and 3. Local EHS risks - associated with the impacts and effects of CO_2 storage and un-planned loss of containment. These EHS risks can be split into: - surface release, potentially resulting in asphyxiation and ecosystem impacts (tree roots, ground animals, effects of CO_2 seepage on ground- and surface water quality); - effects of impurities on the subsurface; - impacts of CO_2 in the subsurface, through metal or other contaminant mobilisation, which could be augmented by the presence of certain impurities; - quantity-based (physical) effects such as ground heave, induced seismicity, displacement of groundwater resources and damage to hydrocarbon production; - occupational and local EHS risks posed by the presence of large volumes of pressurised CO_2 at injection facilities and storage sites.

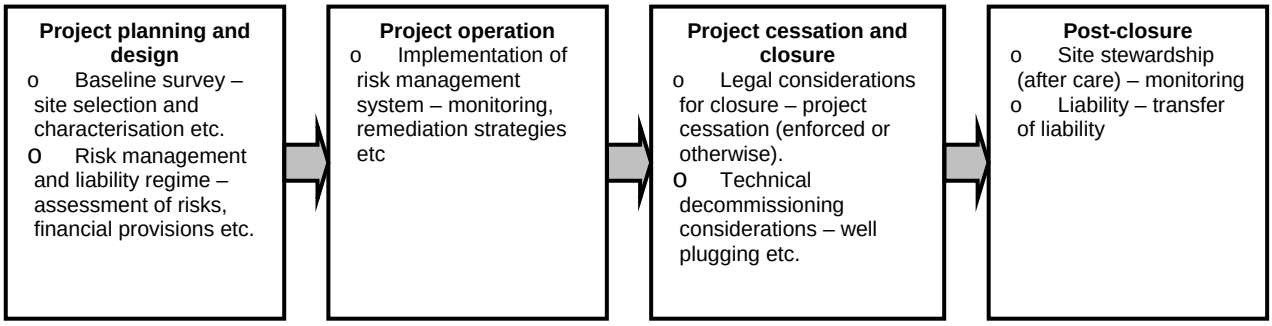
1.2 Requirements of a management framework

Based on the impacts and risks highlighted (Table 1), a regulatory framework for CCS must include powers that cover *inter alia*:

- *Risk assessment and management* – so as to enforce the assessment and management of each of the risks presented by a CCS project, including setting out technical standards on design, construction, operation and closure of a CCS activity;
- *Verification and assurance* – so as to ensure consistent and appropriate standards for storage site selection across the EU-27 (perhaps via an EU-level technical approval committee, which serve to approve the first demonstration projects as a minimum[1]);
- *Enforced closure* – to create provisions for termination of operation in cases where severe problems are identified (and impose conditions on this termination);
- *Liability* – to establish liability arrangements including:
    - liability for any local or global environmental damage that may occur;
    - upfront financial provisions in the event of insolvency of the operator;
    - rules governing transfer of liability to the state.

In this context, CO_2 storage sites present the greatest regulatory challenge because of the novel nature of the activity and the lack of analogous regulatory regimes in place. Particular elements that need to be included in a CO_2 storage site regulatory management framework are highlighted below (Figure 2).

Figure 2 Summary of key regulatory needs for CO_2 storage site management*



* More details regarding these issues are outlined in Annex I.

Regulatory modifications are needed to ensure that the CO_2 storage activities can be enabled (i.e. that potential legal barriers and prohibitions are removed), taking into consideration:

- Water and waste legislation (Water and Waste Framework Directives etc.)
- Licensing of storage site prospection (Licensing Directive)

Moreover, there are some potential enabling pieces of legislation that could serve – via modification – to put in place and enable the development of risk assessment and management controls for CCS activities including *inter alia*:

- Land use planning legislation (EIA Directive)
- Industrial pollution control legislation (IPPC Directive; Emissions Trading Directive)
- Major-accident hazard legislation (Seveso II Directive)
- Liability legislation (Environmental Liability Directive)
- Waste management legislation (Landfill Directive, Transfrontier Shipment of Waste Regulation)
- Indirectly via legislation such as the Habitats Directive and Worker Safety Directive

A more detailed review of policy choices in this context is outlined below.

[1] Although the legal basis for this would need to be checked against relevant EU competencies in the field of land use planning, Art 175 of the EU Treaty.

2 Inclusion of CCS in the EU ETS

The EU ETS is considered to be the principal policy instrument to incentivise CCS, and there is political will at EU and Member State level for recognition of the technology in the scheme. The Commission has expressed its intention to recognise CCS in Phase II of the EU ETS (2008-12) through voluntary Member State opt-in under Art 24 of the Emissions Trading Directive. However, the precise modalities for inclusion remain subject to debate, but the key issues to consider for inclusion are:

- to recognise captured CO_2 as non-emitted and thus absolve the responsibility of the operator to surrender allowances for non-emitted CO_2 which is transferred outside of the installation boundary, and
- to ensure that any emissions of CO_2 across the chain is accounted for in order to maintain the environmental integrity of the scheme i.e. that CO_2 is not simply vented elsewhere outside the scheme boundaries.

2.1 Options for including CCS in the EU ETS

Under the present Directive, Art. 24 opt-in would require the whole chain of CO_2 source, capture, transport, injection and storage to be included in the ETS as one installation, and appropriate monitoring and reporting guidelines (MRG) to be established. The installation is allocated allowances in line with similar installations (CO_2 sources) not employing CO_2 capture. This approach allocates all the risk and liability for emissions on the one installation. In the medium term it would be useful to provide more flexibility to deal with the potential for multiple operators using common carriage networks. There are two main options for further flexibility:

1. Consider elements of the CCS chain (source and capture; transport; injection and storage) as separate installations in their own right, and establish appropriate MRGs for each (excluding the CO_2 source which would already be subject to incumbent MRG provisions). The capture plant in this case is assumed to form part of the source installation, which transfers CO_2 to the pipeline installations (and subsequently the storage installation). Pipelines and storage facilities would be allocated zero allowances (EUAs) in order to incentivise minimal loss of CO_2. This has the advantage of severing links between different components of the chain, facilitating multiple-operator developments, and clearly allocating the risk and liability for emissions to each element across the chain of operations, and would create a "chain of custody" for the CO_2 from source to storage.
2. Consider the CO_2 source and capture plant as one installation, and apply transfer provisions for this installation to licensed transport and storage facilities[2]. The EU ETS monitoring and reporting guidelines or a licensing or permitting regime would include provisions for pipeline and storage site operators to monitor and report emissions back to the transferring installation in order that they reconcile these emission against their inventory of exported CO_2 (i.e. creation of a "chain of custody" for CO_2 via the EU ETS monitoring and reporting guidelines). Risk and liability for reconciling emissions would likely need to spread amongst operators through private contracts between exporting installations, pipeline operators and storage site operators; this would be an entirely commercial matter.

Option 1 is in essence a more transparent and certain way of regulating Option 2, the latter relying on private contracts which could be open to dispute, litigation and lack of transparency. As such, Option 1 is recommended as the preferred policy option for the EU beyond Phase II (beyond 2012).

2.2 Regulatory coverage achieved through the EU ETS

In terms of regulatory coverage, including CCS in the EU ETS will create provisions for the following regulatory needs:

- *Recognition of non-emitted CO_2 in emissions trading* – this will be achieved, although there will be a need to amend EU law on pollution inventories to ensure appropriate recording of emissions i.e. the European Pollutant Transfer and Release Registry.
- *Risk management; Verification (monitoring scheme design and monitoring and reporting obligations)* - will be created for CO_2 producers, transporters and storage site operators. The proposed monitoring and reporting plan for each installation will be subject to regulatory approval under Art. 4-6 of the Emissions Trading Directive. Reported emissions data can be used to compile National Greenhouse Gas inventories and support AAU trading under Article 17 of the Kyoto Protocol.
- *Risk assessment [partial] (baseline survey - site selection, characterisation, risk assessment)* – as the monitoring scheme must be based on the site characteristics (including identified potential leakage

[2] This approach was proposed by ERM/DNV in 2005, based on the guidance provided in the EU ETS Phase I monitoring and reporting guidelines (Decision 2003/156/EC)

pathways) and an assessment of the risk of leakage (e.g. realistic sub-surface modelling procedures that predict the movement of CO_2 over time and identify locations where emissions might occur), then inherently the accompanying monitoring and reporting guidelines would require detailed site assessment, characterisation and risk assessment to be carried out. Updates of the characterisation and risk assessment would also be needed reflecting improved resolution of the subsurface achieved through monitoring (adaptive learning principle)[3].

- *Risk management (monitoring CO_2 purity)* - monitoring and reporting will inherently require laboratory analysis of exported, transported and injected CO_2 because of the effects impurities could have on accounting errors.
- *Risk management and liability transfer (monitoring conditions for a storage site post-closure)* - a Greenhouse Gas Permit issued under Art 4 of the Emissions Trading Directive could provide competent authorities with the power to enforce monitoring obligations as long as considered necessary, including during the post-closure phase of projects. Termination of the monitoring and reporting obligations could be made conditional on competent authority satisfaction that the storage site poses a low-level of risk to the environment from seepage i.e. that the CO_2 is securely trapped in the storage formations. At that point, the permit to emit could be withdrawn. In essence, termination would need to be coupled with liability transfer as if the site emits CO_2 post permit withdrawal, the operator would be in breach of EU law. However, termination of a Greenhouse Gas Permit is unlikely to prove a satisfactory legal instrument for the basis of liability transfer and would need to be complemented with a parallel permitting regime (see below).
- *Liability – Global risk (remediation obligations for global damage from transport and storage installations)* - Inclusion of pipelines and storage sites as installations in the EU ETS, and allocating zero allowances will confer an obligation on operators to surrender allowances equal to any emitted CO_2. Therefore, this inherently creates a remediation obligation in respect of the global impact of emissions, and also serves to maintain the environmental integrity of the EU ETS. However, the practicalities need serious consideration: the lifetime of the installations, the capability of monitoring regimes to detect leakage, and the likely amount of any leakage are all relevant factors.

Based on this analysis, inclusion of CCS in the EU ETS will trigger some important regulatory obligations, although some gaps will remain.

2.3 Remaining gaps and ambiguities

Following recognition of CCS in the EU ETS, remaining regulatory gaps would include:

2.3.1 Risk assessment and management

- It would not provide any regulatory coverage for, and thus assessment of, local EHS risks posed by the CO_2 capture, transport and storage installations;
- It would only provide for partial regulatory controls on site characterisation and selection procedures, although monitoring scheme design would require approval ahead of the commencement of injection activities. The timing of the monitoring scheme design and approval under the EU ETS would likely come after development consent for the project, and therefore, an alternative regulatory instrument to ensure full risk assessment prior to approval of the monitoring scheme design i.e. prior to the granting of a development consent; will be required.
- In the case of CO_2 purity, whilst monitoring may take place, no direct controls on or reporting obligation on impurities content or any enforcement procedures in the case of co-injection of undesirable substances could be brought about under these provisions. Such stipulations would need to be laid down in either the development consent and/or site authorisation.

2.3.2 Verification and assurance

- Whilst a Greenhouse Gas Permit would only be issued by a competent authority upon satisfaction that emissions could be satisfactorily monitored and that the operator was sufficiently competent to implement the monitoring programme outlined, the process is not sufficiently robust to ensure the site assessment, characterisation and risk management elements of project approval had been fulfilled.

2.3.3 Liability

[3] These requirements are laid down in the Tier 3 monitoring and reporting approach developed by the IPCC for CO2 stroage sites (see Chapter 5, Volume 2 of the 2006 IPCC Revised Guidelines for National Greenhouse Gas Inventories)

- It could not be used to create upfront financial provisions to cover costs in the event of operator insolvency;
- It does not create any liability or remediation obligations for any localised third-party damages caused by leaking CO_2;
- It does not create any clear provisions under which liability can be transferred. Termination of a GHG permit under Art 4 of the Emissions Trading Directive would not provide a sufficiently robust legal basis upon which liability could be transferred back to the host country.

2.3.4 Forced cessation of activities

- It does not lay down any conditions for site closure;
- It does not provide for any legal basis with regards to enforced cessation of operations that are not performing satisfactorily. Withdrawal of a GHG permit does not entail cessation of operations as a badly performing site would continue to emit (unlike the case of withdrawal of an IPPC permit);

Consequently, additional regulatory instruments will be necessary, as reviewed below.

3 Filling the gaps with other EU legislation

The primary pieces of legislation for consideration in the context of filling the gaps remaining from the EU ETS include:

- The EIA Directive
- The IPPC Directive
- The Seveso II Directive
- The Environmental Liability Directive

All of these may go some way to filling the gaps outlined, as reviewed below.

3.1 Risk assessment and management

The **EIA Directive** lays down requirements for operators to:

- Undertake an environmental impact assessment to identify, describe and assess in an appropriate manner the direct and indirect effects of a project on human beings, flora and fauna, soil, water, air, climate and the landscape and interactions thereof.

Presently CCS operations are excluded, although elements (such as certain industrial installations, pipelines, and drilling activities) are included in some way (either in Annex I or II). Conceivably, by conferring the EIA Directive requirements onto CCS via inclusion in Annex I of the Directive, the following obligations could be conferred onto operators:

- *Site selection, characterisation (including CO_2 fate and behaviour studies)* – these would be required in order to demonstrate that the impacts had been appropriately assessed such that the competent authority could form an opinion with regards to safety of the project and thus whether the project should be authorised. Whilst these issues could be potentially covered by the EU ETS as outlined above, it is unlikely that these obligations would be triggered in sufficient detail at the development consent phase of a project i.e. it is likely that the EU ETS provisions would not apply in the project planning phase.
- *Risk assessment*– in order to demonstrate to the competent authority the risks posed did not pose an undue threat to human health or the environment.
- *Design of risk management system* – such that the competent authority was satisfied that the risks posed by the project could be effectively managed by the operator.
- *Monitoring of potential receptors* – part of a project's development consent could include obligations on monitoring potential receptors, at the discretion of the issuing competent authority. This would be linked to the level of risk considered to be posed by the operation.
- *Pipeline routing* – taking into account risks to human health and the environment.

The EIA Directive would provide for only minor regulatory control with regards to the technical details of storage site construction and operation, and would need to be complemented by other legislation (e.g. IPPC Directive).

Conferring **IPPC Directive** requirements on to CO_2 storage operations would also set down the following obligations for operators in respect of risk assessment and management:

- *Technical design standards* – at the planning and authorisation stage: to demonstrate use of best available techniques, including: the way in which the installation is designed and built (Art 2); accident prevention measures (which could provide for consideration of secondary containment features) (Art. 3(e)), describe sources of emissions from the installation, undertake a baseline site condition assessment, and outline the proposed technology used (Art. 6(1)).
- *Monitoring* – during operation: to set out release monitoring requirements, specifying measurement methodology and frequencies etc. (Art. 9(5)), and would also confer the 2006 IPCC National GHG Inventory Guidelines, via consideration of the horizontal BREF document on General Monitoring Principles.
- *Standards for site closure* – to cease operations in a way such that pollution risks are avoided and the site is returned to a satisfactory state (Art. 3(f)). This would take into consideration the pre-construction site condition assessment, and would place an obligation on operators for remediation of any damages caused by the site. These provisions could be used to complement the monitoring conditions enforced under the EU ETS (as described above).

Conferring IPPC Directive requirements would require CO_2 injection facilities and storage sites to be added to Annex I of the Directive. In the absence of any stand-alone legal instrument that includes technical specifications for storage site design; there would be a need to prepare a BREF document for CO_2 storage[4]. This might include information on, *inter alia*: data collection procedures for site characterisation; reservoir modelling techniques in terms of both static Earth model construction and dynamic modelling procedures; quality control and quality assurance procedures for developing modelling data and modelling procedures; risk assessment of the overall scheme design based on different scenario analysis of modelling results; technical installation design in terms of above ground operations; well bore design and integrity, including cements, casings, in-situ monitoring systems; other monitoring systems; well plugging technologies etc.

For CO_2 capture, the majority of installations that would be likely to employ CO_2 capture are already qualifying IPPC installations (e.g. power plants, refineries, cement works, chemical plants), and as such, its provisions would be triggered. The attendant BREF documents for these activities would need to be updated to reflect latest knowledge on CCS, and additionally there is probably a need to consider development of a horizontal BREF on CO_2 capture techniques.

The **Seveso II Directive** could be used to enhance the level of risk assessment applied to CO_2 storage operations. In particular, it would require of operators:

- *Risk assessment* – to notify the competent authority about the quantity and physical form or stored substances (Art. 6(2)(e)), and details of the planned activity of the storage facility (Art. 6(2)(f)). These provisions would require operators to undertake detailed information on the nature of risks posed by the proposed operation.
- *Risk management* – to prepare a safety report, which would cover, *inter alia*, identification and management of major-accident hazards and the measures put in place to prevent accidents; incorporation of adequate safety in design, construction, operation and maintenance; demonstration that an emergency plan had been put in place; and provision of sufficient information on siting new activities (Art. 9(1))

The same obligations would apply to CO_2 capture facilities if CO_2 was included in Annex I (Part 1) of the Seveso II Directive, subject to certain qualifying criteria/thresholds to avoid unintended consequences.

3.2 Verification and assurance

Conferring EIA, IPPC and Seveso II Directive requirements would present a three-tier approvals procedure to cover risk assessment and risk management, enforceable by competent authorities at the Member State level. It would also introduce statutory consultation with other competent authorities, as well as public consultation on development consent applications and operational performance[5]. Notwithstanding this

[4] It is worth noting that the Landfill Directive repeals the need for a BREF document for landfills as the technical requirements laid out therein are considered to provide sufficient coverage for the IPPC permitting of landfills.

[5] Under Art. 6(1) and (2) of the EIA Directive. Statutory consultation will open up the scope for a raft of other EU legislation to be taken into account at the development consent phase, including the Habitats Directive, the Wild Birds Directive, the Water Framework Directive, the Groundwater Directive etc. Under the IPPC Directive: Art. 15 requires public reporting of permit conditions and emissions performance. Art. 16 requires information sharing amongst Member States, with a view to updating of best available techniques to reflect latest technological developments.

three-tier approach, there remain some issues and ambiguities in respect of whether such a regulatory framework would provide sufficiently robust verification and assurance for CCS activities, in particular approvals for CO_2 storage sites, taking into consideration the following:

- A key challenge in relying on the EIA Directive provisions to fulfil all the requirements for site selection at the planning consent stage is that the burden or proof lies with the operator to convince the local competent authority of the level of risk posed by the operation, which would remain open to differential interpretation across Member States. Consequently, this could lead to lower quality projects being accepted, and also potential distortion of the EU ETS market through the authorisation of lower cost storage sites, with higher risk of seepage, because of lower regulatory requirements. As such, there could be a need to complement EIA Directive requirements with more prescriptive provisions on site selection and characterisation procedures, laid out in a new stand-alone piece of legislation such as a Regulation, Directive, or Decision. This could specifically outline *de minimis* criteria for Member State competent authorities with regards to site selection and characterisation that must be considered prior to CO_2 storage site development consent;
- IPPC permit applications in general require a greater level of technical detail in terms of the precise planned operations at the site, relative to environmental impact assessments, which generally require the applicant to show in broad terms how the risks to human health and the environment have been taken into account and the measures planned to mitigate these risks. Consequently, it may be essential to confer IPPC requirements onto CO_2 storage activities in order to ensure the provision of a corresponding high-level of technical information prior to authorisation. A BREF Document could provide a basis for setting *de minimis* criteria for site authorisation, but could take some time to develop and be overly prescriptive at this stage. It may be preferable to create guiding principles in new legislation;
- There is no clear precedent with regards to the timing of applications for development consents under the EIA Directive and applications for IPPC permits. Sometimes an IPPC permit will be prepared ahead or concurrently with an environmental impact statement, but more often the more complex IPPC permit application will follow once authorisation under EIA rules has been received. As such, clearer guidance to competent authorities on the level of information to be provided by potential operators, and under which or both regimes (EIA and/or IPPC) in respect of site selection would be warranted.
- Presently it is not clear whether IPPC requirements apply to the subsurface. In the UK, natural gas storage faculties subject to IPPC requirements only require the permit to consider issues presented by the above ground installation.
- It also remains a matter of policy as to whether the Commission considers the conferring of Seveso II Directive requirements onto CO_2 capture and storage facilities is appropriate (noting that pipelines are excluded from Seveso II Directive). There are also jurisdictional uncertainties regarding Seveso II offshore. Conferring its requirements may serve to reinforce the risk assessment procedure and operational safety management for CO_2 storage sites, although presently there appears to be little appetite amongst Member States for such a development[6]. It may be necessary to consider development new risk assessment and risk management procedures specific to CO_2 storage sites via a new stand-alone piece of legislation relevant to CO_2 storage sites. Further consultation on this matter is required.
- There may be a case for introducing an EU level verification process for CO_2 storage site developments, either solely, or via comitology. This could be for all projects, or include of a sunset clause which elapses after a certain period of time or number of projects.

3.3 Liability

Conferring IPPC Directive requirements onto CCS operations would also create regulatory obligations for operators in respect of:

- *Site restoration in the event of local environmental damage* – it would trigger the provisions of the Environmental Liability Directive via Art. 3(f), and thus potentially create obligations in respect of remediation of any damage caused post closure.
- *Liability transfer* – IPPC permits are required to include provisions for definitive cessation of activities, which could be used to provide the basis for liability transfer i.e. that when certain conditions are met as laid out in the permit, then the permit could be withdrawn and liability transferred. These conditions, however, may be open to differential interpretation across Member States and further guidance on these conditions may be required in EU law.

[6] Based on a survey by the UK HSE, provided by the European Commission.

The IPPC Directive does not require the provision of financial securities to cover the cost of restoration in the event of operator insolvency. The Environmental Liability Directive does encourage Member States to take measures to encourage the development of financial security instruments and markets to enable operators to cover their responsibilities under the Directive. Furthermore, there are ambiguities with regard to how the Environmental Liability Directive could apply to Marine Waters, although this could be clarified via appropriate amendment of the Draft Marine Strategy Directive.

Presently, the Environmental Liability Directive does not provide for the type of financial securities that may be applicable to CO_2 storage facilities (such as those laid down by the Landfill Directive Art 8(a)(iv)).

The Seveso II Directive does not include any provisions for remediation or financial provisions to cover damages caused by major-accidents at Seveso qualifying establishments.

Consequently, these existing frameworks would not provide for upfront financial provisions for CO_2 storage sites (subject to their obligations being conferred onto CO_2 storage sites) without specific modifications being made in the legal text (*lex specialis*).

3.4 Forced cessation of activities

Conferring IPPC Directive requirements on CO_2 storage sites would cover:

- *Enforced cessation of activities* – create regulatory certainty regarding the capacity of competent authorities to review permit conditions and repeal permits for poorly performing storage sites i.e. withdrawal of an IPPC permit would constitute enforced closure under Art 13 of the Directive.

Unsatisfactory CO_2 capture operations would also be subject to the IPPC permit conditions of the host installation.

4 Classifying captured CO_2 as a waste

Classification of CO_2 as waste could trigger three additional considerations in respect of CCS activities, as follows:

1. Waste Transfer Notification provisions – under the Trans-frontier Shipment of Waste Regulation, producers of CO_2 would be under a "duty of care" as a notifier to ensure that they transferred waste [CO_2] to a licensed waste management handler (who was suitably ensured against potential damages arising from waste transfer), and that the waste was disposed of in a licensed waste management facility. An audit trail via notifications and authorisations would apply, thus establishing a chain of custody for the CO_2 from source to storage[7].
2. Hazardous Waste Directive provisions – this would place an obligation on operators to separate out hazardous and non-hazardous waste for disposal where technically and economically feasible, which could apply in the case of certain impurities in the captured CO_2 stream. The Hazardous Waste Directive has no *de minimis* provisions.
3. Landfill Directive Provisions – subject to resolution of ambiguities in the Landfill Directive (relating to matters such as landfill of "liquid" waste, "underground storage", and jurisdictional coverage offshore), the Directive could apply to CO_2 storage installations if captured CO_2 is classified as waste. As such, provisions relating to site selection, site design, waste acceptance criteria (including sampling obligations), provision of a financial security, closure procedures, technical standards for closure, after-care considerations, and technical committee review, would all apply.

In broad terms, this type of scheme reflects that proposed for Option 2 in Section 2.1 i.e. the creation of a 'duty of care' across the CO_2 chain of custody that is directly linked back to the producer and thus placing the liability solely on the producer. It is questionable whether this type of regime would add any regulatory certainty regarding CCS planning and operational practices as:

- The waste notification procedure would present only similar obligations as those achieved by recognition of CCS operations under the EU ETS (Option 2 in Section 2.1) i.e. creating a CO_2 chain of custody. Moreover, it would require development of a new set of notification and authorisation procedures, and would govern only transboundary shipment, with the risk that approaches within the national boundaries of Member States would differ.

[7] Although presently for waste movements inside national boundaries, adoption of these principles are only voluntarily enforceable by Member States. A full review of Member State waste handling legislation has not been undertake for the purposed of this study

- It is unlikely to be technically or economically feasible to remove trace hazardous impurities from captured CO_2 streams.
- Whilst the technical requirements laid out in the Landfill Directive do the same issues as those posed by CO_2 storage, namely: site selection, operation, decommissioning and after-care, these differ somewhat to the technical elements required to regulate the storage of CO_2 in subsurface pore space. As such, the Directive and its Annexes would require significant amendment to be applicable to both landfills CO_2 storage sites.

Consequently, there is probably no advantage to conferring Community waste management legislation onto CCS operations as it is likely to require a number of amendments to the existing legislation to be fully applicable. Notwithstanding this conclusion, the Landfill Directive can serve as a useful template upon which to model a new piece of stand-alone legislation relevant to CO_2 storage installations, if considered necessary as a matter of policy.

5 Summary and conclusions

CCS can be included in the EU ETS from Phase II (although modifications for Phase III (2012-17) to allow each element of the CCS chain (source, transport, injection and storage) to be designated as separate installations in their own right would be useful). Under the current system, appropriate MRGs can be established for each element (excluding the CO_2 source which is already subject to MRG provisions). Inclusion in the EU ETS can create the following regulatory obligations:

- Recognition of non-emitted CO_2 in emissions trading.
- Monitoring scheme design and monitoring and reporting obligations, including partial risk assessment.
- Monitoring CO_2 purity (partial).
- Monitoring post-closure.
- Remediation obligations (partial) in respect of emissions of CO_2 to the atmosphere (global risks).

Under such as scheme, a number of regulatory gaps and ambiguities persist, in particular in relation to control on impurities, site closure, liability transfer, site selection and characterisation (although the latter would trigger a requirement for *a priori* determination and approval of a monitoring plan), estimation of potential impacts and remediation of local damages.

The EIA, IPPC, the Environmental Liability Directive, and potentially the Seveso II Directive requirements could serve to close these gaps as follows:

- *Risk assessment and management* – EIA, IPPC and Seveso II Directives all require prior demonstration of the environmental and human health risks posed by major development projects, which could include CCS activities through appropriate amendment of the legislation.
- *Verification and assurance* – EIA, IPPC and Seveso II Directives all require consideration to be made of the risks of a project by competent authorities in Member States. It is questionable whether the regime would provide a consistent regulatory approval approach, and may need to be complemented by either guidance documents or new legislation laying down more prescriptive approaches.
- *Enforced closure* – conferring IPPC Directive requirements onto CO_2 storage sites would provide the basis for forced cessation of operations. These conditions would also apply for CO_2 plants employed at IPPC qualifying installations.
- *Liability* – conferring IPPC Directive requirements would trigger the Environmental Liability Directive requirements in respect of any damages arising post site closure. However, it does not create obligations for upfront financial provisions to be made by the operator in the event of insolvency.

Thus, these provisions are subject to the following policy considerations:

1. Whether differential conditions for authorisation under the EIA Directive by competent authorities in Member States is acceptable. There may be a need to develop in additional legislation outlining standardised *de minimis* assessment criteria that must be taken into account prior to granting CO_2 storage site development consent.
2. Whether reliance on a BREF document under the IPPC Directive is considered to be a sufficiently robust regulatory instrument to lay down technical standards for CO_2 storage site selection, characterisation, construction, operation, monitoring, closure and stewardship provisions. If it is not, then new stand-alone legislation will be needed to enforce such technical requirements.
3. Whether there is a need to lay down legal obligations for operators to take out financial securities for operations to cover closure, decommissioning and stewardship costs in the event of insolvency.

Presently, neither the IPPC Directive nor the Environmental Liability Directive require such securities to be taken out.

4. Whether the Seveso II Directive obligations would provide a necessary additional level of risk assessment and risk management ahead of IPPC Directive obligations. Alternatively, there may be a need to introduce a new type of risk assessment and risk management procedure for CO_2 storage sites in a new stand-alone piece of legislation.

Based on the discussion presented, it is likely that conferring EIA and IPPC Directive requirements on CO_2 storage would provide a useful basis for authorisation and operational permitting of CO_2 storage sites, and could potentially fill many of the remaining gaps left by EU ETS inclusion in relation to risk assessment and risk management. It would also create conditions for verification and assurance over site selection via the authorisation/permitting process, although this may need further legal instruments to ensure consistent enforcement across Member States. An IPPC permitting regime would trigger Environmental Liability Directive requirements; however, this would not provide a legal basis for requiring upfront financial provisions for storage site operators. An IPPC permit would also provide a basis for enforced cessation of activities, as well as potentially acting as a basis for liability transfer.

Thus, there remains is a critical policy decision regarding whether there is a need to complement or replace the provisions under the EIA and IPPC Directive with a more prescriptive approach. This could be achieved through development of a new stand-alone piece of legislation specific to CO_2 storage site development and operation. Conferring of Seveso II Directive requirements on CO_2 capture, transport and storage activities is also an outstanding policy decision.

It is reasonable to conclude that on the whole, issues related to CO_2capture and transport would be covered by existing legislation regulating analogue industrial activities, subject to whether Seveso II provisions are considered to be an appropriate regulatory instrument to further manage these activities.

Application of Community waste management legislation is unlikely to provide additional regulatory certainty, and would require significant amendments to the existing regime for it to be applicable, suggesting that it may be more appropriate to invest the effort in developing new stand-alone legislation for CO_2 storage sites. Notwithstanding this conclusion, the Landfill Directive provides for a useful template for a potential approach to developing such legislation in so much as it includes provisions for site selection, site design, waste acceptance criteria (including sampling obligations), provision of a financial security, closure procedures, technical standards for closure, after-care considerations, and technical committee review.

Table 2 Coverage of regulatory needs for CCS operations that potentially apply to existing or new EU regulation.

Project Phase	Element	Sub-element	Emissions trading	Filling the gaps				Waste	MS Legislation
			EU ETS	EIA	IPPC	Seveso II	ELD	L/fill Directive	
CAPTURE									
Plant planning	Technology choice	Use of BAT			X				
Plant operation	Recognition of non-emitted CO2		X						
	Other emissions	NOx, SOx, solid waste			X				
	Local EHS risks					X?			X
TRANPSORT									
Pipeline planning	Appropriate routing			X					
Pipeline operation	Global risk of leakage		X						
	Local EHS risks from leakage					X?	X?		X
STORAGE									
Storage site planning and design	Baseline survey	Site selection	X?	X?	X?			X?	
		Site characterisation and fate and behaviour studies for injected CO_2	X?		X?	X?		X?	
		Estimation of potential impacts (risk-based assessment)	X?		X?	X?		X?	
	Risk management and liability regime	Design of risk management system, including financial securities						X>	
		Application of appropriate QA/QC and external assurance	X?	X?	X?	X?		X?	
Storage site operation	Implementation of risk management system	Operation of above-ground installations		X?	X			X?	
		Monitoring of CO_2 flows and emissions above and below ground	X		X	X		X?	
		Remediation obligations	X		X?	X?	X	X	
		Monitoring of CO_2 purity.	X		X			X	
Storage site cessation and closure	Legal considerations	Conditions upon which site closure might commence	X?		X			X	
	Technical decommissioning considerations	Well plugging and abandonment techniques			X?	X?			
Storage site post-closure	Site stewardship (after care)	Ongoing monitoring obligations	X		X		X		

Project Phase	Element	Sub-element	Emissions trading	Filling the gaps				Waste	MS Legislation
			EU ETS	EIA	IPPC	Seveso II	ELD	L/fill Directive	
	Liability	Ongoing liability provisions and liability transfer	X		X		X?		

Key: X = covered or potentially covered if obligations conferred onto CCS activities
X? = partial coverage or ambiguity over coverage if obligations conferred onto CCS activities

6 Choices for regulating CO_2 capture and storage

Based on the analysis presented in this paper, several policy options for CO_2 storage sites can be envisaged. These can be summarised as:

i) Inclusion of the full chain of CCS activities in the ETS on the basis of defining each as separate installations covering CO_2 source and capture; transportation; injection and storage. Modify existing EU legislation (EIA, IPPC, Seveso, and Environmental Liability) to cover gaps remaining from EU ETS inclusion without the introduction of any new stand-alone legislation on CO_2 storage. Disapply waste legislation. This would rely on the Emissions Trading Directive to create a "chain of custody" for CO_2, harmonised development consent procedures under the EIA Directive for storage sites, IPPC BREF Documents to provide technical standards for site selection, operation, closure and stewardship, and the Environmental Liability Directive to account for liability post-closure etc.

ii) As for (i) for EU ETS, but develop new stand-alone complimentary legislation that fills gaps, whilst also conferring *all* the relevant Directive requirements onto CCS activities. Disapply waste legislation. The stand-alone legislation could broadly mirror the Landfill Directive and cover appropriate outstanding risk assessment and risk management procedures;

iii) Similar to (ii) for EU ETS and new stand-alone legislation, but conferring *only selective* relevant Directives, for example, the EIA Directive alongside a new stand-alone piece of legislation. Disapply waste legislation;

iv) As for (iii), but develop new stand-alone legislation to cover *all* remaining gaps *without* conferring requirements from *any* other existing Directives. Disapply waste legislation;

v) Inclusion only of the combustion and capture elements of CCS activities in the ETS on the basis of transfer of CO_2 from the source installation (including the capture plant) and the establishment of a "chain of custody" for the transferred CO_2 via either the transfer provisions of the EU ETS monitoring and reporting guidelines, the development of new licensing regime for pipelines and storage sites, or perhaps use of Community waste management legislation (based on the notification and authorisation procedure under the Trans-frontier Shipment of Waste Regulation).

vi) Continue the application of waste legislation to CO_2 capture and storage, and establish chain of custody requirements and modify the Landfill Directive to be applicable to CO_2 storage sites (subject to clarification of certain components present in the legislation, including "liquid waste" prohibition, the definition of "underground storage" and territorial scope of the Directive).

These policy choices need to take into consideration the policy considerations outlined in Section 5 (in the list number 1-4 on page 10).

Annex A – Regulatory needs for CO_2 storage sites

Table 1 Regulatory needs for CO_2 storage sites

Project Phase	Element	Sub-element	Notes
Project planning and design	Baseline survey	Site selection	- identification of a suitable sites, taking into consideration site characteristics.
		Site characterisation and fate and behaviour studies for injected CO_2	- Factors include: regional seismicity, potential trapping mechanisms, delimitation of storage site boundary, potential migration pathways, secondary containment features ("storage complex" paradigm). Achieved through static and dynamic reservoir simulation modelling (long-term and short term); - Injection strategy, CO_2 delivery rate, and reservoir injectivity/permeability. - Identification of potential receptors for (human populations, sensitive ecosystems, commercially important resources);
		Estimation of potential impacts (risk-based assessment)	- Range of hazard scenarios (leakage, induced seismicity, displacement of formation fluids, mobilisation of metals) - Estimation of likelihood, probability potential frequencies for such scenarios; - Consequence analysis; - Acceptability of risks.
	Risk management and liability regime	Design of risk management system, including financial securities	- Injection strategy and scheme design (linked to delivery rate and reservoir injectivity); - Monitoring scheme design for the injected CO_2 plume and surrounding zones and receptors; - Remediation strategies and technologies - A priori financial provisions to cover cost of decommissioning, any damages, remediation requirements and after care, especially in the case of operator insolvency.
		Application of appropriate QA/QC and external assurance	- Appropriate use of data sources, modelling assumptions, application of expert judgment, external expert committees, consultation, and external verification
Project operation	Implementation of risk management system	Operation of above-ground installations	- Siting of above ground installations; - Good operational practice; - Operator competency.
		Monitoring of CO_2 flows and emissions above and below ground	- For the purpose of early detection of CO_2 seepage or unintended migration; - For chain of custody and GHG accounting obligations. - Including wells, CO_2 plume and surrounding zones and potential receptors; - Need to history match and recalibrate models – incorporate principle of adaptive learning in order to continuously improve sub-surface knowledge.
		Remediation obligations	- Need to ensure liability allocated for remediation of any damages caused (local and global)
		Monitoring of CO_2 purity.	- Needed for GHG accounting purposes. - Also to ensure that storage safety isn't compromised by impurities, and/or - Operators do not use CCS and a means of co-injecting hazardous substances (unless permitted).
Project cessation and closure	Legal considerations	Conditions upon which site closure might commence	- Maybe a need to specify the conditions under which site closure would commence (pressure conditions, volume stored etc.); - Need for enforced closure procedure for unsatisfactory sites.
	Technical decommissioning considerations	Well plugging and abandonment techniques	- Based on best available techniques at the time of decommissioning
Post-closure	Site stewardship (after care)	Ongoing monitoring obligations	- To ensure continued safe storage post closure. Also for assessing long-term storage stability.
	Liability	Ongoing liability provisions and liability transfer	- Need to consider the conditions for which satisfactory evidence that secure storage is achieved, upon which monitoring may cease or be reduced, and liability could be transferred from the operator to host government.

Annex B - Potential issues and modifications to existing legislation

This Annex highlights some clarifications and modifications that would be needed in order to confer the requirements of existing legislation onto CCS operations.

Emissions Trading Directive

CO_2 capture, transport and storage

1. Phase II – opt-in source installation, capture, transport and storage as one installation under Art. 24. Legal provisions already set out for in draft Phase II monitoring and reporting guidelines.

2. Phase III+ options are
    - provide for separate opt-in of transport and storage elements
    - include CO_2 transportation [fixed technical installations i.e. pipelines] and CO_2 storage sites as installations under CCS activities in Annex I of the Emissions Trading Directive.

    - Assume coverage of CO_2 capture installation as part of qualifying installations via the existing "*technical connection*" definition of installation in the Directive.

3. Consider whether the legal arrangements for greenhouse gas permits under Articles 4-6 set down conditions that are suitable for enforcement of monitoring, reporting and surrender of allowances post-storage site closure. In this context:

    - Art. 4 sets out the legal right to emit greenhouse gas emissions for qualifying installations y way of issuance of a greenhouse gas emissions permit. Installations listed in Annex I not holding a greenhouse gas emissions permit may not emit greenhouse gases listed in Annex I. On this basis, and assuming pipelines and storage sites would be included as installations in Annex I from Phase III, then a leaking storage site or pipeline operator without a valid greenhouse gas emissions permit would be in breach of the conditions of the Directive, so long as the permit conditions were enforced beyond the cessation of injection operations. It is foreseeable that the permit conditions could be enforced post-closure.

    - Art. 6 sets down the conditions for permit holders, including - under Article 6(2)(b) monitoring requirements, Art.6(2)(d) reporting requirements, and Art. 6(2)(e) "*an obligation to surrender allowances equal to the total emissions of the installation in each calendar year…r*". On this basis, as long as the greenhouse gas emissions permit remained in force post-closure, then the operator would remain under obligation to monitor, report and surrender allowances, regardless of whether injection operations had ceased.

    - Art. 7 also outlines conditions for changes in installations. These create an obligation for the operator to notify the competent authority of any changes in function, extension, or identity of the operator in relation to the greenhouse gas permit.

4. Consider whether there is a general need to amend the Directive to reflect the nature of CO_2 pipelines and storage sites i.e. that of a *potential* source of CO_2 emissions. The present Directive wording is more aligned with installations that emit CO_2 by way of standard operational activities. In this context:

    - Art. 5 sets out the conditions for application of a greenhouse gas permit. This may require some modification to make the conditions relevant for CCS installations, as follows (shown in square parenthesis):

        - Art. 5(b) – "*the raw and auxiliary materials used* [or handled] *which is likely* [or potentially could] *lead to emissions of gases listed in Annex I*"
        - Art. 5(c) – "*sources* [or potential sources] *of emissions of gases listed in Annex I from the installation*"

5. These obligations for operators would be withdrawn upon transfer of liability. Transfer of liability would require the greenhouse gas emissions permit to be withdrawn, and obligations for monitoring and reporting would subsequently fall on Member State, via Decision 280/2004/EC, Decision 2005/166/EC, and UNFCCC National Communications inventory reporting obligations.

Risk assessment and risk management

EIA Directive

CO_2 capture

1. Assume coverage for of CO_2 capture plant under existing provisions of the Directive through activities and installations already listed in Annex I and Annex II of the Directive. Note: this also includes major retrofits (under "…*change or extension of project...*" under Annex II Paragraph 13)[1].

CO_2 transportation

1. Assume coverage for CO_2 pipelines under existing provisions of Annex I of the Directive covering "*Pipelines for the transport of gas, oil or chemicals with a diameter of more than 800mm and a length of more than 40km*" (paragraph 16), and Annex II "*Oil and gas pipeline installations (projects not included in Annex I)*" (paragraph 10(i)). See Annex B above.

There is a need to consider:

- Whether these definitions are directly conferrable onto CO_2 pipelines (e.g. does "gas" or "chemicals" cover CO_2?)
- Whether an amendment may be brought in via *lex specialis* to change the scope of application to alternative technical specifications (i.e. whether these specifications are relevant, and what is the appropriate instrument for such an amendment).
- Whether an EIA should be made mandatory for all CO_2 pipelines? Whether they should all be Annex I installations, and regardless of size or length (taking into consideration that smaller integral pipelines in an installation need to be excluded).

There is probably a need to consult with Member State competent authorities on this matter.

CO_2 storage

1. Assume that Annex II Paragraph 3(d) "*Underground storage of combustible gases*" excludes CO_2 storage form its scope (as CO_2 is non-combustible).

2. Consequently, there will be a need to amend Annex I of the Directive to include CO_2 storage sites within the scope of the Directive. Possible catch-all wording [or selected parts of] for an amendment might include:

   "22. Carbon dioxide capture and geological storage activities covering installations across a CO_2 chain, including:
   - *(a) Carbon dioxide capture installations (new build or retrofit) at industrial installations*
   - *(b) Carbon dioxide pipelines greater that 800mm in diameter and 40 km in length transporting carbon dioxide for the purpose of geological storage*
   - *(c) Carbon dioxide site exploration and surveying activities including geological surveys and drilling operations*
   - *(d) Carbon dioxide storage installations, including:*
     - *above ground injection installations*
     - *subsurface storage installations including enhanced hydrocarbon production activities, and including surrounding zones (the storage complex), and other activities with a technical connection to the storage installation, such as wells, boreholes and other monitoring devices and activities*
     - *the long-term status of the installation covering site closure, decommissioning, and long-term stewardship [??]*
     - *allocation of liability for any human health, environmental or property damages resulting from the storage in and/or seepage from the CO_2 storage complex [??]"*

Paragraph (d) indents 3 and 4 may not be in keeping with the general principles and scope of the EIA Directive. Inter-service consultation on this matter is recommended.

[1] Note: Annex II installations and activities are subject to EIA at Member State discretion.

IPPC Directive

CO_2 capture

1. Assume coverage of CO_2 capture activities via the existing "*technical connection*" definition of installation in the Directive. Note: this would include coverage for retrofits via Art. 9(2) and "*Changes by operators to installations*" clauses in Art. 12.

2. Update the following BREFs to reflect the latest thinking on prospects for CO_2 capture as BAT (see also Annex C):

   - Large Combustion Plant BREF (version 07/2006)
   - Cement and Lime Manufacturing BREF (version 10/2001)
   - Mineral Oil and Gas Refineries BREF (version 02/2003) [may be others]

3. Develop cross-cutting BREF for CO_2 capture technologies.

CO_2 transportation

1. Assume that IPPC Directive coverage is not applicable to CO_2 pipelines. All routing issues would be considered under EIA Directive provisions.

2. Assume technical standards would be enforced under EU and Member State laws governing environment, health and safety that are applicable to other types of gas pipelines. Probably a need for Member State consultation on this matter.

CO_2 storage

1. Assume sub-surface elements of qualifying installations presently excluded from the scope of the IPPC Directive.

2. Consequently, there will be a need to amend Annex I of the Directive to specifically include CO_2 storage sites within the scope of the Directive. Possible catch-all wording for an amendment might include:

   "7. Carbon dioxide storage installations, including:
   - *above ground injection installations*
   - *subsurface storage installations including enhanced hydrocarbon production activities, and including the surrounding zones (the storage complex), and other activities with a technical connection to the storage installation, such as wells, boreholes and other monitoring devices and activities*
   - *the long-term status of the installation covering site closure, decommissioning, and long-term stewardship*
   - *allocation of liability for any human health, environmental or property damages resulting from the storage in and/or seepage from the CO_2 storage complex"*

Seveso II Directive

CO_2 capture, transport and storage

1. Consider as a matter of policy, whether Seveso II Directive obligations are applicable to CCS activities. Consultation with Member State competent authorities on the matter is recommended.

2. If yes, include CO_2 as a named substance in Annex I Part 1 of the Directive, taking into consideration the following options to avoid unintended consequences for industries already using CO_2:

   - *The origin of the CO_2*. The amendment could specify that it is only applicable to CO_2 captured from industrial processing, including fuel combustion, chemical manufacture, clinker production, and/or natural gas sweetening. This approach may conflict with the underlying principles of the Directive, since for other substances no distinction with regard to their origin has been made;
   - *The quantities of CO_2 handled and stored*. This would require further research in order to establish appropriate threshold in order not to create unintended consequences for other industrial activities;

- *The pressure under which it is handled and/or stored*. This could be combined with a quantity threshold to develop risk scenarios appropriate to captured CO_2 streams;
- A combination of the above.

Verification and Assurance

EU ETS Directive

CO_2 storage

1. Consider whether the Greenhouse Gas permit issued under Arts. 4-6 of the Directive might constitute sufficient legal basis for approval of a CO_2 storage site monitoring and reporting plan. Probably yes.

2. Provide clarification on whether the timing of the issuance of a Greenhouse Gas permit under Art. 4-6 of the Directive is coherent the timing of development consents under EIA and IPPC Directives. Under the present system this is unlikely. Consequently, there is probably a need for the process to be complemented within other EU law (such as IPPC permit applications) with a view to incorporating into Greenhouse Gas permit application at the relevant time.

3. Consider whether a Greenhouse Gas permit would constitute a sufficient legal basis for enforcing ongoing monitoring of storage site post-closure. Probably yes. Withdrawal of the permit would not constitute transfer of liability to the state.

EIA Directive

CO_2 storage

1. Consider the scope for harmonising development consents granted under the EIA Directive via introduction of new EU law outlining *de minimis* criteria that Member State competent authorities must be taken into account prior to granting CO_2 storage site development consent.

2. Consider whether there is a need for EU level verification and authorisation for all CO_2 storage site development applications (with or without sunset clause).

IPPC Directive

CO_2 storage

1. Existing provisions of the Directive already provide regulatory certainty over project verification and authorisation (Art. 3-6, 9, 13). This is subject to Member State competent authority interpretation.

2. A BREF document on CO_2 storage could serve to harmonise storage site design and operation, including monitoring scheme design, across the EU.

3. Note: Art. 15 requires public reporting of permit conditions and emissions performance. Art. 16 requires information sharing amongst Member States, with a view to updating of best available techniques to reflect latest technological developments.

4. Consider providing clearer guidance on interaction between development consents for CO_2 storage sites under the EIA Directive and IPPC permit applications to ensure that appropriate level of technical information is taking into consideration in the project planning phase. Also, avoid double regulation (note: Art. 6(2) allows for consideration of information in applications already made in respect of the EIA and Seveso II Directive).

5. Ensure that Art. 9(5) requiring emissions monitoring obligations in IPPC permit applications is harmonised with Greenhouse Gas permit applications. This approach could allow for appropriate risk assessment and risk management at development consent phase of projects.

Liability

IPPC Directive

CO_2 storage

1. Consider the scope for including a requirement for financial provisions to be included via specific amendment of the IPPC Directive. Commission Legal Service should be consulted on this matter.

2. Revocation of an IPPC permit could constitute the legal basis for liability transfer of a storage site to the state. Commission Legal Service and Member States should be consulted on this matter.

Environmental Liability Directive

1. Include provisions for amendment of the Environmental Liability within the draft Marine Strategy Directive to ensure it applies to environmental pollution to marine waters.

2. Undertake wider consultation on the applicability of the Environmental Liability Directive, taking into consideration the conclusions of the Task 1 report (see Section 9.5), including such items as:

   - The state of scientific knowledge at the time of when the emission was released.
   - The definition of "occupational activity" in relation to closed sites, although it can be assumed that a storage site with a valid IPPC permit would constitute an operational site (see Enforced Closure below).
   - Transfer of liability to other entities.
   - Clarification of the time limit on liability, taking into consideration the timeframes associated with CO_2 storage.
   - Clarification over the provisions on natural phenomenon.

Enforced closure

IPPC Directive

1. Art 13 of the IPPC Directive should provide the legal basis for enforced closure of a CO_2 storage site operation. Consultation with IPPC team and Commission Legal Service on the matter is recommended.

2. The IPPC permit will need to remain valid beyond the enforced closure in order to maintain operator liability for the obligations as described in this paper.

Removal of barriers in existing legislation

Water Framework Directive

1. There is a need to amend Art 11(3)(j) of the Water Framework 2000/66/EC to provide for an exemption for CO_2 injection activities along the lines of those provided for other injection activities.

2. Consider whether there is a need to set limits on the level of impurities allowed in injected CO_2 streams.

3. Ensure that the amendment does not allow for the co-disposal of other waste materials added to the injected CO_2 stream. Possible wording in this context might be:

   " injection of carbon dioxide for long-term storage into geological formations which for natural reasons are permanently unsuitable for other purposes, and where storage will not have an effect on access to or quality of other usable groundwaters" [and]

   "Injected CO_2 streams consist overwhelmingly of carbon dioxide, and they may contain incidental associated substances derived from the source material and the capture and storage processes used, and that no wastes or other matter are added for the purpose of disposing of those wastes or other matter.[2]"

[2] This text is consistent with the text in the agreed amendment to Annex I of the 1996 London Protocol to the 1972 London Convention on Marine Pollution by Dumping of Wastes and Other Matter.

Waste Legislation

1. The current views is that waste legislation should be amended so as to remove ambiguity as to whether:
   - captured CO_2 constitutes a waste;
   - CO_2 storage constitutes a waste disposal activity;
   - injection into underground storage constitutes landfill; and,
   - CO_2 containing impurities would be considered as waste (and potentially as hazardous waste) by virtue of the presence of certain substances.

2. If the waste legislation is to be disapplied for CCS activities, there is a need to amend Art. 1 of the Waste Framework Directive 2006/12/EC, to exclude from the definition of waste CO_2 streams transported, injected and stored in so far as regulated by the proposed risk management regime.

Annex C - Potential updates required for IPPC Best Available Technique reference manuals

This annex provides some thoughts on issues presented by IPPC Best Available Technique Reference manuals (BREFs) in permitting installations employing CO_2 capture technologies.

Present treatment of CO_2 capture in BREFs

IPPC qualifying installations are required to consider the application of BAT when setting emissions limit values in the permit[3], as well as for the ensuring that all the appropriate preventative measures are taken against pollution. Under Article 16(2) of the Directive, the European Commission arranges for an information exchange on BAT for the respective qualifying activities, as well as cross-cutting issues, to be updated every 3 years. This information exchange is catalogued in the relevant BREF documents. In respect of qualifying installations potentially employing CO_2 capture (Large Combustion Plants, Mineral Oil Refineries, Cement Plants etc.), the following statements can be found:

- **Large Combustion Plant BREF** (version 07/2006) – Under "*Common Processes*" (Section 3.9.2; page 131): "*Given current technology, increasing the thermal efficiency of energy-generating processes and techniques is the most important measure in reducing the amount of greenhouse gases emitted per unit of energy produced.*" And that "*To reduce the emissions of CO_2 further, different technical options are currently under development or at a research stage. These technical options for CO_2 capture and disposal are not yet applied to large combustion plants, but they might be available in the future*."

  Furthermore, under "*Coal and Lignite Combustion*" (Section 4.5.5 Thermal efficiency; page 268) the BREF suggests that: "*For the reduction of greenhouse gases, in particular releases of CO_2 from coal- and lignite-fired combustion plants, the best available options from today's point of view are techniques and operational measures to increase thermal efficiency. Secondary measures of CO_2 capture and disposal, as described in Annex 10.2 of this document, are at an early stage of development. These techniques might be available in the future, but they cannot yet be considered as BAT*." Similar views are outlined elsewhere in the BREF under relevant combustion plant sections (see "*BAT for liquid fuel-fired boilers – Thermal efficiency*" (Section 6.5.3.1, page 396) and "Thermal efficiency of gas-fired combustion plants" (Section 7.5.2, page 477)).

  Annex 10.2 of the BREF presents some introductory information on the status of CO_2 capture techniques (based on a 1992 publication from the IEA Greenhouse Gas R&D Programme), but outlines again that the primary focus of reducing CO_2 emissions is increasing thermal efficiency of the combustion process.

- **Cement and Lime Manufacturing BREF** (version 10/2001) – under the section "*Controlling other emissions to air*" (Section 1.4.8.1, page 45) the document suggests that "*All measures that reduce fuel energy use also reduce the CO_2 emissions*." No reference is made to the use of CO_2 capture for the purpose of abating carbon oxide emissions in cement production.

- **Mineral Oil and Gas Refineries BREF** (version 02/2003) – under the section entitled "*CO_2 emission control and abatement*" (Section 4.23.2, page 324) the document concludes that "*a feasible abatement technology for CO_2 is not available. CO_2 separation techniques are available but the problem is the storage and the recycling of the CO_2.*"

Presently all relevant BREF documents advocate the best available technique for reducing CO_2 emissions is to improve fuel efficiency in the installation. Moreover, the BREF for large combustion plant is more explicit in stating that CO_2 capture cannot be considered to be BAT. The first is in tension with the energy penalty posed by CO_2 capture, and the second conflicts with CCS deployment in IPPC qualifying installations. Consequently, clearer guidance for regulators in Member State competent authorities on how the deployment CO_2 capture plants should be considered when assessing BAT in IPPC permits is probably warranted. An update to reflect the current prospects for CO_2 capture as BAT in relevant BREF documents is required, although the timelines for this is may be slow (3-5 years for BREF development for more complex technologies) and more prompt guidance for regulators may be necessary through an alternative mechanism.

[3] Although Art. 26 EU ETS Directive removes the obligation for CO_2 emission limit values in IPPC permits for installations qualifying under the scheme unless it is necessary to ensure that no significant local pollution is caused – see below.

Development of a horizontal BREF on CO_2 capture technologies

Whilst CO_2 capture is not listed as a category of qualifying installation in Annex I of the Directive, it is likely that under the definition of installation[4] (where a "technical connection" is referred to), such equipment will be subject to IPPC permitting considerations. As such there may be a need to introduce a cross-cutting BREF document relevant to CO_2 capture technology.

In this respect, many of the technical components applied in emergent clean-coal and CO_2 capture processes (amine stripping; gasification technologies; H_2 manufacture; air separation units; oxygen fired furnaces etc) are mature technologies which have been successfully used in commercial operations for some time in other industrial activities (mineral oil refining; natural gas processing; iron and steel production, glass melting etc.). Consequently, indicative BAT guidance for many components may be present in existing BREF documents (e.g. the BREF for Mineral Oil and Gas Refineries [op cit.] includes a range of guidance on amine solvent use and on gasifier technologies[5]). These should be drawn on to rapidly develop an appropriate horizontal BREF note on CO_2 capture technologies.

Transboundary and cross media effects

Although CO_2 is not listed in Annex III of the IPPC Directive, and CO_2 emissions limits values may be exempted from EU ETS qualifying installations, permitting decisions must be influenced by BAT, even where other emissions may be negatively impacted by the presence of CO_2 capture (e.g. fly-ash generation, amines solvent waste etc).

Consequently, permitting conflicts could arise where deployment of CO_2 capture could lead to an increase in emission of pollutants that are directly listed in Annex III of the Directive, or are covered by other requirements of the Directive (e.g. to ensure the no significant pollution is caused; to use energy efficiently). clearer guidance for the setting of emissions limit values is therefore probably warranted in this context, taking into appropriate consideration the trade-offs between CO_2 capture on the one hand and resultant increases in discharges of other listed pollutants on the other.

This would need to take into consideration existing guidance on handling trade-offs as outlined in the BREF Document on Economics and Cross-Media Effects[6], and views of Member State regulators on how this document may be applied in this context. Such guidance may also need to consider competing and/or overriding environmental policy priorities within the European Community with regards to climate change and other environmental considerations.

[4] Under Article 1 of the IPPC Directive: 'installation' shall mean a stationary technical unit where one or more activities listed in Annex I are carried out, 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;
[5] A detailed review of these is considered to be beyond the scope of this study.
[6] BREF Document on Economics and Cross-Media Effects, July 2006. European IPPC Bureau, Seville.