CO2 Capture Project®

UPDATE ON SELECTED REGULATORY ISSUES FOR CO_2 CAPTURE AND GEOLOGICAL STORAGE

FINAL REPORT NOVEMBER 2010









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UPDATE ON SELECTED REGULATORY ISSUES FOR CO2 CAPTURE AND GEOLOGICAL STORAGE

FOCUSING ON THE EU, US, CANADA AND AUSTRALIA

This report was prepared for the CO_2 Capture Project by Ioannis Chrysostomidis and Evan Stamatiou and reviewed by Lee Solsbery, from Environmental Resources Management. It covers the regulatory landscape existing at the end of 2010. This is a fluid area and some jurisdictions, for example Alberta, Canada, are moving to address gaps in their regulatory environments.

About the CO_2 Capture Project

The CO_2 Capture Project (CCP)
The CO_2 Capture Project (CCP) is a partnership of seven major energy companies working together to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage.

Since its formation in 2000, the CCP has undertaken more than 150 projects to increase the science, economics and engineering applications of CO_2 capture and storage. The group has been working closely with government organizations - including the US Department of Energy, the European Commission and more than 60 academic bodies and global research institutes. The CCP has completed the second of three phases and has now embarked upon the third phase of its crucial work to develop and test next generation CCS technologies. The insights of this work are critical in helping to reduce or eliminate CO_2 emissions associated with ongoing use of fossil fuels.

The CO_2 Capture Project (CCP) commissions regular reviews of government and institutional policies and incentives influencing the development of CCS. This is the fourth report published by the CCP looking at specific regulatory issues for CO_2 Capture and Geological storage in the EU, US, Canada and Australia.

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CO_2 Capture Project Phase Three participating organizations

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Need for robust CCS regulatory frameworks

As carbon capture and storage (CCS) is increasingly recognised by policy-makers as a key carbon abatement technology, legal and regulatory frameworks for CCS are emerging in several jurisdictions worldwide. Commercial investors in CCS project need to have a comprehensive framework which ensures that all aspects of the regulatory process are covered and can be understood when evaluating project risk. Governments should therefore continue to further develop regulatory frameworks and address the gaps that remain in the treatment of CCS projects, in order to accelerate demonstration and widespread deployment.

Regulatory frameworks for CCS are at various stages of development and a number of important issues remain unresolved. In order to ensure that CCS projects are viable and successful, particular effort will be required by policy-makers and regulatory agencies in all jurisdictions to ensure that:

- Licensing and permitting procedures do not present unnecessary delays to CCS deployment whilst also providing adequate assurance to the public that sites approved are safe and secure;
- Authorities are able to assure CCS project developers that all regulatory requirements for a CCS project have been agreed by governments and can be communicated clearly to project sponsors;
- Unresolved issues concerning long-term liability, transfer and financial provisions do not impose inordinate risk to commercial investment, thereby delaying widespread CCS deployment; and
- The development of legal frameworks at different levels of government (e.g. federal and state level) do not give rise to unaligned policy-making and regulation, thereby leading to uncertainty for CCS project investors and operators.

This report provides an up-to-date review of a number of regulatory issues applicable to CCS projects identified as priority areas by the CCP3 team, and identifies potential barriers or gaps. The report also presents a survey of existing and emerging monitoring, reporting and verification (MRV) guidelines and requirements applicable to CCS, as well as perspectives from CCS project developers and regulators on key regulatory issues.

Overview of regulatory developments

Significant progress has been made during the last few years across the jurisdictions under study towards the development of legal and regulatory frameworks for CCS. However, a number of remaining gaps and challenges remain within the regulatory regimes.

- In the **European Union**, the CCS Directive establishes a legal framework for regulating CCS. The Directive addresses key legal requirements pertaining to

CCS activities, including permitting, MRV and long-term liability. Member States are required to transpose its provisions into national law by June 2011. However, regulatory interpretation of the Directive is likely to vary across Member States and precise details pertaining to, for example, the transfer of long-term liability and financial security provision, remain unresolved at present.

- In the **United States**, the ongoing uncertainty regarding federal climate change policy presents the key barrier to CCS deployment. In the absence of CCS-specific legislation, various legal issues remain unresolved including the financial responsibility of operators, long-term site stewardship liability and pore-space rights. There is a significant effort underway to close the gaps and complete a CCS regulatory framework that is largely driven at the state level at present.
- In **Australia**, the regulatory framework for CCS is being developed largely on the basis of the existing oil and gas regime. Legislation is currently in place for CCS undertaken in Commonwealth waters, onshore Victoria, Queensland and South Australia. Legislation is also being developed by New South Wales and Western Australia for onshore CCS. The shelving of Australia's emissions trading scheme presents a significant barrier to short-term deployment of CCS projects whilst a number of regulatory gaps remain including the financing and regulation of common CO_2 transport infrastructure.
- In **Canada**, the existing regulatory regimes for oil and gas (provincially based) have been used to accommodate existing CCS activities. The one exception is in cases where storage activities are to take place on Federal lands; however this is not anticipated in the near term. The licensing frameworks have not yet been amended to fully accommodate CCS at a provincial level, with the exception of Alberta which is currently undertaking a CCS regulatory review and has recently announced legislation to enable CCS regulations to be completed in 2011. This legislation is scheduled to be passed in the fall 2010 session of parliament. Other provinces including British Columbia and Saskatchewan are expected to develop the appropriate frameworks for CCS activities.

Requirements for Carbon Capture Readiness

Various non-regulatory definitions of requirements for CCR have been made, including those proposed by the International Energy Agency (IEA) GHG R&D Programme and, more recently, by the Global Carbon Capture and Storage Institute (GCCSI). The major piece of existing legislation with direct CCR requirements upon project developers is the EU CCS Directive, and Member States are currently in the process of interpreting the CCR provisions as part of their transposition requirements. Elsewhere, in Australia some state governments (notably Queensland and Western Australia) have included CCR requirements as a pre-requisite for planning approval for coal-fired power stations. Although direct CCR requirements are not in place in Canada or the US, some (US) state-level and federal (Canada) GHG policies may in effect serve to incentivise CCR for new build facilities including power plants, oil sands plants and refineries.

However, most regulatory and non-regulatory CCR requirements are at present focused on fossil-fuel fired power plants only.

CCR requirements are also sometimes required by investors and lending banks, or else voluntarily sought by project developers for public acceptance reasons. Standardisation bodies like TÜV Nord and industry associations such as the European Power Plant Suppliers Association (EPPSA) have issued their own CCR definitions and guidance. An important recent development is the requirements for consideration of CCR within The Carbon Principles (whose signatory banks include Bank of America, Citi, Credit Suisse, JPMorganChase, Morgan Stanley and Wells Fargo). CCR requirements and definitions vary according to a range of factors including their scope and level of detail; overly prescriptive requirements may prove onerous to project developers.

CO_2 storage permitting and licensing

The development of robust licensing frameworks for CCS exploration and storage activities are vital in promoting wider CCS deployment and speeding up the project cycle. In the EU, the CCS Directive provides the overarching legal framework for permitting CCS activities in the Member States, based on both the exploration and CO_2 storage phase. The Directive requires Member States to consider other potential uses for the subsurface and surface areas where CO_2 storage might take place (e.g. hydrocarbon extraction). Member States are currently in the process of interpreting the Directive and key issues such as third party access and interactions with petroleum licenses remain unresolved at present.

The US and Canada are currently working towards finalisation of their frameworks for licensing CO_2 storage. In the US, storage activities will be regulated at a federal level through the existing Underground Injection Control (UIC) permitting program. Some US states are also actively engaged in the process of developing their own regulatory frameworks for permitting CO_2 storage activities, requiring close attention between federal and state level requirements, as well as legal complexities involving permitting across more than one state. In Canada, the Federal and Provincial regulatory frameworks in place for the oil and gas sector provide the basis for the existing and future regulation of CCS projects.

In Australia, a robust permitting and licensing frameworks is in place under the amended Commonwealth Offshore Petroleum and Greenhouse Gas Storage Act (OPGGS). However, the interaction of CO_2 storage licensing with existing subsurface interests in Western Australia, New South Wales and Queensland has not yet been addressed in present regulations, which would likely involve amending the states' existing petroleum legislation.

Impurities in injected CO_2 streams

At the international level, legal barriers to the geological storage of CO_2 in geological formations under the seabed have been removed through the adoption of related risk management frameworks under the London Protocol and OSPAR Convention.

The purity requirements of injected CO_2 streams are dealt with at an EU level under the CCS Directive and the recently published draft EC implementation guidelines. The purity of the CO_2 stream also has implications under the EU ETS, as avoided CO_2 emissions will be recognised only according to the concentration of the GHG stream transferred between the different ETS installations across the CCS chain. Because the Directive places the responsibility of proving that the CO_2 stream is pure enough to be stored safely on the CO_2 storage operator, it will be important for the storage site operator to put in place clear arrangements with the provider of the CO_2 stream to ensure the stream contains impurities below the relevant risk levels.

At a Federal level in the US, the presence of impurities within the injected CO_2 stream could fall under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act 1980 (CERCLA) or the Resource Conservation and Recovery Act 1976 (RCRA) potentially resulting in liabilities upon the storage operator. The proposed EPA rule suggests that substances can be added to anthropogenic CO_2 streams to facilitate injection or storage but that additional waste streams cannot be added for the purposes of disposal.

In Canada, adoption of a similar definition of what constitutes a suitably pure CO_2 stream for storage to that of the London Protocol by the Federal government regarding credit-eligible CCS activities may exclude some acid gas injection operations from consideration, with adverse economic and regulatory consequences. Two industry associations are currently studying options for a CO_2 purity standard for use in CCS activities in Canada. Australia has endorsed the London Protocol definition of a permitted CO_2 injection stream as one which is "overwhelmingly carbon dioxide" for both off-shore and on-shore geological storage.

Pore space ownership

A critical requirement for undertaking CCS projects is the need to assign property rights associated with the sub-surface pore space in which the CO_2 is stored, including the interaction of such rights with the ownership of other resources contained in the same pore space - such as oil, natural gas and ground water.

In the EU, ownership of deep subsurface pore space is generally vested in individual Member States. Nonetheless, there is still a need to deal with agreements between storage operators and mineral interest owners, where the latter may own the geologic formation or at least retain a property right to extract minerals from the subsurface.

Under the US regime, CCS storage operators need to acquire the rights to the pore space into which the CO_2 will be injected and property ownership issues will generally be matters of individual state law. Several states are developing CCS-specific statutes to clarify subsurface ownership issues and facilitate CCS operations.

In Canada, there is no specific property rights legislation in relation to CO_2 storage - a number of ownership, rights interaction, and access issues need regulatory clarification and it is likely that existing legislation governing oil, gas and water activities will be extended to cover these. Under the Australian constitution, as with the UK, all sub-surface ownership rights are expressly vested in the Crown. Due to a lack of case law precedent regarding ownership of deep subsurface pore space, considerable effort has been made at state level to clarify subsurface ownership.

Liability issues

The potential liabilities associated with CCS projects, both during the operational phase and also the post-closure period, presents a significant risk to project operators and investors. The treatment of long-term liability provisions, including state transfer and financial responsibility remains uncertain in several jurisdictions and acts as a barrier to timely project deployment.

Within the EU, the CCS Directive provides the overarching regulatory framework for dealing with liabilities associated with CO_2 storage, and Member States are likely to interpret the requirements differentially (e.g. including whether liabilities may be capped or unlimited and their quantifiable basis).

While there is no comprehensive framework in the US which specifically addresses long-term liability for CCS activities, there are a number of Federal and state regulations with a bearing on long-term liability. In most states, operational liability lies with the operator, and long-term liability is expected to be assumed by the state. Long term liability remains a key unresolved issue for project developers and a variety of responses are being - or might be - pursued by different States (for example, through an industry generated fund some provide exclusions for any fund liability relief due to gross negligence etc. and others state that if the fund runs out of money then operator will be held again liable). Also some States (e.g. State of Wyoming) are advocating that the Federal Government needs to take on long term liability as it is the agency that is pursuing GHG reductions

In Canada a process of reviewing and amending existing legislation to address liability issues is underway. Although long-term liability is addressed in the Australian CCS frameworks, the arrangements differ between Commonwealth and State schemes.

1 INTRODUCTION

This report has been prepared for Phase 3 of the CO_2 Capture Project (CCP3) by Environmental Resources Management Limited (ERM) over the period June – September 2010.

The report provides an up-to-date review of a number of regulatory issues applicable to Carbon Capture and Storage (CCS) projects identified as priority areas by the CCP3 team. The report focuses on a number of key regulatory issues pertaining to CCS capture and storage activities that are of particular interest to the CO_2 capture project this year. It draws on desk-based research and interviews held with individuals from government, industry and academia within a number of jurisdictions including the European Union, the United Kingdom, the United States, Canada, and Australia.

The purpose of the interviews was to:

- Establish a practical insight into the potential regulatory and permitting issues and gaps associated with CCS project development
- Attempt to identify how a future regulatory or permitting scheme may be developed for CCS projects in countries where there are requirements at the moment using a 5 year horizon;
- Address specific additional requirements;
- Provide a clear indication of the level of preparedness of regulators to deal with CCS project enquiries;
- Highlight potential regulatory barriers to the successful implementation of a CCS project.

Views and opinions that came out of the interview process are not presented separately due to confidentiality arrangements; however they are incorporated throughout the report and in the key conclusions of this study.

The authors would like to gratefully acknowledge the support received Robert Van Voorhes, Manager at the Carbon Sequestration Council and Dr. Meredith Gibbs, Senior Associate at Blake Dawson, along with all those individuals and institutions that contributed their views to this report but asked for their details to remain confidential.

1.1 PROJECT BACKGROUND

The primary objective of the CO_2 Capture Project (CCP) is to develop new, breakthrough technologies to reduce the cost of CO_2 separation, capture, and geologic storage from fossil fuel-fired power plants and other industrial processes. The CCP also has a parallel work stream exploring issues related to Policies and Incentives that apply to CCS activities. Phase 3 of the CCP is planned to be an industrial-scale demonstration of some CCP2 technologies, which would be a major step towards commercial deployment.

The CO_2 Capture Project first commissioned ERM to carry out an inventory and review of government and institutional policies and incentives influencing the development of policy in CO_2 capture and geological storage in 2002. The first ERM review was completed in January 2003 and identified a number of key issues of interest to the CCP. There were two subsequent reports (second report completed in 2004 and third in 2005) that both updated the original January 2003 study and provided an analysis of the regulatory issues identified during the reviews.

This study provides a further update on a number of key regulatory issues pertaining to CCS capture and storage activities that are of particular interest to the CO_2 capture project this year.

1.2 *AIMS & OBJECTIVES*

More specifically, the main objectives of this work are to:

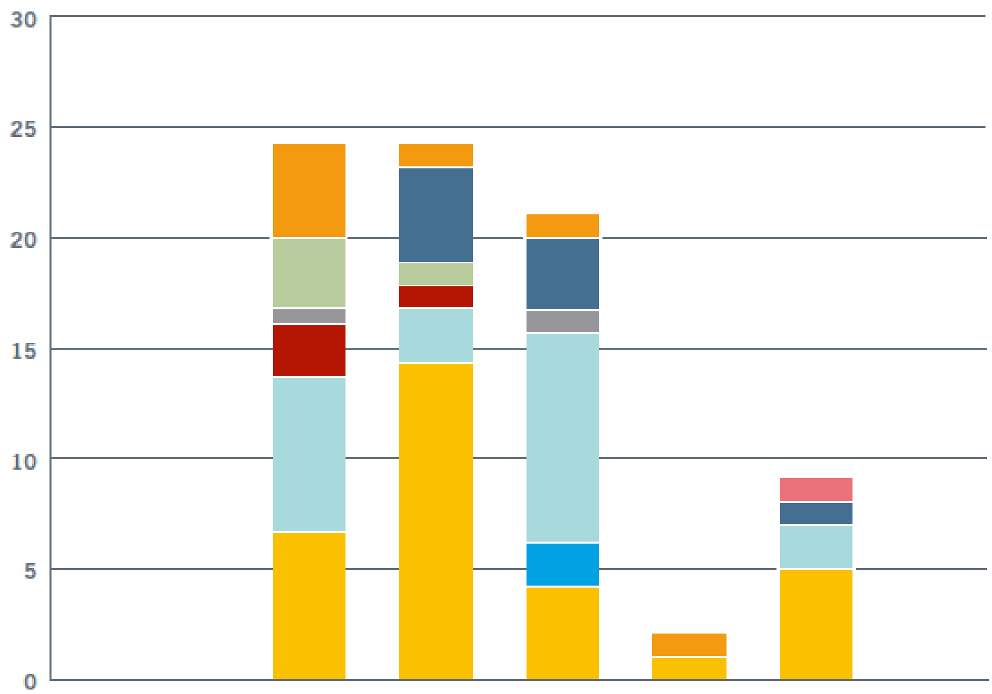
- Undertake a review of selected regulatory issues associated mainly with the capture and storage stages of CCS, as identified by the CCP3 P&I team, flag any potential barriers or gaps, and propose strategies for overcoming these barriers;
- Survey existing and emerging monitoring, reporting and verification (MRV) guidelines and requirements applicable to CCS; and
- Provide perspectives from CCS project developers and regulators on key barriers and gaps related to regulatory approval of CCS projects.

1.3 *OVERVIEW OF REGULATORY ISSUES*

Significant progress has been made during the last few years towards the development of legal and regulatory frameworks for CCS, particularly in the EU, Canada, Australia and in the United States at both federal and state level.

Progress in clarifying the legal and regulatory environments for CCS projects in these national jurisdictions has encouraged investment in, and development of, CCS projects. The bias towards CCS project initiatives being targeted towards developed countries is clearly demonstrated in *Figure 1.1* below. However, even in these jurisdictions, there are a number of remaining gaps and challenges in the regulatory regime for CCS.

Figure 1.1 Overview of large-scale CCS project initiatives as of April 2010



REGION	IDENTIFY	EVALUATE	DEFINE	EXECUTE	OPERATE	TOTAL
Africa					1	1
Australia & New Zealand	4	1	1	1		7
Canada		4	3		1	8
China	3	1				4
East Asia	1		1			2
Eastern Europe	2	1				3
Europe Area	7	3	10		2	22
Middle East			2			2
USA	7	14	4	1	5	31
TOTAL (2010)	24	24	21	2	9	80
TOTAL (2009)	20	21	14	3	9	67

Source: *GCCSI The Status of CCS Projects Interim Report 2010, April 2010*

More specifically:

- In the **European Union**, the CCS Directive (Directive 2009/31/EC) was issued in April 2009 and establishes a legal framework for regulating the environmentally safe and permanent storage of carbon dioxide (CO_2). Member States are required to transpose its provisions into national law by June 2011. The Directive addresses key legal requirements pertaining to CCS activities, including permitting, MRV and long-term liability. However, regulatory interpretation of the Directive is likely to vary across Member States and precise details pertaining to, for example, the transfer of long-term liability and financial security provision, remain unresolved at present. EU guidance documents are expected to be published by end 2010, and from the end of 2010 the first transposition measures may be officially communicated to the Commission and will then have to be checked for conformity with the Directive [1].

- In the **United States**, there are various legal issues that remain unresolved in the absence of CCS-specific legislation. These unresolved issues relate in particular to the financial responsibility of operators, long-term site stewardship liability and pore-space rights. There is a significant effort underway to close the gaps and complete a CCS regulatory framework that is largely driven at the state level at present.
- In **Australia**, the regulatory framework for CCS is still being developed. While offshore CCS Commonwealth legislation (largely based on oil and gas regulation) and onshore CCS legislation for some states are in place, further regulation and administrative guidelines are still under development. Regulation to date has focused mainly on issues associated with the storage phase of CCS operations rather than capture. The financing and regulation of common CO_2 transport infrastructure is also an area that requires further elaboration. The shelving of Australia's emissions trading scheme, the Carbon Pollution Reduction Scheme (CPRS), is also seen as a significant barrier to short-term deployment of CCS projects because of the high start-up costs for early movers in the absence of support via a carbon price signal.
- In **Canada**, regulatory regimes for oil and gas have been used to accommodate existing CCS activities, except in cases where storage activities are to take place on Federal lands [2]. The licensing frameworks have not yet been amended to fully accommodate CCS at a provincial level, with the exception of Alberta which is currently undertaking a CCS regulatory review expected to be complete in 2011.

To help ensure that CCS projects are viable and successful, particular effort will be required by policy-makers and regulatory agencies in all jurisdictions to ensure that:

- Licensing and permitting procedures do not present unnecessary delays to CCS deployment whilst also providing adequate assurance to the public that sites approved are safe and secure.
- Authorities are able to assure CCS project developers that all regulatory requirements for a CCS project have been agreed by governments and can be communicated clearly to project sponsors (or if some gaps in regulation remain, identify the areas that would have to be finalised, and the manner in which a project would then obtain the regulatory clearances needed to support an investment decision).
- Unresolved issues concerning long-term liability, transfer and financial provisions do not impose inordinate risk to commercial investment, thereby delaying widespread CCS deployment.

(1) Carbon Capture and Storage Legal and Regulatory Review 2010 (OECD/IEA, 2010)
(2) Storage activity on Federal lands is expected only in limited territories in the far North, thus it will likely not be significant.

- The development of legal frameworks at different levels of government (e.g. federal and state level) do not give rise to unaligned policy-making and regulation, thereby leading to uncertainty for CCS project investors and operators.

Governments should continue to further develop regulatory frameworks and address any gaps that remain in the approval process and/or legal treatment of CCS projects, in order to accelerate demonstration and widespread deployment. Commercial investors in CCS project need to have a comprehensive framework which ensures that all aspects of the regulatory process are covered and can be understood when evaluating project risk.

1.4 REPORT STRUCTURE

The remainder of this report is structured as follows:

- *Section 2* explores how Carbon Capture Readiness (CCR) is defined and mandated - both directly and indirectly - in the EU, US, Canada and Australia.
- *Section 3* presents an overview of existing or proposed CO_2 storage permit application procedures and licensing frameworks for the different jurisdictions.
- *Section 4* provides a short overview and comparative analysis of regulatory requirements concerning the treatment of impurities present in a CO_2 stream for CO_2 injection and storage.
- *Section 5* presents a discussion of property rights associated with the sub-surface pore space in which the CO_2 is stored, including the interaction of such pore space rights for the purpose of CO_2 storage with the ownership of other resources (e.g. oil and gas, ground water).
- *Section 6* discusses the liabilities associated with capture, transport and injection activities during both the operational phase of CCS projects and those associated with the storage site during the post-closure period.
- *Section 7* presents an overview of the monitoring, reporting and verification (MRV) requirements for CCS within the studied jurisdictions.

2 *CARBON CAPTURE READINESS*

2.1 *OVERVIEW*

Carbon Capture Readiness (CCR) is a concept whereby emissions-intensive installations (e.g. fossil-fuel power stations) are required to make specific arrangements in advance to ensure the technical and economic feasibility of carbon capture, transport and storage in the future for all or part of the CO_2 emissions from that installation's operation.

The rationale for CCR requirements is that appropriate up-front planning for future CCS capability at an installation will help to avoid high retrofit capture costs, reduce the risk of stranded assets and 'carbon lock-in' and facilitate a smooth transition to widespread CCS deployment. The definition of CCR also provides governments, companies and non-governmental organizations (NGOs) with clear assurance that CCS can be implemented at a given facility in future in support of national CCS regulatory or policy obligations.

The first internationally recognised definition of CCR, albeit having no formal regulatory force, is the International Energy Agency (IEA) GHG R&D Programme definition from 2007. A further attempt to upgrade that definition was led jointly by the Global Carbon Capture and Storage Institute (GCCSI) and the Carbon Sequestration Leadership Forum (CSLF), also engaging with the IEA GHG R&D Programme (definition presented in *Section 2.2).*

CCR-specific regulatory definitions and requirements exist in the European Union's CCS Directive (3) and in the UK's Department of Energy and Climate Change's (DECC) CCR Guidance developed within the context of transposing the CCS Directive into UK law (presented in more detail in *Section 2.3.2*) (4).

In general, all CCR definitions and regulatory requirements have moved from what was initially a minimum requirement for space on the site to accommodate future capture operations, to subsequently include transport and storage considerations. Furthermore, CCR definitions have expanded to include requirements upon operators to propose the capture technology they intend to use. These additional requirements and their applicability to different jurisdictions are discussed in detail in the remainder of this section.

Standardisation bodies like TÜV Nord and industry associations such as the European Power Plant Suppliers Association (EPPSA) have also issued more detailed guidelines on CCS readiness. CCS readiness is also sometimes required by investors, lending banks and NGOs - or voluntarily sought by project developers for public acceptance reasons.

(3) Directive 2009/31/EC on geological storage of CO2

(4) Carbon Capture Readiness: a guidance note for Section 36 Electricity Act 1989 consent applications

These issues are also discussed in further detail in this section.

2.2 NON-REGULATORY CCR DEFINITIONS

This section presents an overview of non-regulatory CCR definitions (such as those put forward by the IEA GHG R&D Programme and the GCCSI), and CCR certification schemes such as that developed by TÜV Nord in Germany.

2.2.1 *IEA GHG R&D Definition*

In 2006, when CCR was a relatively new concept, there was an urgent need to define a general set of criteria to help promote CCR. The IEA Greenhouse Gas R&D Programme therefore commissioned a study to contribute towards drafting a CCR definition, as summarised in *Box 2.1.*

Box 2.1 IEA GHG R&D CCS ready definition

A CO_2 capture ready power plant is a plant which can include CO_2 capture when the necessary regulatory or economic drivers are in place.

Developers of capture ready plants should take responsibility for ensuring that all known factors in their control that would prevent installation and operation of CO_2 capture have been identified and eliminated.

This might include:
- A study of options for CO_2 capture retrofit and potential pre-investments
- Inclusion of sufficient space and access for the additional facilities that would be required
- Identification of reasonable route(s) to storage of CO_2

Competent authorities involved in permitting power plants should be provided with sufficient information to be able to judge whether the developer has met these criteria.

Source: IEA GHG R&D Programme, *CO_2 Capture Ready Plants*, 2007

The IEA GHG definition aimed to be employed as a basis to facilitate development of detailed guidance on a national level, and is thus fairly broad. At its core is the premise that CO_2 capture from a given plant must be feasible by the time necessary regulatory or economic drivers have been established. Although only broadly defined, it identifies the need, in principle, to consider both capture technology and proximity to suitable storage site(s).

2.2.2 *GCCSI Definition*

The GCCSI, in collaboration with governments, industry and bodies such as the CSLF and IEA GHG R&D Programme, developed and proposed an internationally harmonized definition as well as guidelines for CCR. The definition was built upon existing CCS Ready research and definitions, and was refined through a wider consultation process.

The definition is longer and more comprehensive than the IEA GHG R&D Programme definition. It is split into three parts that stipulate detailed requirements for each of the CCS components around capture, transport and storage readiness.

A notable addition to the IEA GHG R&D Programme definition is the inclusion of public 'awareness' criteria, and the requirement for capture, transport and storage 'readiness' to be maintained or improved over time. The supporting document to the definition also introduces three levels of stringency for the capture, transport and storage readiness criteria, with level one being the most flexible and easiest to achieve and level three the most detailed and stringent (for example, level one necessitates only the identification of possible capture technologies, whereas level three stipulates technology selection obligations).

The GCCSI definition (see *Box 2.2.*) is somewhat unclear in relation to the number of criteria that may need to be met by an operator in order to be considered "Capture Ready" – i.e., must a facility meet *all* the elements in the GCCSI definition in order to be seen as Capture Ready? Furthermore, a key question relates to how 'acceptable economic cost' might be defined in practise, and by whom. At the same time, however, the GCCSI approach provides flexibility for policymakers to assess, on a case by case basis, the applicability of each CCR criterion in their jurisdiction depending on local power generation mix profiles, CO_2 sequestration options, and other country specific considerations. Some commentators have argued that the GCCSI definition is already too prescriptive - others that it is too vague. An overly prescriptive definition of CCR could however have the adverse effect of discouraging companies from making the initial investments required for CCS demonstration.

It appears that agreement is still needed on what the *minimum* criteria are for an installation to be deemed as "CCS Ready", and what additional elements might be added to those minimum CCR criteria, if any, as added requirements or 'best practice' in certain jurisdictions.

Box 2.2 GCCSI Proposed International Definition of CCS Ready

Capture Ready

A CO_2 Capture Ready plant satisfies all or some of the following criteria:

1. Sited such that transport and storage of captured volumes are technically feasible;
2. Technically capable of being retrofitted for CO_2 capture using one or more reasonable choices of technology at an acceptable economic cost;
3. Adequate space allowance has been made for the future addition of CO_2 capture-related equipment, retrofit construction, and delivery to a CO_2 pipeline or other transportation system;
4. All required environmental, safety, and other approvals have been identified;
5. Public awareness and engagement activities related to potential future capture facilities have been performed;
6. Sources for equipment, materials, and services for future plant retrofit and capture operations have been identified; and
7. Capture Readiness is maintained or improved over time as documented in reports and records.

Transport Ready

A CO_2 Transport Ready plant satisfies all or some of the following criteria:

1. Potential transport methods are technically capable of transporting captured CO_2 from the source(s) to geologic storage ready site(s) at an acceptable economic cost;
2. Transport routes are feasible, rights of way can be obtained, and any conflicting surface and subsurface land uses have been identified and/or resolved;
3. All required environmental, safety, and other approvals for transport have been identified;
4. Public awareness and engagement activities related to potential future transportation have been performed;
5. Sources for equipment, materials, and services for future transport operations have been identified; and
6. Transport Readiness is maintained or improved over time as documented in reports and records.

Storage Ready

A CO_2 Storage Ready plant satisfies all or some of the following criteria:

1. One or more storage sites have been identified that are technically capable of, and commercially accessible for, geological storage of full volumes of captured CO_2, at an acceptable economic cost;
2. Adequate capacity, injectivity, and storage integrity have been shown to exist at the storage site(s);
3. Any conflicting surface and subsurface land uses at the storage site(s) have been identified and/or resolved;
4. All required environmental, safety, and other approvals have been identified;
5. Public awareness and engagement activities related to potential future storage have been performed;
6. Sources for equipment, materials, and services for future injection and storage operations have been identified; and
7. Storage Readiness is maintained or improved over time as documented in reports and records.

Source: Global CCS Institute, Defining CCS Ready: An Approach to An International Definition, 2010.

2.2.3 CCR Certification

TÜV Nord in Germany has prepared a "Carbon Capture Ready" certification mark for new power generation plants (TN-CC 006). Although the EU CCS

Directive has not yet been fully transposed into Member State national legislation, *all* of the proposed new coal-fired power plants in Germany have obtained this TÜV Nord Carbon Capture Ready certification mark. This certification has similar but more detailed criteria than the IEA and the GCCSI CCR definitions, covering capture, transport and storage 'readiness' components as well as potential impacts upon plant safety and environment (5).

This Certification is initially valid for 5 years with an obligatory periodic verification after 2.5 years. An examination is also required if significant design changes occur. These measures are in place to ensure that the CCR provisions stay in place over the operating period of the plant(s).

One aspect not seen elsewhere is the requirement for the operating company to contribute to R&D in the field of CCS. The operator can choose which R&D activities to undertake, and can also choose whether to undertake R&D activities within their own company, or to finance R&D efforts of external institutions, on the condition that the externally financed R&D will be commensurate to the chosen technology and 'performance capacity of the operating company'. According to the standard, the operating company must contribute a 'reasonable amount' to R&D activities associated with CCS.

The TÜV Nord certification is intended to contribute to a factual and logical approach in discussions between operators, official bodies and the public on matters relating to CCS, and at this stage it is not clear whether CCS certification schemes will be officially recognised by governments as a guarantee of compliance. However, it is evident that when liaising with official bodies, such certifications can provide valuable proof with regards to CCR during approval procedures for new power plant construction projects.

It is expected that more CCR certification standards could emerge in the upcoming years. A key question for any such certification is the extent to which obtaining them means actual regulatory requirements have been satisfied. A CCS project developer will clearly hope that obtaining such a CCR certification in good faith and proceeding with a project under the terms of such a certification provides some certainty to the project investment. The real assurance to investors will come when government regulators recognise such certifications and clarify the extent to which obtaining them satisfies government requirements for projects. From a project proponent's perspective, such certification scheme, while possibly useful in a voluntary regime, will also raise costs for a project not yet fully developed. Concerns could be raised by project proponents about the magnitude of such costs versus their benefits.

(5) See http://www.tuev-nord.de/en/Power_plant_check_1639.htm

2.3 *REGULATORY CCR REQUIREMENTS*

This section presents an overview of existing or proposed regulatory CCR requirements. Where these exist, installations are legally required to meet the CCR requirements as part of the regulatory permitting and planning process. These are summarized in *Table 2.1* and are presented in more detail by country in the remainder of this section. As can be seen, CCR requirements focus on new build thermal power stations; other major CO_2 sources such as refineries, ammonia plants, cement kilns, blast furnaces and oil and gas processing facilities are not directly covered. However, CCR may be indirectly incentivised for sources other than power plants through other areas of GHG policy. For example, in order to avoid the stringent GHG targets for new facilities under Canadian legislation, new-build oil sands plants and refineries may be incentivised to employ CCR within facility design.

2.3.1 *Overview*

In the **EU**, CCR regulatory requirements imposed by the EU CCS Directive (6) were required to be transposed into law by 25 June 2009, rather than the Directive's principal deadline of 25 June 2011. In response, CCR measures are already in force in the UK (adopted under the Electricity Act), and are currently being transposed into the national legislation of other EU Member States. Within the jurisdictions studied, only the EU has direct CCR requirements; the other regions do not currently have similar regulatory requirements for CCR in place, although regimes such as emissions performance standards (EPS) for new-build power plants can be said to indirectly promote the *de facto* use of CCR.

In the **US,** now that the American Clean Energy and Security Act is no longer under consideration by the Senate, there are no current or planned regulatory CCR requirements for new coal-fired power stations. A number of legislative proposals with potential relevance to CCS have failed to pass through Congress; at present the future potential treatment of CCR remains unknown.

In **Canada**, CCR is not mandated directly but would be promoted indirectly through a number of policies and incentives that have been in proposed by the Federal Government since 2008. For example, one such proposal was for new coal plants, oil sands plants and refineries built after 2012 will effectively have to be CCR to be exempt from GHG emission targets (7). To date these proposals have not passed into legislation, and the government has moved away from a CCR approach for thermal power towards performance standards. A similar policy approach is expected for other sectors as well. Overall, momentum on climate change regulations has been slowed with the failure of the Copenhagen meetings to reach the required level of international agreement on action.

(6) Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide
(7) Minister of Environment:: Regulatory framework for industrial greenhouse gas emissions.

In **Australia**, CCR is not required or defined at the federal level. However, some state governments (notably Queensland and Western Australia) have included CCR requirements as a pre-requisite for planning approval for coal-fired power stations.

CCR requirements, developed by regulators and other organisations, are summarised in the remainder of this section.

Table 2.1 Overview of regulatory CCR requirements (including emissions performance standards) [(8)]

Country	Key document	Regulatory Authority	Status	Applies to	Eligibility Thresholds	Approach to mandating or promoting CCS readiness
EU	Directive on Geological Storage of CO_2 [(9)]	European Commission EC	In force (2009)	All combustion plants (construction licence after 2009)	300 MW +	
UK	Carbon Capture Readiness (CCR): A guidance note for Section 36 Electricity Act 1989 [(10)].	Department of energy and climate change (DECC) / Infrastructure Planning Commission	In force (2009)	All power plants under the Large Combustion Plant Directive (excluding Energy from Waste)	300 MW +	"no barriers" approach – the developer needs to prove there are no known barriers to CCS. Using IEA as guidance.
Germany	Gesetz zur Regelung von Abscheidung, Transport und dauerhafter Speicherung von Kohlendioxid [(11)].	Bundesministerium fur Wirtshaft und technologie (BMWI)	In consideration	New coal-fired power plants	Not specified	
US - Federal	None at present (various Acts with CCR relevance have failed to pass through Congress)	N/A	N/A	N/A	Not specified	N/A
US - California	SB 1368 Emission Performance Standards [(12)]	California Energy Commission (CEC)	In force (2006)	New coal-fired power plants	Not specified	Through emission standard.
Canada - Federal	The approach would apply a performance standard to new coal-fired electricity generation units, and units that have reached the end of their economic life, through regulations under the Canadian Environmental Protection Act (CEPA), 1999 [(13)]	Provincial governments	Expected to to come into force on July 1, 2015.	New and extended life coal-fired electricity generation units with a capacity of 10MW or more and end-of-life is the longer of 45 years from the unit's commissioning date or the expiry date of the power purchase agreement (PPA) in effect at the time of the policy announcement.	360 to 420 t/GWh	Goal driven incentives on policy level. Coal-fired plants that incorporate carbon capture and storage technology will be exempt from the standard until 2025

(9) Directive 2009/31/EC of the European Parliament and of the Council on the geological storage of carbon dioxide

(10) U.K. Department of Energy and Climate Change (U.K. DECC). (2009a). Carbon capture readiness (CCR): A guidance note for Section 36 Electricity Act 1989 consent applications (Publication no. URN 09D/810).

(11) Bundesministerium fur Wirtshaft und technologie (BMWI): Gesetz zur Regelung von Abscheidung, Transport und dauerhafter Speicherung von Kohlendioxid

(12) California Energy Commission (CEC). (2006). *SB 1368 emission performance standard*

(13) http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=55D09108-5209-43B0-A9D1-347E1769C2A5

Country	Key document	Regulatory Authority	Status	Applies to	Eligibility Thresholds	Approach to mandating or promoting CCS readiness
Australia – Federal	No federal document applicable to CCR directly.			New coal-fired power plants	N/A	Condition to planning
Australia – Western Australia	Western Australia: EPA Report 'Bluewaters Power Station Expansion – Phase III and IV, Collie' 2010.	Western Australian EPA	Not enforceable until EPA recommendation accepted by Minister.	New coal-fired power plants	N/A	Project approval subject to plant being built 'CCS ready', in which CCS retrofit will be undertaken once defined by the EIA as 'technically and economically viable'.
Australia – Queensland	Queensland: *ClimateSmart 2050 strategy*	Queensland EPA	In force (2007)	New coal-fired power plants	N/A	Project approval subject to plant being built 'CCS ready', whereby plants have 'been designed with plans and milestones for incorporation of operational CCS, and that there are no known barriers to installation once the technology has been proven on a commercial scale'.

2.3.2 *European Union*

In the EU, a CCR requirement was introduced by the Directive on Geological Storage of CO_2 (Directive 2009/31/EC) (from here on referred to as EU CCS Directive). It requires that all combustion plants with a rated electrical output of 300 megawatts (MW) or more meet the following conditions:

- Suitable storage sites are available
- Transport facilities are technically and economically feasible
- It is technically and economically feasible to retrofit for CO_2 capture

The above CCR requirements, consistent with the EU legislative process are quite broad and it remains to be seen how they may be translated to specific requirements at a member state level.

United Kingdom

The UK is the only EU Member State to have issued comprehensive policy guidance on CCR as detailed in two 'Guidance on Carbon Capture Readiness' documents published in November 2009. The policy stipulates that CCR is required as part of the application and permitting process for all combustion power plants [(14)].

There are five broad key requirements in relation to:

1. Availability of space
2. Technical feasibility of capture
3. Technical feasibility of transport
4. Proven existence of the storage area; and
5. Economic feasibility of CCS

Consistent with the EU CCS Directive, these requirements apply to all new facilities of 300 MW or higher capacity, including all fossil fuels and biomass plants regulated under the large Combustion Plant Directive (LCPD), but excluding energy from waste.

There is some anecdotal evidence that in response to the CCR requirement, some developers have since revised the capacity rating of their proposed plants to just below the 300 MW threshold, mainly in relation to biomass generation units. For example, Drax Power originally proposed several 350MW biomass stations but following publication of the CCR Guidance they subsequently submitted applications for 290MW.

In addition to the CCS Directive, the UK requires:

(14) Section 36, Electricity Act, 1989

- The area set aside for carbon capture plant not to be disposed of or used for any purpose which could inhibit its use at a later date, for example to be used a nature reserve; and
- The availability of space and other requirements to be continuously reported after construction and operation.

2.3.3 *United States*

The US has not yet formalized any mandatory CCR requirements at a Federal level. With several legislative proposals (including the The American Clean Energy and Security Act) having failed to pass through Congress and continuing regulatory uncertainty, the lack of comprehensive climate change legislation acts as the key barrier to CCS deployment in the US. However the proposed US EPA GHG Rule, along with state level initiatives, could in practise place indirect CCR requirements on power plant developers. Although now considered to have little or no chance of passing through Congress, the proposed American Clean Energy and Security Act would also have CCR implications if implemented. The Federal and State level initiatives are further discussed in the remainder of this section.

US Environmental Protection Agency GHG Rule

As described above, the regulatory framework underpinning - and the potential for incentivising - CCS projects is currently undermined by a lack of regulatory certainty concerning greenhouse gas legislation and climate change policy at a federal level. For example, there remains considerable uncertainty as to how the EPA will regulate CO_2 and other greenhouse gases. The Clean Air Act provides for several methods including declaring National Ambient Air Quality Standards, New Source Performance, and other provisions: the EPA has yet to decide which approach to adopt.

The EPA's proposed GHG rule, also known as the "tailoring rule", requires that from January 2011, electricity producers, manufacturers and oil refineries that emit 75,000 tonnes of CO_2 (or GHG equivalent) or more per year, and that are already regulated under the Clean Air Act need to obtain an operating permit. To obtain a permit, the operator must demonstrate that it is using the best available technology (BAT) to limit emissions, either when building a new plant, or overhauling existing infrastructure. This provision had initially been interpreted to indicate that installations should be CCR. However, the EPA has consulted with industry regarding application of CCS and has indicated that the rule intends to "look at moving forward already demonstrated technologies, not innovative technologies that have yet to be properly demonstrated" (15).

However, the role of the states is important in this context. The EPA delegates authority under the Clean Air Act to the states through State Implementation Plans. Several states (including Texas) have informed the

(15) See http://planetark.org/enviro-news/item/57471

EPA that they are unable to comply with the January 2011 mandate under the GHG rule and have filed lawsuits against EPA for pushing through its plans without consulting or informing the states. In short, it is not yet clear whether the US EPA GHG rule will serve to bring in CCR in the US or not.

American Clean Energy and Security Act [16]

The proposed American Clean Energy and Security Act, although no longer under consideration by the Senate, would not formally specify CCR requirements but require that all coal and petroleum coke-fired power plants built after the adoption of the Act would have to reduce 50% of their direct CO_2 emissions by 2025.

The Act would have mandated that two years after its adoption, further detailed CCS regulation must be put forward (along the lines of the EU CCS Directive), in which further provisions/guidelines regarding CCR might be included.

State Level Initiatives

At a state level, there is also an outlook for more stringent emission performance limits in future for all new or retrofitted power plants such as the ones in the state of California [17]. This could place indirect CCR obligations on fossil fuel fired power projects (other than gas) in order to meet future compliance. Emissions performance standards (EPS) have been in place since 2006 in California and have effectively prevented the building of new coal plants in favour of natural gas and renewables.

Senate Bill SB1368 (2006) sets down an Emissions Performance Standard (EPS) of 1,100 lbs per MWh (500 kg per MWh) for base load generation plant owned by, or under long-term contract to, publicly owned utilities. The requirements apply to new power plants, refurbishments or purchases of power plants. The implementing provisions for Assembly Bill AB1368 [18] allow for CCS to be recognised as an eligible technology for meeting EPS requirements by recognising stored CO_2 as not emitted, on the following basis:

"For covered procurements that employ geological formation injection for CO_2 sequestration, the annual average carbon dioxide emissions shall not include the carbon dioxide emissions that are projected to be successfully sequestered. The EPS for such power plants shall be determined based on projections of net emissions over the life of the power plant. Carbon dioxide emissions shall be considered successfully sequestered if the sequestration project meets the following requirements:

(1) Includes the capture, transportation, and geologic formation injection of CO_2 emissions;

(16) H.R. 2454, The American Clean Energy and Security Act, 2009

(17) California Energy Commission (2006). SB 1368 emission performance standard, 500 kg of CO_2 per MWh at present which is equivalent to emissions from an efficient gas-fired power plant

(18) Regulations Establishing and Implementing a Greenhouse Gases Emission Performance Standard for Local Publically Owned Electric Utilities. Chapter 11: Greenhouse Gas Emission Performance Standard. §2904(c)

(2) Complies with all applicable laws and regulations; and

(3) Has an economically and technically feasible plan that will result in the permanent sequestration of CO_2 once the sequestration project is operational."

These terms also allow for public utilities to procure power procurements from capture-ready plants with the later addition of CO_2 capture, so long as it has a "technically feasible plan" for employing CCS at some future date. The greater challenge posed by the regulation as it stands relates to what may qualify as applicable laws and regulations. At present, California does not have any applicable laws that address long term storage of CO_2 in the subsurface and previous attempts to pass Assembly Bills relating to geological storage of CO_2 have been prevented by some NGOs. Currently proposed CCS projects in California are employing hydrocarbon reservoirs to store CO_2 which bypass the need for appropriate regulations by covering the activity under hydrocarbon law (e.g. Hydrogen Energy California project at Bakersfield). However, it is also important to note that the provisions of the EPS apply to all imports of electricity into the State, and so would apply to the application of CCS to any power plant on the Western Area power grid that is providing power to California under contract to a public utility.

Several other states have since developed emissions performance standards which may provide a similar indirect incentive to building power plants CCR (19).

2.3.4 *Canada*

In Canada, no legal requirements for CCR exist. In 2008, the federal government announced a set of industrial carbon emissions intensity targets that increase in stringency over time. In practice, these could place an indirect CCR requirement on coal-fired power plants and oil sands plants coming into operation in 2012 onwards (20).

However in June 2010, the government signalled a change (21) in terms of the principal mechanism that it will employ in order to reduce GHG emissions from industry and power generation. It is now expected that a sector-by-sector emissions reduction approach would be adopted based on a set of performance standards (22). More specifically, for the electricity sector it is expected that all coal-fired electricity generating units will have to meet a stringent emissions performance standard. The standard will be based on parity with the emissions performance of high-efficiency natural gas

(19) Illinois SB 1987, 2009; Maine LD 2126, 2008; Massachusetts SB 2768, 2008; Montana SB 25, 2007; Oregon SB 101, 2009; and Washington SB 6007, 2009.

(20) Namely for two reasons 1) it was expected that CCS technology would be required by 2018 in order to meet these future targets and 2) power plants that are CCR would have been eligible to postpone compliance of their emissions targets.

(21) Environment Canada, News Release, Government of Canada to Regulate Emissions from Electricity Sector, June 23, 2010

(22) For example, in the transportation sector, draft regulations have already been published mandating an average 5 per cent renewable fuel content in gasoline.

generation, and will represent an improvement in emissions of about 50 per cent per gigawatt hour (GWh) generated [23].
The performance standard would be applied to new and extended life coal-fired electricity generation units with a capacity of 10MW or more and end-of-life is the longer of 45 years from the unit's commissioning date or the expiry date of the power purchase agreement (PPA) in effect at the time of the policy announcement.

In these regulations, new coal-fired plants that incorporate carbon capture and storage technology will be exempt from the standard until 2025. The draft regulations for the electricity sector are expected to be published early in 2011, with final regulations to be published later that year and to come into force on July 1, 2015.

At the time of writing no further specific information was made available in relation to these regulations; however, the explanation above provides a clear indication that CCR could be indirectly required for new coal units coming into operation before 2015 in order to meet the proposed.

2.3.5 Australia

Australia has an advanced CCS related regulatory system, focused on sequestration in terms of the interaction with the stationary energy (electricity generated from coal and natural gas) & petroleum industries. However, at a federal level, nothing is mandated in terms of CCR [24].

The Federal Labour Government's pre-election climate change policy, released on 23 July 2010, outlines support for the construction of future coal fired power stations, but it also stipulates that these power stations must be "carbon capture and storage ready", thus meaning that they must be capable of being retrofitted with carbon capture technology and meet "best practice" coal emission standards (proposed as 0.86 tCO_2/MWh). The policy document A Cleaner future for power stations [25] states that proponents must 'adequately ensure that CCS is taken into consideration when designing and building future power plants, including planning for sufficient land, pipelines for removal of CO_2, suitable storage sites and connectivity of the generator to CCS technologies'.

In addition, the Labour Government (whose majority in Parliament was confirmed on 7 September 2010) says it will require the owners of new coal-fired generators to agree to retrofit CCS technologies within an appropriate time after they become commercially available. The standard for CCS-ready,

(23) The performance standard would be set at the emissions intensity level of Natural Gas Combined Cycle (NGCC) technology, a high-efficiency type of natural gas generation, and would be in the range of 360 to 420 t/GWh; average coal-fired power plant employing carbon capture and storage (CCS) technology with a capture rate of approximately 70% of its emissions.
(24) CCR is not mentioned in the Regulatory Guiding Principles for Carbon Dioxide Capture and Geological Storage (updated in 2009), which the Australia government published with the aim to achieve a nationally-consistent framework for CCS activities in each Australian jurisdiction
(25) See www.alp.org.au/getattachment/1c885f7d-da5c.../cleaner-power-stations/

tailored for Australian conditions, will be determined by the Government in consultation with stakeholders. The new standard will take into account existing draft standards as a starting point. These commitments were further outlined in a key policy speech presented by Prime Minister Julia Gillard, but have not been turned into any Federal regulation, and no further detail on defining "CCR" and "best practice" has been provided.

At state level however, both Queensland and Western Australia have included CCR requirements as a pre-requisite for planning approval for coal-fired power stations. The Queensland Government has stated through its *ClimateSmart* 2050 strategy that it will only approve coal-fired power stations if they use world's best practice, low-emission technology, and are 'CCS ready'. The Queensland Government has defined CCS Ready as meaning that generators must demonstrate that new plants have been designed with plans and milestones for incorporation of operational CCS, and that there are no known barriers to installation once the technology has been proven on a commercial scale (26).

In Western Australia, the EPA recently recommended to the Minister for Environment that the proposed Griffin Power Bluewaters coal power station expansion only be approved on the conditions that it is 'Carbon Capture and Storage Ready' and retrofitted for CCS when the EPA decides that CCS is technically and economically viable (27).

2.3.6 *Summary – comparing the scope of CCR requirements*

The regulatory requirements for CCR (either through direct regulation or indirect promotion) can be compared across the jurisdictions by considering their scope - i.e., which elements of CCR apply.

The main elements of CCR regulatory requirements and definitions can be broadly grouped as relating to:

- Space Availability;
- Transport;
- Storage Identification;
- Storage Quantification;
- Technical Feasibility;
- Economic Feasibility; and
- Specific Pre-investments.

Table 2.2 provides an overview of these key elements in the CCS relevant regulations of the different jurisdictions examined above.

As shown, space, transport and storage requirements are a common feature in all jurisdictions. Overall, the application of all of these CCR components

(26) http://www.climatechange.qld.gov.au/pdf/factsheets/1energy-n4.pdf
(27) EPA Report 'Bluewaters Power Station Expansion – Phase III and IV, Collie', Government of Western Australia, (2010).

would effectively use the "no barriers" approach –i.e. the operator needs to demonstrate that there are no known technical or economic barriers that could prevent the installation and operation of the chosen CCS technology.

These CCR elements as they apply across jurisdictions, along with a discussion of their implications for developers, are presented in *Annex A.* This illustrates that, at the moment, there is no single definition being applied for CCR – what counts as CCR differs across jurisdictions.

Table 2.2 Presence of CCR components in different jurisdictions

Specific CCR requirements	**Space Availability**	**Technical feasibility**	**Economic feasibility**	**Specific pre-investments**	**Transport**	**Storage Identification**	**Storage Quantification**
EU	Present	Present	Present	Not Present	Present	Present	Not present but likely as an indirect necessity
EU-UK	Present	Present	Present	Not Present	Present	Present	Present
US	Not present but likely as an indirect necessity	Not present but likely as an indirect necessity	Not present but likely as an indirect necessity	Not Present	Not present but likely as an indirect necessity	Not present but likely as an indirect necessity	Not present but likely as an indirect necessity
Canada	Not present but likely as an indirect necessity *	Not present but likely as an indirect necessity *	Not present but likely as an indirect necessity	Not Present	Not present but likely as an indirect necessity *	Not present but likely as an indirect necessity *	Not present but likely as an indirect necessity
Australia*	Present *	Present *	Not present but likely as an indirect necessity	Not Present	Present *	Present *	Not present but likely as an indirect necessity

Colour Coding

Present	Not present but likely as an indirect necessity	Not Present

* Not regulatory but could be allowed through planning permits or licensing.

2.4 *CCR REQUIREMENTS USED BY LENDERS*

CCR can also be a requirement posed by investors and lending banks, mainly for new or major refurbishments/expansions of existing power plants (mainly coal-fired) in developed countries. The Carbon Principles (whose signatory banks include Bank of America, Citi, Credit Suisse, JPMorganChase, Morgan Stanley and Wells Fargo) provide a good example of lenders viewing projects with CCR positively and requiring an assessment of CO_2 capture, transport and storage options for all fossil fuel power generation plants of over 200 MW in the US (*Box. 2.3*).

Box 2.3 CCR considerations for power plants within the Carbon Principles

4. Evaluation of Qualifying Fossil Fuel Generation Plant technology and siting. Discuss:
   c) Carbon capture capability of the technology, including economic evaluation of carbon capture installation or retrofit, addressing:
      i) The steps and estimated costs of installation or retrofit.
      ii) Source of estimated costs of retrofit, recognizing that third-party vetting or a RFP process provides higher certainty to estimates.
      iii) Sizing of the equipment (e.g., boiler, steam turbine, compressors) to allow future CO_2 capture or modifications needed to allow for CO_2 capture.
      iv) Spacing and logistical considerations.
      v) The estimated timeline for installation or retrofit.
   d) Geologic investigations performed to assess potential for CO_2 storage including:
      i) Plant siting and distance to suitable CO_2 sinks.
      ii) Potential storage sites that could meet CO_2 storage needs.
      iii) Results of investigations and characterizations of a potential storage site to establish whether reservoirs with adequate capacity, injectivity, seal effectiveness are available to accommodate the CO_2 throughout the lifetime of the project at an acceptable cost.
      iv) State regulatory framework for obtaining permits for storage and overall liability regime.
   e) Pipeline infrastructure and costs needed for CO_2 transport to appropriate potential storage locations. Discuss steps necessary to obtain rights-of-way and estimated costs and feasibility of obtaining those rights.

Source: the Carbon Principles: Fossil Fuel Generation Financing Enhanced Environmental Diligence Process

Because most utilities will seek (or require) debt finance for new build power plant investment, the development of CCR requirements under the Carbon Principles and/or other lending due diligence protocols may become at least as material in the US and other OECD regions in relation to promoting CCR plant. This will depend on the extent to which the Carbon Principles are strictly followed by the lenders who have signed up to them. It will be interesting to see if the CCR provisions in the Carbon Principles actually serve to effect the inclusion of CCR in a project or cause project developers to seek finance from other lenders who do not follow this aspect of the Principles.

Individual banks may also have specific internal policies on how CCS technology and its future application, i.e. CCR, should be addressed for financing of power projects. For instance, investment bank West LB's policy for activities related to coal-fired power generation requires that projects seeking financing in high income countries must provide the physical space necessary to carry out CO_2 capture in future.

Existing CCR requirements, posed by banks and other organisations are summarised in ***Table 2.3***.

Table 2.3 Overview of CCR requirements used by lenders

Country	Key document	Organisation	Status	Applies to	Eligibility Thresholds	Approach to mandate or promote CCS readiness
US	The Carbon Principles Fossil Fuel Generation Financing Enhanced Environmental Diligence Process (28)	Carbon principles signatory banks including Bank of America, Citi, Credit Suisse, JPMorganChase, Morgan Stanley and Wells Fargo	In force	Fossil fuel generation plants in the US	Over 200 MW for new coal-fired capacity or over 200 MW for expansion of capacity	Project financing risk based approach that evaluates positively CCR project plans.
High Income Countries (As defined in the World Bank Country Groups)	Policy for Business Activities Related to Coal-Fired Power Generation (29)	WestLB	In Force (to be reviewed January 2011)	Coal-fired power generation in high income countries	Applies to significant project financings	Operators/owners of the coal-fired power plant are required to provide the physical space necessary to carry out carbon capture.

(28) http://carbonprinciples.org/documents/Carbon%20Principles%20Enhanced%20Diligence%20Final_pdf.zip

(29) http://www.westlb.com/cms/sitecontent/westlb/westlb_de/en/wlb/csr/Sustainability/Archive/Environmental_and_Social.-bin.acq/qual-StdArticleContentParSys.0004.Cc13AttachmentList.0001.AttachmentFile/WestLB_Policy_for_Business_Activities-re_Coal_Fired_Power_G

3 CO_2 STORAGE PERMITTING AND LICENSING

3.1 *INTRODUCTION*

The development of robust licensing frameworks for CCS exploration and storage activities are vital in promoting wider CCS deployment and speeding up the project cycle.

There are essentially two generic approaches to regulating CCS exploration and storage activities – either through:

1. Integrated exploration and storage licensing frameworks that interact with CO_2 storage legislation, as is the case in the EU; or
2. Legislative amendments or decisions usually associated with existing oil and gas exploration legislation, as is the case in Australia, Canada, and partially in the US.

This section presents an overview of existing or proposed CO_2 storage permit application procedures and licensing frameworks for EU, US, Canada and Australia. It also highlights barriers, gaps or other issues of interest to storage site operators, which may include, *inter alia*:

- Third-party access requirements;
- Provisions for interactions between CO_2 storage and Petroleum Licences such as:
  - CO_2 storage Licence and existing Petroleum Licences in the same geographical area; or
  - Licensing of existing Petroleum Licence areas for CO_2 storage; or
  - simultaneous licensing of an area for Petroleum and CO_2 Storage purposes;
- Reasonableness of time periods for storage permit application ;
- Public consultation procedures and associated timelines; and
- Other special license provisions, for example in the event of transfer of license, discovery of petroleum reserves, etc.

3.2 *OVERVIEW*

In the **EU**, the CCS Directive provides the overarching legal framework for permitting CCS activities in the Member States, based on both the exploration and CO_2 storage phase. The Directive outlines the procedures and requirements for permitting storage sites, including the requirement for undertaking potentially lengthy environmental impact assessments (EIA), mandated under the EU EIA Directive, and public consultation activities. In the granting of the storage permit, priority will be given to the holder of the exploration permit over competitors, although exploration permits can be withdrawn if no storage activities are undertaken within a reasonable period.

Although the CCS Directive does not specifically establish any priority in relation to exploration and existing uses of the formation, Member States are required to consider other potential uses for the subsurface and surface areas where CO_2 storage might take place (e.g. hydrocarbon extraction).

EU Member States are in the process of transposing the CCS Directive into their national regulatory frameworks, and the **UK** has recently published its Response to a consultation on draft regulations permitting of CO_2 storage.

Under the UK framework, it is possible for rights to be granted in respect of two or more developments which partially or wholly overlap where this is technically feasible and can be safely managed. However, the response only partially resolves issue such as third party access and interactions with petroleum licenses; regulations for third party access to CO_2 pipelines and storage sites are expected in December 2010 (30).

The US and Canada are currently working towards finalisation of their frameworks for licensing CO_2 storage.

In the **US**, storage activities will be regulated at a federal level through the existing Underground Injection Control (UIC) permitting program. In July 2008, the US EPA proposed an amendment to the UIC programme in order to develop Federal permitting requirements specifically for underground injection of CO_2; a final rule is expected in 2010 or 2011. Some states are also actively engaged in the process of developing their own regulatory frameworks for permitting CO_2 storage activities, requiring close attention between federal and state level requirements, as well as legal complexities involving permitting across more than one state.

In **Canada**, the Federal and Provincial regulatory frameworks in place for the oil and gas sector provide the basis for the existing and future regulation of CCS projects. Under the current framework, only Provinces can regulate CO_2 injection activities, and the existing oil and gas regimes adequately cover many CCS activities, except in cases where storage activities are to take place on Federal lands. The licensing frameworks have not yet been amended to fully accommodate CCS at a provincial level, with the exception of Alberta. In Alberta, the titleholder to petroleum, natural gas and minerals also owns the storage rights in that geological formation.

In **Australia,** a robust permitting and licensing frameworks is in place under the amended Commonwealth Offshore Petroleum and Greenhouse Gas Storage Act (OPGGS). At a federal level, if a CO_2 storage operation presents risks to existing or future petroleum extraction and other resources, the government is required to either mitigate or refuse a storage permit. A similar risk mitigation approach is also present in state regulations in Queensland and Victoria. However, the interaction of CO_2 storage licensing with existing subsurface interests in Western Australia, New South Wales and

(30) Carbon Capture and Storage Legal and Regulatory Review 2010 (OECD/IEA, 2010)

Queensland has not yet been addressed in present regulations, which would likely involve amending the states' existing petroleum legislation [31].

3.3 *EUROPEAN UNION*

In the EU, the CCS Directive applies to all CO_2 storage in geological formations within the EU Member States, and lays down requirements covering the entire lifetime of a storage site. Under the Directive, the permitting and licensing framework for CO_2 storage involves two phases associated with exploration and storage activities.

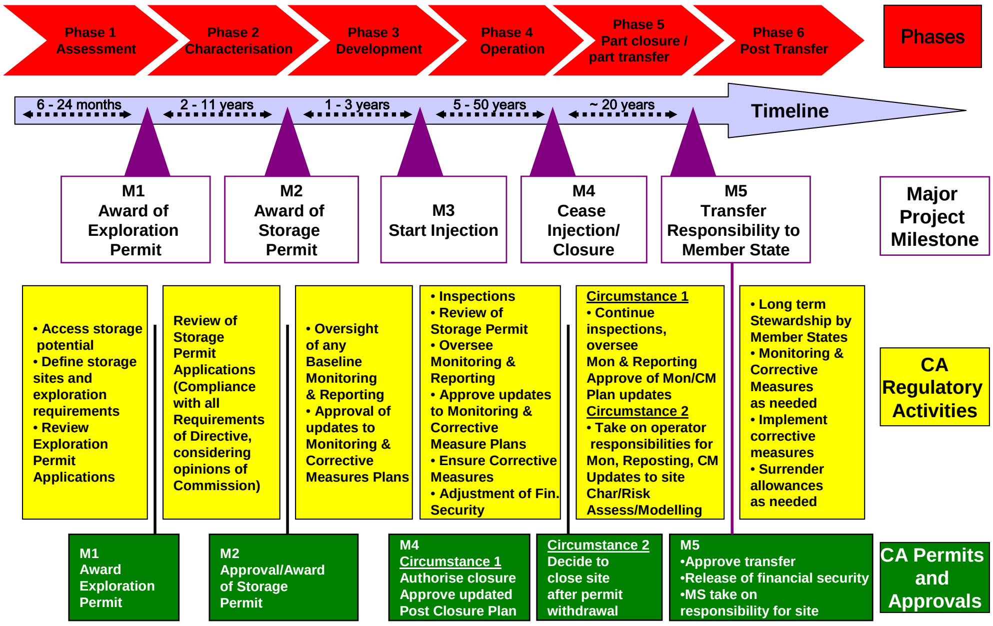
1. The **exploration** phase and a corresponding permit are required for activities where further information is needed to determine the suitability of the proposed site for CO_2 injection. The necessity of permitting and licensing during the exploration phase is left at the discretion of the Member State.
2. A **storage** permit is a written decision by a Member State Competent Authority (CA) authorising the geological storage of CO_2 in a suitable storage site by the operator [32]. This requirement is at the core of the CCS Directive and is further discussed in *Section 3.3.3*.

The granting of storage rights at a Member State level is contingent upon the exploration phase. Therefore, in the granting of the storage permit, priority will be given to the holder of the exploration permit over competitors, in acknowledgment that the former will generally have made substantial financial investments. However, should the holder of the permit not develop the resource over a determined period of time, they would then no longer retain these rights.

Figure 3.1 presents a summary of the CO_2 storage life cycle phases, major project milestones, competent authority regulatory activities, associated permitting milestones and timelines. These elements are discussed in further detail in the remainder of this report.

(31) However, in practise, the petroleum licensing regime may be clear to existing operators. For example, on Barrow Island where Chevron will operate the Gorgon CCS Project, the regulatory regime is well understood because oil has been produced there for forty years.
(32) Note: Permitting is not required for projects that are undertaken for research, development or testing of new products and processes. The storage threshold for the determination of such projects is 100,000 tonnes of CO_2 or less per year.

Figure 3.1 Summary of CO_2 Storage Life Cycle Phases and Milestones



Source: Modified by ERM based on original figure from "Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 1 on CO_2 Storage Life Cycle Risk Management Framework', 17 June 2010. Note: CA = Member State Competent Authority

The key steps and timelines required for the acquisition of exploration and storage permits are outlined in *Table 3.1.*

Table 3.1 Permitting Procedures and Timelines in the EU

Stage	Predicted timeline[1]	Activities	Governing body or document
Exploration permit [2]	6 months – 2 years	Data collection, preparation of application and CA decision time	EU CCS Directive
Exploration activities incl. preparation of EIA and supporting documentation for storage permit application	2–11 Years	Preparation of data for Storage permit and EIA including site selection and characterisation, seismic, drilling and injection testing/monitoring, project development plans and design	Annex I of EU CCS Directive; EIA Directive
Storage permit application (including EC Consideration)	6-8 months	Pre-injection monitoring	EU CCS Directive

[1] Timeframes are indicative only, and will depend on the storage option and local circumstances
[2] The necessity for an Exploration permit is to be determined by the Member State on case-by-case basis
[3] Duration of two years is possible for an oil and gas storage option not requiring exploration, and smooth and established regulatory approval system.

3.3.1 *Exploration permitting*

The use of exploration permits are dealt with under Article 5 of the CCS Directive. Permits will be granted by the Member State CA at a national level for defined acreage release areas. Member States have the right to determine the areas within their territory from which storage sites may be selected and to determine whether an exploration phase to determine the suitability of the site is necessary.

Similar to current permitting regulations in Australia, the holders of exploration permit will be given priority to obtain storage permits. For this reason, Member States need to ensure that the procedures for the granting of exploration permits are open to all entities possessing the necessary capacities - and that there are no conflicting uses of the storage site.

To ensure that the area is explored and that the permit is used appropriately by the holder, an exploration permit can be withdrawn if no activities are carried out within a reasonable time period.

Throughout the period of exploration, the operator must gather appropriate data to demonstrate the integrity of the storage site, i.e., that the site has no significant risk of leakage, and that no significant environmental or health impacts are likely to occur.

The suitability criteria relating to the characterisation and assessment of the potential storage site and surrounding area are specified in Annex I of the CCS Directive, and are based upon the following three steps:

- Step 1: Data collection
- Step 2: Building the three-dimensional static geological earth model
- Step 3: Characterisation of the storage dynamic behaviour, sensitivity characterisation, and risk assessment

3.3.2 *Planning process*

Once the suitability of the site has been established, and the supporting geological data is gathered, the most burdensome task for the operator in the preparation of the Storage permit application will be the environmental impact assessment (EIA) required under the planning process pursuant to the EIA Directive (85/337/EEC) [33].

An overview of the key elements of an EIA application process of interest to CCS project developers is presented in *Box 3.1*:

(33) CCS Directive, Directive 2009/31/EC, amended the Annexes I and II of the EIA Directive (85/337/EEC), by adding projects related to the transport, capture and storage of carbon dioxide (CO2).

Box 3.1 *Overview of EIA Application*

Upon developer's request, the competent authority sets out the EIA information to be provided by the developer. The environmental authorities must be informed and consulted throughout the process. The public must be informed and consulted – a common practice is a 30 day public consultation after the EIA report is publicly published. If the EIA report is substantially changed as the result of the consultations, it has to be put for another public consultation and so on, until there are no significant changes needed. The competent authority decides on the acceptability of the report and the project, taken into consideration the results of consultations. The public is informed of the decision afterwards and can challenge the decision before the courts.

EIA approval procedures will likely be protracted for many projects. This is due to factors such as:

- The large amount of information that needs to be gathered for the EIA application;
- The involvement of numerous environmental authorities (which can vary depending on standard practice in different Member States); and
- Public consultation/participation requirements.

According to one source, the average cost of an EIA for a CCS storage site ranges between 70,000 and 100,000 Euro, and normally takes about 1 year to be completed (34). In ERM's view, such costs could be significantly higher if, *inter alia*, the EIA process in a given location is highly contentious amongst stakeholders or governments, if multiple jurisdictions have the right to impose terms in the negotiation/approval of an EIA, and/or the location of a proposed storage site is particularly environmentally sensitive for some site specific reason(s).

3.3.3 *Storage permitting*

Once the EIA is complete, the CCS project developer can progress with the Storage permit application. The key requirements for a storage permit application are dealt with under Article 7 of the Directive (see *Box 3.2*).

(34) Koornneef et al. (2008) Environmental Impact Assessment of Carbon Capture & Storage in the Netherlands

Box 3.2 *Key Storage Permit Application Requirements under the EU CCS Directive*

- Proof of the technical competence of the potential operator.
- Characterization of the storage site and storage complex and an assessment of the expected security of the storage
- Total quantity of CO_2 to be injected and stored, as well as the prospective sources and transport methods, the composition of CO_2 streams, the injection rates and pressures, and the location of injection facilities
- a description of measures to prevent significant irregularities
- a proposed monitoring plan
- a proposed corrective measures plan
- a proposed provisional post-closure plan
- proof that the financial security or other provisions (in support of Article 19) will be valid and effective before commencement of the injection

Source: EU CCS Directive, Article 7

The specific modalities of storage permit application requirements may vary across Member States according to national regulatory regimes and storage site ownership considerations. For example, in the UK a valid Crown Estate Lease is required as part of the application procedure.

The storage permit will include monitoring and reporting provisions, site closure procedures and liability requirements. These topics and their implications for operators are further discussed in corresponding sections of this report (see *Sections 6* and *7*).

Public consultation requirements

The public and other third parties can influence the procedure by requesting additional information and by challenging information that has been presented. Therefore, in cases where there is public or third party opposition to the project, this stage of permitting process is particularly vulnerable to the risk of delay. The interpretation of public consultation requirements within varies across the licensing framework of Member States, For example, in the UK, the proposed licensing framework charges offshore CO_2 storage permit applicants with the duty to consult and maintain effective communication with mariners and those with fishing interests, and refrain from activities that unjustifiably interfere with navigation or fishing interests.

CO_2 storage projects, at least in the demonstration and early commercialisation stage, will be susceptible to additional delays due to their complexity and novelty. Shell's Barendrecht project, summarised in ***Box 3.3,*** provides a useful example.

Box 3.3 Shell's Barendrecht Project

Shell's Barendrecht project aims to permanently store CO_2 from the Nederland Raffinaderij at Pernis in two depleted gasfields near the Dutch town of Barendrecht. The project will result in a reduction of CO_2 emissions by the refinery with some 0.4 million tonnes per year. The project has faced public opposition which has resulted in project delays as there is a densely populated residential area above the proposed storage sites. Furthermore, the local council has stated that it intends to stop the project in the courts if the government approves the project.

Source: Shell, 2009. see: www.shell.nl/co2opslag

The developer should therefore prepare for these potential delays, and attempt to mitigate the risk of delay by ensuring robust support from the public (to an achievable extent) and regulatory authorities so as to speed up the permitting process.

The European Commission will maintain oversight of all storage permit applications and issue an opinion to Member States within 4 months from submittal date. It would be up to individual Member States to follow the EC's recommendations, but significant deviations would be accepted provided there is a full and well-reasoned justification by MS competent authorities. Such situations would likely create public perception issues for the projects in question, and are unlikely to happen frequently. It is expected that, as CCS moves from demonstration to full commercialisation, the EC oversight will diminish and responsibility would ultimately lie solely with the national MS CAs.

3.3.4 *Interactions with petroleum licences*

The CCS Directive does not specifically establish any priority in relation to exploration and existing uses of the formation but it requires that MS CAs consider other potential uses for the subsurface and surface areas where CO_2 storage might take place such as:

- Exploration and exploitation of resources (oil, gas, coal, water, geothermal and wind energy); and
- Storage operations (i.e. natural gas)

Attention to this issue needs to be given by individual MS in their licensing frameworks to avoid future conflicts and ensure optimal future uses of the formation.

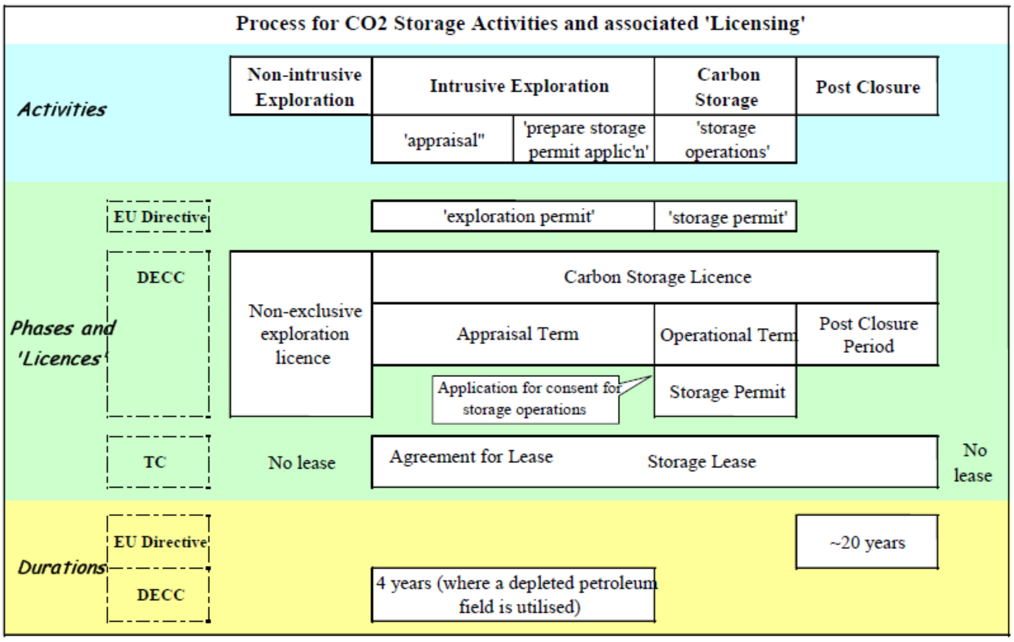
3.3.5 *UK licensing framework*

In the UK, the Government has taken steps to provide a legal framework for the conduct of carbon storage operations in the UK. The Energy Act 2008 provides for a regulatory regime for storage of CO_2 in the UK offshore area. It also vests property ownership rights for storage in the Crown. The Act also provides for relevant existing offshore oil and gas legislation to be applied to facilities used for CO_2 storage.

The Government's licensing regime for storage activities, introduced in October 2010 – part of the transposition of the EU carbon storage Directive - is intended to ensure that there is a clear, fit-for-purpose regulatory framework to encourage investment in such storage developments.

The licensing framework is summarised in *Figure 3.3*.

Figure 3.2 *Process for CO_2 storage licensing in the UK*



Source: Government Response to the Consultation on the Proposed Offshore Carbon Dioxide Storage Licensing Regime (DECC, August 2010), based on BP response. See http://www.decc.gov.uk/en/content/cms/news/pn10_97/pn10_97.aspx

In the consultation on the regulations, many respondents asked for clarification on how licence and leasing arrangements would interact. The Government envisages that the licence to store CO_2 offshore will refer to an essentially two dimensional plan, authorising the relevant activities within that area and its downward projection, in the same way as the established petroleum licences. However, the storage permit when issued will contain three-dimensional definitions of the storage site and the storage complex, and the authorisation conveyed will relate to these areas. Under the proposed arrangements, the initial agreement for lease issued by The Crown Estate will relate to the same area as the licence, and the subsequent lease will incorporate the same definition of the site as that in the permit.

Consultation respondents also sought clarification on potential overlaps between CO2 and petroleum developments. The consultation document had made it clear that established rights to extract petroleum would not be compromised by the storage arrangements, but that the existence of petroleum rights in a particular area would not preclude the grant of storage rights over the same or overlapping areas, provided the different activities did not conflict. The consultation document also indicated that it was not the Government's intention to consent to an overlapping development except where there is evidence that suitable liability and operational agreements are in place.

The Government's response to the consultation considers that this approach can be built on to address specific situations in which developments are more nearly adjacent than previously, or even where two projects address separate formations which overlap in plan. However, it is acknowledged that a cautious approach is necessary in such situations, aiming at progressive reduction of risks and uncertainties. It is indicated that although the UK Government will not rule out proposals for new developments merely because they are closely adjacent or overlapping in plan with an existing or already consented development, developers considering any such project should recognise that:

1. potential interactions will require more consideration;
2. the burden of proof that any interactions can safely be managed and that the activities will not conflict lies with the developer of the new (second, or subsequent) project; and
3. consent will necessarily be refused if the existing evidence base is inadequate to support any such proof.

The consultation also suggested that licensees of existing petroleum developments might have priority rights to apply for a subsequent redevelopment of the reservoir as a CO2 store. This is still under consideration.

With respect to ensuring third party access to storage sites, as required under the EU CCS Directive, the UK Government set out its approach as part of its clean coal industrial strategy 'Clean coal: an industrial strategy for the development of carbon capture and storage across the UK' in March 2010. This document proposes a rather hands-off market-based approach to third party access, indicating that '*it is likely that where a licensed site has available capacity, the Government would expect to see this made available to third parties on reasonable terms subject to maintaining the integrity of the storage site*'. Further clarification on this issue, and other implementation details, is expected later in 2010.

3.4 UNITED STATES

CCS **exploration activities** in the US on privately owned land will be facilitated through private lease contracts as with other (oil and gas) exploration activities. Exploration activities on Federal public lands will be regulated by the US Bureau of Land Management that ultimately has the authority to issue permits and leases for such activities.

CCS **injection activities** at a federal level will be regulated through the existing Underground Injection Control (UIC) permitting programme under the Safe Drinking Water Act (SDWA). The US EPA proposed an amendment to the UIC programme in July of 2008 in order to develop Federal permitting requirements specifically for underground injection of CO_2. A final rule is expected in December 2010 or January 2011.

The SDWA provides States an option to assume primary enforcement responsibility, or primacy, to oversee injection wells in their State. Subsequent to the final EPA rule, states with primacy will have a period of 270 days to update their primacy programmes to comply with the new requirements. If they do that then states will be able to issue permits for Class VI wells; if not then authority will revert to US EPA regions. To have primacy for the Class VI portion of the programme states need to meet federal requirements and submit evidence to the US EPA within the 270 days.

The EPA has encouraged, and plans to help States to assume primacy for Class VI wells because it believes that States may provide for a comprehensive approach to managing CCS projects by promoting integration of sequestration activities under SDWA into a broader framework for managing CCS at the state level. Some states are actively engaged in the process of developing their own regulatory frameworks for permitting CO_2 storage activities, and will need to ensure that their regulations are at least as stringent as those that will be finalised under the Federal UIC requirements. The Federal Government will seek to maintain a robust role in assuring that minimum Federal standards are met through periodic review of UIC programs in those states that have assumed primacy.

The basic steps and predicted timelines in the permitting process as they would follow from the UIC requirements if they were to be finalised in their present form are outlined in *Table 3.2*.

Table 3.2 Timelines for permit procedures on Federal Public Lands in the US

Stage	**Predicted timeline**	**Possible simultaneous actions**	**Governing body or document**
Exploration Phase	N/A	N/A	Likely to be regulated by the US Bureau of Land Management
Preparation for **Class VI Well Injection permit*** - geological data gathering, AoR delineation based on computer modelling, etc.	1 year	Pre-injection monitoring.	UIC Requirements

Injection permit **application processing** at the permitting authority, including 30 day public consultation	4-8 months	Pre-injection monitoring.	UIC Requirements

* Note: preparation time does not include research and exploration of the geological area – it is assumed that site suitability will already have been determined.

3.4.1 *Planning process*

According to the US National Environmental Policy Act (NEPA), an Environmental Assessment (EA) or Environmental Impact Statement (EIS) is required for CCS exploration and storage activities receiving federal funding (35). The regulatory requirements for an EIS are more detailed than the requirements for an EA. Public consultation requirements under NEPA are presented in summary below.

The EA/EIS preparation and publication are conducted by the agency providing support to the project. EPA has a review function but does not typically prepare the reports. There is no EA/EIS requirement for UIC permitting of a project that does not receive federal funding of some sort.

Public Consultation Requirements under NEPA (36)

As part of the planning process, agencies are required to identify and invite the participation of interested persons. The EPA subsequently publishes a Notice of Availability in the Federal Register for public comment.

The comment period is at least 45 days long and the EPA may conduct public meetings or hearings as a way to solicit comments. However, the comment period may be longer, at the EPA's discretion. When the public comment period is finished, the EPA analyses comments, and conducts further analysis as necessary. The EPA must respond to all substantive comments received from other government agencies and from members of the public.

It is worth noting that when a proposed action is part of a wider permitting process as would be the case for CCS storage activities, there will be opportunities for the public to comment on regulations for that permitting process and on the proposed UIC permit itself in addition to the public consultation process associated with the EA/EIS discussed above for projects receiving federal support. Public involvement is also required by most Federal agency land use planning related regulations.

There are both administrative and judicial options available for blocking the conclusion of the above process. A few Federal agencies also have an administrative appeals process. These include the Bureau of Land Management, which is likely to be involved in permitting CCS exploration

(35) 42 U.S.C. § 4321
(36) Council on Environmental Quality (CEQ), Citizen's Guide to the National Environmental Policy Act (NEPA), Dec 2007

activities. After the administrative appeals process has been exhausted, citizens or organisations deeming that a Federal agency's actions still violate NEPA may seek additional judicial review in Federal court under the Administration Procedures Act.

The public and other stakeholders opposed to CCS projects therefore have a number of options to block or at least delay CCS exploration and/or storage activities under the above public participation process.

3.4.2 *Injection permitting*

The proposed EPA rule to amend the existing US UIC program, if finalised, would ensure consistent permitting of the underground injection of CO_2 operations across the US. An operator that intends to inject CO_2 for geologic sequestration will need to apply for a UIC permit for a Class VI well - a new category of wells proposed by UIC Requirements specifically for geologic sequestration of CO_2.

Existing CCS pilot and demonstration projects can currently apply for an injection permit through the exploration and testing under EPA's guidance for Class V Experimental Technology Wells for Geologic Sequestration Projects. Existing UIC regulations allow some types of injection wells to be permitted individually or as part of an area permit. Most carbon storage projects will have multiple wells, so the operators may want to ensure that states will be able to issue area permits for their injection wells. The permitting process for an area permit is essentially the same as for an individual well, but the area permit specifies in one document and through one permitting process the requirements to be met by each of the authorized wells.

An overview of the information needed to be submitted by developers to the permitting authority for a Class VI Well UIC permit is presented in *Box 3.4.*

Box 3.4 US Class VI Well UIC Permit Information Requirements

- Maps of the injection wells
- Delineation of the Area of Review (AoR) as determined through computational modelling and all artificial penetrations within the AoR
- Maps of the general vertical and lateral limits of USDWs
- Maps of the geologic cross sections of the local area
- The proposed operating data and injection procedures
- Proposed formation testing and stimulation program
- Well schematics and construction procedures
- Contingency plans for shut-ins or well failures
- Demonstration of financial responsibility to plug the well, to provide for post-injection site care, and site closure

Source: Federal Requirements under the Underground Injection Control Programme for Carbon Dioxide Geologic Sequestration (EPA, 25 July 2008)

A Class VI permit for underground injection of CO_2 will also require the operators to follow general well construction and operating requirements;

conduct well integrity testing; implement monitoring, recordkeeping and reporting of injection activities; follow procedures for site closure; and prove financial responsibility. These topics are further discussed in corresponding sections of this report.

Under the draft proposed Rule, upon receiving the Class VI permit application, the permitting authority would be required to provide public notice and the opportunity for public input in the form of a 30-day comment period with public hearings. The permitting authority will have to respond to public inquiries and prepare a responsiveness summary that becomes part of the public record.

The responsibility for the inclusion of the public within the permitting regime therefore lies with the Competent Authority and not the developer, as is the case in the EU.

3.4.3 Interactions with petroleum licences

Existing legislation in the US does not explicitly deal with any interactions between CO_2 storage activities and other activities such as hydrocarbon production. This could potentially pose problems if one operator wants to seek a permit for a long-term storage site for CCS, while another operator involved in hydrocarbon production asserts the right to drill into and/or extract material in a zone which could impact the integrity of the CCS storage site. Unless such ambiguity is clarified, such interactions could be detrimental to the success of a CCS storage site.

3.4.4 Permitting rules at state level

As described above, the SWDA provides States an option to assume primary enforcement responsibility, or primacy, to oversee injection wells in their State. States issue UIC permits for injection wells onshore and could implement those requirements for wells inside State territorial waters.

Some states are delegating CCS permitting responsibilities to either Environmental or Oil and Gas Agencies - or to a combination of both in some cases.

Louisiana, Montana and Oklahoma have enacted laws authorizing the development of rules, but have not yet issued rules. Texas is in the process of issuing rules. West Virginia has a study group but has not yet started to develop any rules.

The following states have issued their own permitting rules:

- Kansas
- North Dakota
- Washington
- Wyoming

The evolution of state-level permitting frameworks may give rise to legal complications where a CCS project involves one or more states. As well as giving rise to potential inconsistencies of approach between federal and state level regimes, state permitting agencies may face resource constraints (e.g. relating to reviewing and validating complex computational models) in the event of widespread CCS deployment. Such factors suggest a need to enhance coordination on the development of permitting frameworks between the federal and state level.

3.5 CANADA

At present, no CCS specific regulatory or policy framework has been developed at a Federal level in Canada in relation to exploration or storage permitting, as most CCS activities are expected to be licensed at a provincial level. This is because under the current framework only Provinces can regulate CO_2 injection activities. Existing regulatory regimes for oil and gas adequately cover many CCS activities and have been used in the permitting process of existing and proposed CCS projects. It is likely that the regulatory frameworks currently in place for the oil and gas sector will provide the basis for future CCS regulation.

An overview of the situation at a Province level is provided further in this section.

3.5.1 *Planning process*

CO2 storage operators may need to prepare an environmental assessment (EA) for any CCS capture, exploration and storage activities, either at a Federal or Provincial level (37).The triggers for such an assessment will differ across the Provinces.

Public consultation requirements

A key part of the EA process is to seek input from the public, First Nations (i.e. indigenous people), interested stakeholders and government agencies in relation to a proposed project. Public comments must be received within the time limits established for the formal public comment period. There are two public comment periods (1st on draft application, and 2nd on the Application for an Environmental Assessment Certificate), and each typically runs a minimum of 30 days and a maximum of 75 days. The consultation process is issue based, i.e. once an issue is raised, whether by one or 100 people, the issue is sent to the proponent who responds to the issue. Both the issue and response are posted on the Project Information Centre. Detailed public consultation requirements will also vary across provinces in Canada.

(37) Pursuant to either federal act such as the Canadian Environmental Assessment Act, S.C. 1992, c. 37 (CEAA) or provincial acts

3.5.2 *Alberta*

Alberta has well-developed regulatory frameworks in the oil and gas sector that are applicable to CCS projects and the Alberta CCS Development Council concluded in its March 2009 report that Alberta's regulatory preparedness for CCS is well advanced (38).

In Alberta, the competent authority for regulating and permitting CCS activities is the Energy Resources Conservation Board (ERCB). ERCB recently stated their intention (39) to use existing Directives 056 and 065, which together set out the key application requirements for prospective exploration and CO_2 storage activities in Alberta.

More specifically, to commence CO_2 injection, the operator must undertake the following three-step process:

1. Obtain the **right to dispose** of CO_2 into an underground geological formation: In Alberta, the mineral rights owner is either the Alberta Crown (Alberta Energy) or Freehold (private ownership). A letter to the applicant (40) from the mineral rights owner or lessee authorizing the CCS operations is generally acceptable to demonstrate the right to dispose of CO_2. However new legislation will clarify if this right can only be obtained by way of a sequestration agreement with the Government of Alberta.

2. Obtain a **well licence:** Directive 056 sets out key requirements and procedures applicable to ERCB licensing of a CO_2 disposal well, including a participant involvement programme (Section 2), and cites additional regulatory requirements (Appendix 2).

3. Obtain a **CO_2 disposal scheme**: Directive 065, Unit 4, sets out requirements and procedures for making an application to the ERCB for approval of disposal of fluids containing CO_2. Section 4.2 of Directive 065 sets out the application requirements specific to acid gas disposal (CO_2 is classed as an acid gas). Directive 065, Unit 2, also covers enhanced recovery schemes, which may be connected to carbon capture facilities. Directive 051 (Injection and Disposal Wells) sets out well classifications, completion, logging, and testing requirements for wells injecting CO_2.

Additional site-specific or project-specific information may be required to address issues related to public interest.

The basic steps and predicted timelines in the permitting process in Alberta are outlined in *Table 3.3*.

(38) Carbon Capture and Storage Legal and Regulatory Review 2010 (OECD/IEA, 2010)
(39) Energy Resources Conservation Board, Bulletin 2010-22, June 29 2010
(40) As described in Directive 065, Section 4.2.2: Equity and Safety

Table 3.3 *Timelines for the permit procedures in Alberta*

Stage	Predicted timeline	Possible simultaneous actions	Governing body or document
Obtain the right to dispose of CO_2 into an underground geological formation	N/A	N/A	Alberta Crown (Alberta Energy)
Obtain a well licence	-	-	Directive 056
Obtain a CO_2 disposal scheme	-	-	Directive 056 and Directive 065

* Note: preparation time does not include research and exploration of the geological area – It is assumed that site suitability has already been determined.

Interaction with Petroleum Licenses

As a part of the previously noted ongoing CCS regulatory review, Alberta will also be assessing the permitting framework for CO2 storage activities and any interaction with Petroleum Licensees or other existing users.

3.5.3 Other Province level developments

British Columbia also has a mature oil and gas sector whose well developed regulatory framework is applicable to CCS development. The Petroleum and Natural Gas Act governs storage reservoir rights, underground storage and disposal relating to oil and natural gas operations. The Province is in the process of creating a regulation listing prescribed substances such as CO_2 from any source, to be disposed or stored in underground storage reservoirs [(41)]

Saskatchewan also has an existing regulatory framework that accommodates CO_2 injection, and commercial-scale EOR projects with CO_2 storage are underway governed by existing regulations. The Province is currently reviewing whether additional regulatory clarification is required to assist the development of CCS projects [(41)].

3.6 AUSTRALIA

The Australian federal Government has jurisdiction over Commonwealth waters (extending from three nautical miles offshore to the edge of Australia's continental shelf) and the States and Territories have jurisdiction over onshore areas and coastal waters (up to three nautical miles). The development of legislative and regulatory systems in each jurisdiction is a matter for the jurisdiction concerned [(41)].

(41) Carbon Capture and Storage Legal and Regulatory Review 2010 (OECD/IEA, 2010)

In 2006, Australia adopted the Offshore Petroleum and Greenhouse Gas Storage Act (OPGGS). The Act establishes access and property rights for CCS activities in offshore Federal waters. The OPGGS was amended in 2008 so as to facilitate the establishment of a regulatory framework that would encompass both petroleum and CO_2 storage activities in Commonwealth (i.e. federal) offshore waters. The new provisions came into force on 1 July 2009 and established a regulatory regime for CCS. Provisions included the allocation of long-term liability for storage sites to the Commonwealth. However, this will be subject to the injecting entity meeting stringent monitoring and reporting requirements after a 15 year assurance period (see *Section 7*). The Commonwealth has since developed the draft Offshore Petroleum and Greenhouse Gas Storage (Injection and Storage) Regulations 2010, circulated for consultation on 3 May 2010.

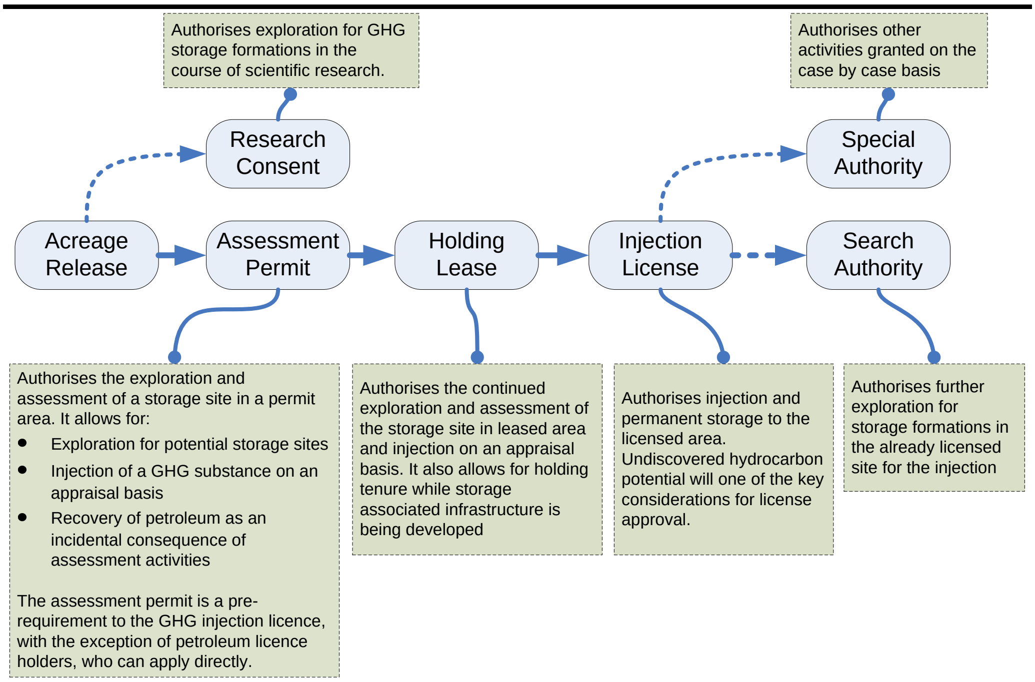
Overall, the OPGGS Act and draft regulations lay out requirements for CO_2 transportation, injection and storage that are similar to existing requirements that regulate the petroleum industry.

The GHG exploration and storage permitting and licensing regime in Australia at a Federal level is outlined in *Figure 3.3* and discussed in further detail in the remainder of this section. The process shown in the figure is based on legislation that exists at a Federal level and will help drive consistency across jurisdictions. The State Governments are now focusing on developing more detailed regulations using the Federal permitting and licensing process as a basis to complete their legislative regimes.

At the state level, Victoria has also enacted its offshore storage legislation - the Offshore Petroleum and Greenhouse Gas Storage Act 2010, which received royal assent on 23 March 2010 and largely mirrors the Commonwealth legislation. Whilst the Victorian Act is consistent with the OPGGS in most respects, the Victorian and Federal offshore Acts differ with respect to one key issue, which is long-term liability. Potential implications are discussed in further detail in *Section 6.6*.

An overview of CO_2 storage permitting and licensing related legislation in Australia at both a Federal and State level is presented in *Table 3.4*

Figure 3.3 ***Overview of permitting and licensing activities for GHG storage in Australia at Federal level***



Source: ERM, 2010

Table 3.4 ***Overview of exploration and CO_2 storage permitting related legislation in Australia***

Jurisdiction	Relevant legislation
Federal Level	Offshore Petroleum Amendment (Greenhouse Gas Storage) Act 2008 Offshore Petroleum and Greenhouse Gas Storage (Injection and Storage) Regulations 2010
Victoria	Offshore: Offshore Petroleum and Greenhouse Gas Storage Act 2010 Onshore: Greenhouse Gas Geological Storage Act 2008
Queensland	Onshore: Greenhouse Gas Storage Regulations 2010
New South Wales	Onshore: (proposed and due to be presented to Parliament late 2010)
Western Australia	Onshore legislation (planned, as an amendment to the existing Petroleum and Geothermal Energy Resources Act 1967) Barrow Island Act 2003 – currently used specifically for the Gorgon Gas Project.

Source: ERM, 2010

3.6.1 *Licensing procedures*

Under the federal OPGGS Act, after a potential GHG storage site has been identified, the greenhouse gas storage acreage is released (42) inviting applications for a Greenhouse Gas Assessment Permit on a work-bid or cash-bid basis. The release of areas for bidding occurs after successful consultation with stakeholders, such as the petroleum industry, environmental actors, entities with fishing and/or other interests. The government then submits all its geological knowledge and formation information to the successful bidder.

(42) in an equivalent manner to petroleum acreage release i.e. via gazette notice

After the declaration of an identified greenhouse gas storage formation in a greenhouse gas permit area, the permittee may apply for a greenhouse gas holding lease if it intends to explore the area or for a greenhouse gas injection licence if it intends to start commercial exploitation.

Greenhouse Gas (GHG) licences must be approved by the Federal Minister for Resources, Energy and Tourism and entered on the GHG titles register. If the applicant is unsuccessful in its bid for the injection licence, it may still apply for the holding licence.

All GHG storage projects will be subject to an Environmental Assessment (EA) and approval as part of the overall licensing process in the relevant jurisdiction under the appropriate legislative regime.

Furthermore, before granting a licence, the assessment must establish that the GHG licence will have no 'significant impact' on an existing title or operation. A definition clarifying what no 'significant impact' might be is yet to be issued. However, it is expected that this would need to be considered on a case-by-case basis.

The predicted timelines in the permitting process in Australia are outlined in *Table 3.5*.

Table 3.5 ***Timelines for CO_2 storage permitting in Australia***

Stage	**Predicted timeline**	**Possible simultaneous actions**	**Governing body or document**
GHG assessment permit (preparation of the data on competency and the authorities decision time)*	4 months	-	OPGGS
Declaration of an identified GHG storage formation and preparation of Environmental Assessment Report (including exploration time)	Up to several years, depending on project details	Pre-injection monitoring.	OPGGS / *Guidelines for Carbon Dioxide Capture and Geological Storage – 2009*
Optional: **GHG holding lease** application*.	1-2 months (can last up to 15 years)	Pre-injection monitoring.	OPGGS
GHG Injection licence application procedure.	4-8 months	Pre-injection monitoring.	OPGGS

* Acts as a reservation of the right to inject in the future for the operator that has invested in GHG assessment permit and the exploration of the storage formation.

The requirement to prove the suitability of the proposed greenhouse gas storage formation lies with the operator in order to apply for the injection licence - a process that can add time-related uncertainty. However, it can reasonably be expected that the CO_2 storage licensing in Australia will be a relatively streamlined process, considering the following:

- The CO_2 storage licensing procedure is based on the well established petroleum licensing framework.
- There are no other parties interacting directly in the licensing process apart from the applicant and the Minister for Resources, Energy and Tourism

The key conditions for a successful GHG injection application for the GHG injection licence are outlined in *Box 3.5*

Box 3.5 Key conditions for GHG injection licence

- The operator has the ability and intent to commence the operations of GHG injection and storage within 5 years after the grant,
- There are no adverse effects on the petroleum production
- The technical qualifications of the applicant and
- Financial resources and technical advice are available to the applicant of the satisfactory draft site plan

Source: OPGGS Act

Public Consultation Requirements

Provision is made for community consultation under existing state (rather than Federal) planning schemes. CCS project proposals would be subject to these provisions. In addition, state CCS legislation has also mandated community consultation to ensure a stringent level of community consultation is maintained for all CCS projects even if the CCS project does not trigger the most stringent planning approvals assessment criteria.

At the state level, in Victoria if a CCS project does not trigger referral criteria for an Environmental Effects Statement, the Victorian Greenhouse Gas Geological Sequestration Act 2008 requires that consultation with affected communities and stakeholders occurs before and during any CCS activity and that a 'community consultation plan' be prepared prior to an application for an exploration authority (43). Guidelines for the development of community consultation plans have been developed by the Victorian Department of Planning and Infrastructure (44). The Guidelines are based on the U.S. National Energy Technology Laboratory (NETL) guidance document "Best Practices for: Public Outreach and Education for Carbon Storage Projects December 2009".

In Queensland, the Greenhouse Gas Storage Act 2009 also stipulates consultation requirements for GHG permit holders. In accordance with the Act, consultation requirements will either be stipulated in the GHG permit, or

(43) The Victorian Greenhouse Gas Geological Sequestration Act 2008, Division 2, Section 153
(44) http://www.new.dpi.vic.gov.au/__data/assets/pdf_file/0015/21417/Attchement3_GCS09_tender_Community_-Engagement_requiremets.pdf

if the GHG permit does not provide for how the consultation must be carried out, it must be otherwise approved by the Minister [45]. The CO_2CRC Otway Project in Victoria is an example which demonstrates positive community engagement based on effective public consultation.

3.6.2 *Interactions with offshore petroleum licences*

Offshore Petroleum and Greenhouse Gas Storage Act 2010

At a Federal level, and for offshore storage, the OPGGS Act and draft regulations 2010 gives priority rights to holders of existing, or "pre-commencement" petroleum title for CO_2 storage activities in their licensed area. By "pre-commencement" petroleum title, the Act refers to those titles that were in existence prior to the passage of statutory GHG provisions. In some cases this includes the right to veto a GHG storage proposal.

There are a number of mechanisms incorporated into the OPGGS which are designed to protect pre-commencement petroleum titles. Amongst others, key mechanisms include:

- **Statutory conditions** are placed on certain GHG titles to ensure that holders of GHG assessment permits and holding leases no not commence "key GHG operations" without prior consent from the Minister. Approval would only be granted if the Minister determined that the GHG operation would not pose a "significant risk of a significant adverse impact" (SRSAI test).
- **Ministerial directions** to GHG title-holders can be provided to mitigate, manage or eliminate an identified SRSAI. GHG title holders are bound to implement any stated Ministerial directions.
- **Granting of GHG injection licences** will also be subject to the SRSAI test to protect the interests of existing petroleum interests.
- **Protection of petroleum discoveries** made even after a GHG injection licence has been granted, in areas where a GHG injection licence overlaps a pre-commencement petroleum title area (providing the title is held by a person other than the injection licensee).

Whilst these mechanisms seek to protect existing pre-commencement petroleum titles, for post-commencement petroleum titles, the OPGGS does not give precedence to either GHG or petroleum interests. Instead, it establishes a level playing field, and allows the Minister to submit a proposal to a "public interest test" to determine which activity should be prioritised where both petroleum recovery and GHG storage cannot co-exist.

At the state level, in Victoria, the Victorian Offshore Act mirrors the provisions incorporated into the OPGGS at a Federal level and provides greater protection for pre-commencement petroleum interests, whilst establishing a level playing field for post-commencement petroleum interests.

(45) The Queensland Greenhouse Gas Storage Act 2009, Chapter 2, Section 85.

The Victorian Act also establishes the SRSAI test for pre-commencement interests, and, similar to the Federal Act, the Minister will have discretion in granting GHG titles subject to the SRSAI test.

4 IMPURITIES IN INJECTED CO_2 STREAMS

4.1 INTRODUCTION

The composition of the CO_2 gas stream intended for geological storage can vary depending on the industrial and capture process involved. In addition to CO_2 and traces of water, other gases, such as O_2, N_2, SO_X, NO_X, H_2, CO and H_2S can be present in various concentrations.

The presence of additional gases may have regulatory and health and safety implications as some may be deemed as waste or hazardous waste, depending on their specific health, environmental, and safety effects. For example, attributes such as flammability, carcinogenicity, mutagenicity and toxicity can trigger multiple health, environmental, and safe handling requirements that will affect the operations of a storage site.

In addition to the above, CO_2 purity can also present operational issues across the CCS chain, e.g.:

- Pipeline specification standards are designed to protect CO_2 pipelines and can influence the accepted CO_2 purity in the transported stream.
- Enhanced oil recovery (EOR) operations can also be compromised by poorer quality specifications.

Since CO_2 stream purity and the presence of pollutants can vary by emitting source and the choice of CO_2 capture technology, determining acceptable levels is vital for establishing conditions under which CO_2 capture, transportation, long-term storage and enhanced oil recovery can take place.

This section presents:

- An overview and comparative analysis of regulatory requirements concerning the treatment of impurities present in a CO_2 stream for CO_2 injection and storage;
- Cases of how regulators have handled analogous substances (e.g. hydrocarbon storage); and
- Indications of how regulators might handle situations where acid/sour gases are injected in addition to CO_2 in a CCS storage site.

4.2 INTERNATIONAL LEGISLATION

At the international level, legal barriers to the geological storage of CO_2 in geological formations under the seabed have been removed through the adoption of related risk management frameworks under the Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1996 (London Protocol) and under the Convention for the

Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention).

4.2.1 *The London Protocol*

The London Protocol aims to protect the marine environment from pollution by dumping. An international convention with 38 signatories, it identifies in Annex 1 seven categories of waste and places various obligations upon Parties in respect of waste dumping at sea. Australia, Canada, most of the EU Member States and other OECD countries are Parties to the Protocol (with the notable exception of the US) [(46)].

Following the Protocol's entry into force in March 2006 and various legal and technical reviews, Australia, co-sponsored by France, Norway and the UK, submitted a proposal to amend Annex 1 in order to allow the storage of CO_2 in sub-seabed geological formations. At the first meeting of the Contracting Parties to the London Protocol in November 2006, the resolution was adopted.

The amendment subsequently entered into force in February 2007 for all Contracting Parties to the Protocol, expect those who sent to the International Marine Organisation (IMO), within the time frame designated under Article 22, a declaration regarding their inability to accept the amendment.

The new Protocol amendment has inserted an eighth category into the Annex 1 category of wastes. This category consists of 'Carbon dioxide streams from carbon dioxide capture processes for sequestration'. Further clarification is provided by way of a new subsection 4, which details the circumstances when CO_2 streams may be considered as legally disposed, as follows [(47)]:

1. disposal is into 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. (Annex 1; subsection 4)

The new provisions inserted into Annex 1 therefore provide a basis for the international regulation of CO_2 sequestration in sub-seabed geological. Point (2) therefore requires that injected CO_2 streams be 'overwhelmingly' pure, a term necessarily open to differential interpretation by Parties. The issue of setting 'acceptable' CO_2 purity levels will be dealt with by the national authorities of the Parties to the Protocol (including Australia, Canada and most of the EU Member States).

The scope of the London Protocol includes the sea, sea bed and sub soil. However, it does not include sub sea bed repositories accessed by land.

(46) See www.imo.org/includes/blastData.asp?doc_id=7541&type=body

(47) International Maritime Organisation, London protocol: specific guidelines for assessment of carbon dioxide streams for disposal into sub-seabed geological formations, adopted by the 2nd Meeting of Contracting Parties in November 2007

4.2.2 *The OSPAR Convention*

In 2007, the Parties to the OSPAR Convention adopted amendments (led by Norway, the Netherlands, France and the UK) to the Convention to allow the storage of CO_2 in geological formations under the seabed. These are currently being ratified by Parties (the UK ratified the amendments to Annexes II and III in April 2010). There are 16 European signatories to OSPAR including the EC. The treatment of CO_2 purity mirrors the London Protocol text, requiring that CO_2 streams from CO_2 capture processes for storage "consist overwhelmingly of CO_2" and "may contain incidental associated substances derived from the source material and capture and sequestration processes used".

4.3 *EUROPEAN UNION*

The purity requirements of injected CO_2 streams are dealt with at an EU level under the CCS Directive and the recently published draft EC implementation guidelines. The purity of the CO_2 stream also has implications under the EU ETS, as avoided CO_2 emissions (the basis for recognising CCS under the ETS) will be recognised only according to the concentration of the GHG stream transferred between the different ETS installations across the CCS chain i.e. capture, transport and storage.

4.3.1 *EU CCS Directive and Implementation Guidelines*

EU CCS Directive requirements on CO_2 stream composition

In common with the London Protocol and OSPAR Convention to which the EC is a Party, The EU CCS Directive states that the a "CO_2 stream shall consist overwhelmingly of CO_2" and that "no waste or other matter may be added to the CO_2 stream for the purpose of disposing" (Article 12.1).

The concentration of all incidental substances (arising from the source, capture or injection process) and any substances added to assist in monitoring and verification must be below levels that would:

(a) adversely affect the integrity of the storage site or the relevant transport infrastructure;

(b) pose a significant risk to the environment or human health; or

(c) breach the requirements of applicable Community legislation.

The CCS Directive requires that composition analysis of CO_2 streams must be undertaken before injection on a continuous basis and that the operator keeps a register of the quantities and properties of the CO_2 stream delivered and injected. The characterisation of CO_2 stream properties is required under Step 3 of the storage site assessment process outlined in Annex 1 (see *Section 3.3.1*).

The procedures under which the risk assessment is reviewed and assessed is further considered in the *Section 7* concerning monitoring and reporting requirements.

Implementation Guidelines on CO_2 stream composition

The draft EC Guidance Documents (GD) on implementation of the CCS Directive [48] provide further information on how to implement the CO_2 stream acceptance criteria of the Directive (Article 12) and lists likely substances of concern. These cover incidental substances and resulting acids, and injection of H_2S.

Incidental substances: The guidance indicates that the concentrations of incidental substances above acceptable risk levels can be decreased by adding additional stages of purification at capture. Incidental substances will differ according to emitting source, fuel and capture technology; streams from natural gas processing for example will likely contain methane, non-methane hydrocarbons (C_2+), and H_2S, which will have to be removed if they reach risk levels. Oxyfuel combustion without FGD is identified as having the most problematic level of contamination out of all capture technologies.

Acid formation: The injection of acid gases could result in reducing storage integrity due to interactions with water in the storage site, such as deterioration of well-bore cement, heavy metal contamination of aquifers and other geochemical changes from acid interactions.

Table 4.1 provides a list of potentially important acids that might be formed from the incidental substances co-injected with the supercritical CO_2 when the CO_2 comes into contact with formation water.

The guidance suggests that Member State authorities restrict the chlorine, SOx, and NOx content in the injected stream so as to prevent potentially high levels of acids that, subject to geological characteristics of the storage site, could pose an unacceptable level of risk.

H_2S: The guidance states that injection of H_2S in CO_2 streams used for the purpose of enhanced oil recovery (EOR) may also have an advantage, as H_2S mixes well with crude oil. It is suggested however that Member States should consider a low limit for H_2S due to the high toxicity of H_2S.

(48) Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 2 on Site Characterisation, CO_2 Stream Composition, Monitoring and Corrective Measures, 17 June 2010

Table 4.1 ***Acids resulting from interactions between incidental substances and formation water*** (49)

Acid	Relative acidity	Volume fraction	Total acidity impact
Hydrochloric acid (HCl)	$2.3*(10)^{14}$	$1.4*(10)^{-3}$	$3.7*(10)^{11}$
Sulphurous acid (H_2SO_4)	$3.5*(10)^{4}$	$1.3X(10)^{-2}$	$5.3*(10)^{2}$
Sulphuric acid (H_2SO_3)	$2.8*(10)^{4}$	$1.3X(10)^{-4}$	4.2
Carbonic acid (H_2CO_3)	$1.0*(10)^{0}$	$8.8X(10)^{-1}$	$8.8*(10)^{-1}$
Nitrous acid (HNO_2)	$1.0*(10)^{3}$	$7.2X(10)^{-4}$	$7.2*(10)^{-1}$

Note: Values are calculated on the oxy-fuel with no FGD (near-worst-case scenario)

Responsibility for CO_2 stream composition

The EC CCS directive and draft implementation guidelines place the responsibility of proving that the CO_2 stream is pure enough to be stored safely on the CO_2 storage operator. However, as discussed above the purity of the CO_2 stream is largely determined by the composition of the stream(s) leaving the capture site(s). It will be therefore important for the operator of the storage site to put in place clear arrangements with the provider of the CO_2 stream (i.e. the capture plant and/or pipeline operator) that the stream contains impurities below the relevant risk levels.

4.4 UNITED STATES

At a Federal level in the US, the presence of impurities within the injected CO_2 stream could fall under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act 1980 (CERCLA) or the Resource Conservation and Recovery Act 1976 (RCRA) potentially resulting in liabilities upon the storage operator.

The injected stream may contain impurities such as mercury regulated as "hazardous substances" under CERCLA. In addition, substances or the constituents of the CO_2 stream could react with groundwater to produce CERCLA-listed hazardous substances such as sulphuric acid (see *Table 4.1*). CERCLA collects tax on chemical and petroleum industries creating hazardous substances and puts it to a trust fund, commonly known as the Superfund, for cleaning up abandoned or uncontrolled hazardous waste sites. It provides broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Whether or not there is a ''hazardous substance'' that may result in CERCLA liability from a CO_2 storage facility depends on the make-up of the specific CO_2 stream and of the environmental media (e.g., soil, groundwater) in which it is stored.

(49) Original table from Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 2 on Site Characterisation, CO_2 Stream Composition, Monitoring and Corrective Measures, 17 June 2010, Modified by ERM

Depending on the composition of the injected CO_2, the Resource Conservation and Recovery Act 1976 (RCRA) may also apply. Broadly stated, the RCRA covers the transport, storage, and disposal of hazardous and solid waste. Relevant to CCS, the Act's definition of "disposal" encompasses underground injection of hazardous waste. Whether the definition of "hazardous waste" includes CO_2 is largely de-pendent upon the presence of impurities within the injected CO_2 stream. The RCRA potentially remains a powerful regulatory tool because the "imminent hazard" provision allows a person to compel a polluting party to clean up almost any type of solid or liquid waste that poses an imminent hazard to human health or the environment. Thus, if a *potentially* harmful situation arises from CO_2 injection, the imminent hazard provision may serve an important role in removing the contamination from groundwater (50).

However, impurities would be injected along with the CO_2 into a well that must meet EPA's requirements for Class VI wells, which were developed based on the requirements and standards for Class I industrial and hazardous waste wells. The corrosion-resistant construction standards, periodic corrosion monitoring and mechanical integrity testing requirements in the geologic storage rule are specifically designed to address this risk (51). The proposed EPA rule suggests that for anthropogenic CO_2 substances may be added to facilitate the injection (e.g. tracer) or storage (which may change the p.h) but that additional waste streams cannot be added for the purposes of disposal. Any stream can be taken from flue gas sources as long as transport and storage activities are not endangered. Note also that pipeline and storage operators have or will have requirements relating to the quality of stream transported or stored.

Washington State mandates that operators must apply available and reasonably applicable technology to treat CO_2 streams to remove contaminants prior to storage.

4.5 CANADA

In Alberta, injection of H_2S is regulated under Directive 065 (Resources Applications for Oil and Gas Reservoirs). Under this Directive, if enhanced hydrocarbon recovery operations involve any H_2S injection and an emergency response plan (ERP) is required, then the ERP must be approved prior to injection approval being issued. ERPs are approved and reviewed for compliance by the ERCB, and the requirements are detailed in Directive 071 (Emergency Preparedness and Response Requirements for the Upstream Petroleum Industry), which requires the licensee to calculate the size of the emergency planning zone (EPZ) for sour gas with a hydrogen sulphide (H_2S) concentration of 0.1 moles per kilomole (mol/kmol) (0.0001 mole fraction or 100 ppm) or greater (52). In addition, if an injection fluid contains H_2S, all

(50) Nathan R. Hoffman. The Feasibility of Applying Strict Liability Principals. Washburn Law Journal, Vol. 49, February 2010

(51) Report of the Interagency Task Force, August 2010.

(52) Directive 071: Emergency Preparedness and Response Requirements for the Upstream Petroleum Industry

pipelines and facilities associated with the scheme must be approved for the appropriate sour service according to Directive 056 (Energy Development Applications and Schedules) [53].

Adoption of a similar definition of what constitutes a suitably pure CO_2 stream for storage to that of the London Protocol by the Federal government regarding credit-eligible CCS activities may exclude some acid gas injection operations from consideration because of the high fraction of H_2S in such streams i.e., the injection stream is not ''overwhelmingly'' CO_2. Alternatively, it may force operators to further separate the CO_2 from the acid gas stream and inject separately the resulting streams of CO_2 and H_2S, with the resulting economic and regulatory consequences [54].

Two industry associations - the Integrated CO_2 Network (ICO_2N) and the Petroleum Technology Alliance of Canada (PTAC) - together with international partners including the Carbon Capture Project and the Alberta Department of Energy have recently joined to undertake a study for determining the a CO_2 purity standard for use in capture, transport and storage activities in Canada. The study will examine CO_2 purity, contaminants, temperature and pressure and looks to build on experiences of CO_2 injection in Alberta. The overall aim is to seek a suitable 'balancing point' between purity requirements and cost effectiveness as it pertains to all stages of a CCS system - capture, transportation, sequestration, as well as enhanced oil recovery (EOR) use. The CO_2 purity study is expected to be completed in early 2011 [55].

4.6 AUSTRALIA

Australia has endorsed the London Protocol definition of a permitted CO_2 injection stream as one which is "overwhelmingly carbon dioxide" for both off-shore and on-shore geological storage. This definition is contained within the Environmental Guidelines for Carbon Dioxide Capture and Geological Storage – 2009 produced by the Environment Protection and Heritage Council (EPHC) of Australia and now legally adopted at a federal level [56].

The Guidelines also indicate that it is possible for an injected stream to include additional quantities of substances already in a CCS stream from sources other than the capture/separation process (i.e. from a facility not related to the primary capture). This would however be subject to a separate assessment and approval process, including a full risk assessment and identification of impacts on the reservoir storage efficiency that arises through changing the composition of the CCS stream.

(53) Directive 065: Resources Applications for Oil and Gas Reservoirs
(54) Stefan Bachu. Legal and Regulatory Challenges in the Implementation of CO2 Geological Storage: An Alberta and Canadian Perspective. Elsevier, 2007.
(55) See http://www.carboncapturejournal.com/displaynews.php?NewsID=569
(56) See http://www.ephc.gov.au/sites/default/files/Climate_GL__Environmental_Guidelines_for_CCS_200905_0.pdf

5 PORE SPACE OWNERSHIP

5.1 INTRODUCTION

There are a number of property rights issues associated with undertaking CCS projects, including *inter alia* ownership of the CO_2 across the CCS chain, intellectual property rights associated with CCS technology and techniques, and property and access rights associated with to infrastructure used on the surface across the CCS chain.

This section focuses on property rights associated with the sub-surface pore space in which the CO_2 is stored, including the interaction of such 'pore space rights ' for the purpose of CO_2 storage with the ownership of other resources (e.g. oil and gas, ground water) contained in the same pore space

The storage component of a CCS project presents arguably the greatest legal complexity, due to its impact on real property rights in relation to land. Real property rights (otherwise known as land rights) are those property rights which pertain to real property [57], including rights to ownership and usage. The exact nature and complexity of the legal issues associated with CO_2 storage will vary between nation jurisdictions given that real property ownership regimes differ between countries.

Subsurface ownership can generally be considered to be:

1. Owned by the proprietor of the surface estate, or
2. Vested in the surface owner as part of a bundle of entitlements, but ultimately owned by the state, or
3. Owned by the state.

Storage reservoirs and injection sites may be subject to competing claims of ownership and usage, in particular where there are mineral and petroleum interests in the vicinity of the storage reservoir. Liability issues may arise where there are competing claims for pore space ownership (or ownership rights) between surface estate owners, CCS storage operators, and mineral and petroleum rights holders.

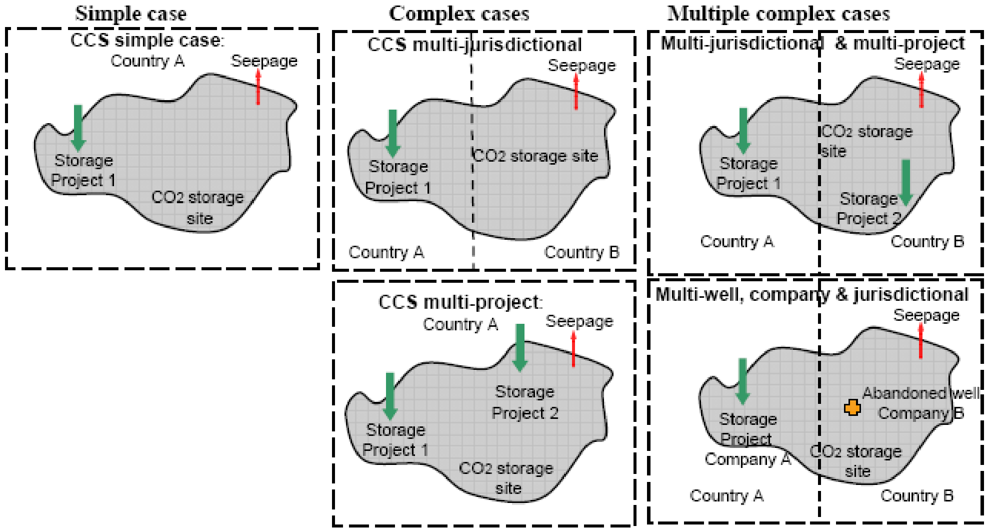
The liability risks presented by a CCS project will similarly vary under different property ownership regimes. Understanding how the litigious risk profile of a CCS project will vary between nation jurisdictions is an essential element of any project due diligence assessment.

(57) Real property, which is often considered synonymous with real estate, is primarily a common law legal term, which in civil law jurisdictions generally translates to 'immovable property'. Both real property/real estate and immovable property can be generally contrasted with 'personal property in common law' and 'movable' property in civil law systems.

5.2 *OVERVIEW*

Property rights considerations will vary according to the setting and complexity of each CCS project. This section focuses on the regulatory provisions and issues associated with a project falling under what the IEA/OECD describe as the 'simple case' model. A 'simple case' model is one which can be described as including a single storage reservoir, located entirely within a single jurisdiction and used by only one storage proponent (see Figure 1.1 published by the IEA).

Figure 5.1 Demonstrating the Simple Case vs. More Complex Cases



Source: Carbon Capture and Storage in the CDM (OECD/IEA, December 2007)

There are several layers of complexity not captured in the 'simple case' model. Conceivably, CCS projects may have project boundaries spanning several jurisdictional boundaries. In other situations a number of storage operations may use a single reservoir for storage, or conversely, a single operation could use a number of storage reservoirs for injection; (see *Figure 5.1*).

In most jurisdictions, 'fee simple' ownership is recognized as the most basic form of comprehensive real property ownership. This arrangement generally entitles the owner of the surface estate to some form of mitigated ownership rights to above-surface and subsurface strata. By conferring ownership rights of the subsurface on individual owners and not on governments by default, the subsurface domain in the majority of jurisdictions can be considered to be under a system of private entitlement to the surface owner. However, because the state grants ownership rights and not absolute ownership, all land ownership remains ultimately vested in the state.

The US is an exception in that it has a land title system whereby real property is considered to be the property of their owner, and not granted to an individual as part of an entitlement. Under the US title system, private parties that own surface estates are assumed to also have right of possession to subsurface strata below that estate. By conferring ownership on individual owners, the subsurface domain is therefore considered to be privately owned by owners of the surface estate or, by mineral estate owners where the mineral estate has been severed from the surface estate (58).

The main property rights issues common to all CCS storage operations along with an overview of other subsurface property rights issues which complicate pore space ownership considerations (such as mineral and petroleum rights and groundwater rights) are presented in *Table 5.1* and discussed in more detail in the remainder of this section.

(58) The US has a 'quasi-allodial' land title system whereby real property is considered to be the property of their owner, and not vested in the government. True allodial title refers to an ownership system where real property is owned free and clear of any encumbrances, and whereby ownership is inalienable, meaning the owner cannot be disposed of ownership rights by any operation of the law.

Table 5.1 Overview of interaction between CO_2 storage rights and other subsurface ownership rights

Country - Jurisdiction	Porous Space Rights Ownership	Interaction with mineral rights	Interaction with hydrocarbon rights	Interaction with groundwater rights
UK	Owned by the Crown	Not applicable: Licensing framework is applicable to offshore CO_2 storage	Where the carbon storage licensee is not the holder of a Petroleum Production Licence relevant to the discovery, the carbon storage licence holder will have no claim on these hydrocarbons	Not applicable: licensing framework is applicable to offshore CO_2 storage
Canada - Alberta	Owned by the Crown	Section 57(1) and (2) of the *Mines and Minerals Act* confirms that the owner of title to petroleum, natural gas and minerals in an underground formation owns the storage rights in that formation. *ERCB Bulletin 2010-22*: letter to the applicant from the mineral rights owner or lessee authorizing the CCS operations must be obtained from the mineral rights owner.	Section 57(1) and (2) of the *Mines and Minerals Act* confirms that the owner of title to petroleum, natural gas and minerals in an underground formation owns the storage rights in that formation.	Section 102 of the *Mines and Minerals Act* allows the Crown to enter into unit agreements that provide for the "use of the subsurface reservoir for the purposes of storage of fluid mineral substances." For saline formations, Section 3(2) of the *Water Act* vests in the Crown, the property in and the right to divert and use water in Alberta. Consequently permission to dispose of CO2 in saline formations might be granted pursuant to the Act.
Canada – Ontario	Owned by the Crown	Interaction with competing subsurface interests has not yet been stipulated	Interaction with competing subsurface interests has not yet been stipulated	Interaction with competing subsurface interests has not yet been stipulated
Australia – Federal (Offshore)	Owned by the Crown (no provision in offshore legislation because Crown ownership is the basic assumption).	For Federal offshore, mineral interests would not be a consideration.	*Offshore Petroleum and Greenhouse Gas Storage Act 2008* Carbon storage is only allowed if it does not impair oil and gas productivity. Proposals would be subject to a "significant risk of a significant adverse impact" (SRSAI) test.	For Federal offshore, groundwater rights would not be a consideration.

Country - Jurisdiction	Porous Space Rights Ownership	Interaction with mineral rights	Interaction with hydrocarbon rights	Interaction with groundwater rights
Australia – Victoria	Owned by the Crown (for onshore, and offshore within Victorian waters).	*Greenhouse Gas Geological Sequestration Act 2008 (Onshore)* S 194 "A person must not carry out any greenhouse gas sequestration operation on any land specified in Schedule 3 to the *Mineral Resources (Sustainable Development) Act 1990* without the written consent of the Minister responsible for that land."	*Offshore Petroleum and Greenhouse Gas Storage Act 2010* Act requires Minister to assess the impact of GHG storage operations on overlapping interests, i.e. petroleum interests using the SRSAI test as with Federal Act. Victorian acts provide greater protections for pre-commencement petroleum interests (that is, those in existence prior to the passage of the relevant GHG provisions). In some cases (specifically, pre-existing petroleum titles and existing post-commencement petroleum production licences), petroleum titleholders have a right of veto over the establishment of new GHG storage operations.	*Greenhouse Gas Geological Sequestration Act 2008 (Onshore)* S 195 "A person must not carry out any greenhouse gas sequestration operation on any land that is owned, vested in or managed or controlled by a water authority without the written consent of the water authority."
Australia - Queensland	Owned by the Crown	*Greenhouse Gas Storage Act 2009* S 220 "An authorised activity for the GHG authority can not be carried out on the land if— (a) carrying it out adversely affects the carrying out of an authorised activity for the exploration authority (non-GHG); and (b) the authorised activity for the exploration authority (non-GHG) has already started."	*Greenhouse Gas Storage Act 2009* S 220 "An authorised activity for the GHG authority can not be carried out on the land if— (a) carrying it out adversely affects the carrying out of an authorised activity for the exploration authority (non-GHG); and (b) the authorised activity for the exploration authority (non-GHG) has already started."	*Greenhouse Gas Storage Act 2009* S 142: Site plan for a GHG stream storage site must be developed and include subsurface modelling. S 144: In preparing the proposed plan, the proposed GHG lease holder must have regard to potential groundwater issues.
Australia – Western Australia	Owned by the Crown	Not addressed in present regulations. It has adopted project-specific legislation to address the states largest CCS project, the Gorgon Gas Project, through the Barrow Island Act 2003	Not addressed in present regulations but likely would involve amending the State's existing petroleum legislation.	Not addressed in present regulations.

Country - Jurisdiction	Porous Space Rights Ownership	Interaction with mineral rights	Interaction with hydrocarbon rights	Interaction with groundwater rights
Australia – New South Wales	Owned by the Crown Small number of estates are registered under 'Old System' granting ownership rights to some forms of minerals	Interaction with competing subsurface interests has not yet been stipulated	Interaction with competing subsurface interests has not yet been stipulated	Interaction with competing subsurface interests has not yet been stipulated
US – Federal (proposed only)	Private – originally with the owner of the surface. Pending legislation: **S. 1856** 'To amend the Energy Policy Act of 2005 to clarify policies regarding ownership of pore space'	IOGCC Model Storage Statute and Regulations (proposed only) CCS Reg project proposes geologic storage can only be issued if storage will not endanger or injure any oil, gas, or other mineral formation (mineral rights primacy)	IOGCC Model Storage Statute and Regulations (proposed only)	Carbon storage is only allowed if there is no risk to present or potential drinking water sources. Groundwater licensee has no rights over the storage capacity. Related legislation: IOGCC Model Storage Statute and Regulations (proposed only) Federal Safe Drinking Water Act, EPA UIC Program
US - California	Owned by the surface estate owner Addressed provisionally by '*Geologic Carbon Sequestration Strategies for California*', September 2007.	Ownership conflicts relating to mineral estate interests addressed by '*Geologic Carbon Sequestration Strategies for California*', September 2007.	Ownership conflicts relating to hydrocarbon rights addressed by '*Geologic Carbon Sequestration Strategies for California*', September 2007.	Ownership conflicts relating to groundwater use interests addressed by '*Geologic Carbon Sequestration Strategies for California*', September 2007.
US - Texas	Subsurface rights generally owned by the surface estate owner.	*Senate Bill (SB) 1387, 2009* Permit for geologic storage can only be issued if storage will not endanger or injure any mineral formation.	*Senate Bill (SB) 1387, 2009* No Permit for geologic storage can only be issued if storage will not endanger or injure any oil or gas formation.	*Senate Bill (SB) 1387, 2009* Permit for geologic storage can only be issued if storage will not endanger or injure any ground and surface fresh water.

Country - Jurisdiction	Porous Space Rights Ownership	Interaction with mineral rights	Interaction with hydrocarbon rights	Interaction with groundwater rights
US - Louisiana	Ownership addressed by *Louisiana Geologic Sequestration of Carbon Dioxide Act*: "Subsurface rights generally owned by the surface estate owner, but the property may be expropriated for the purpose of carbon storage". *HB 1117* "Declared in Public Interest: Eminent Domain for CCS".	*Louisiana Geologic Sequestration of Carbon Dioxide Act*. "The right of eminent domain set out in this Section shall not prejudice the rights of the owners of the lands, minerals, or other rights or interests therein as to all other uses not acquired for the storage facility".	*Louisiana Geologic Sequestration of Carbon Dioxide Act.* "The commissioner shall have authority to prevent the intrusion of carbon dioxide into oil, gas, salt formation, or other commercial mineral strata".	*Louisiana Geologic Sequestration of Carbon Dioxide Act*. "The commissioner shall have authority to…prevent the pollution of fresh water supplies by oil, gas, salt water, or carbon dioxide".
US – Kentucky	Presumed to be surface owner, however, no CCS-specific legislation to clarify.	Not addressed in present regulations.	Not addressed in present regulations.	Not addressed in present regulations.
US – New York	Presumed to be surface owner, however, no CCS-specific legislation to clarify.	Not addressed in present regulations.	Not addressed in present regulations.	Not addressed in present regulations.
US - Wyoming	*HB 89* Surface owner, but may be severed. *HB 80* 80% of pore space owners must agree for the commencement of operation.	*W.S 34-1-152* Mineral Rights have primacy.	*W.S 34-1-152* Mineral Rights (including hydrocarbons) have primacy.	*W.S 34-1-152* Same as federal.

Country - Jurisdiction	Porous Space Rights Ownership	Interaction with mineral rights	Interaction with hydrocarbon rights	Interaction with groundwater rights
US - West Virginia	*HB 2860* Authorizes DEP to regulate geologic sequestration. A working group on geologic sequestration is established to report to the legislature by July 1, 2011, and to clarify pore space ownership. *HB 2860* "Declared in Public Interest: Eminent Domain for CCS".	Mineral Rights have primacy.	Not addressed in present regulations.	Not addressed in present regulations.
US – North Dakota	*SB 2095* Surface owner and may not be severed. Unitization: If owners of 60% of pore space in proposed storage reservoir consent, then Industrial Commission may require that pore space of non-consenting owners be included in storage facility. HB 2095 "Declared in Public Interest: Eminent Domain for CCS".	Mineral Rights have primacy.	Not addressed in present regulations.	Not addressed in present regulations.

Country - Jurisdiction	**Porous Space Rights Ownership**	**Interaction with mineral rights**	**Interaction with hydrocarbon rights**	**Interaction with groundwater rights**
US - Oklahoma	Presumed to be surface owner, however, no CCS-specific legislation to clarify. SB 1765 "Declared in Public Interest: Eminent Domain for CCS".	Mineral Rights have primacy.	Not addressed in present regulations.	Not addressed in present regulations.
US - Montana	*SB 498* Surface owner. Unitization: Unit operation of a geologic storage reservoir possible upon application of persons owning storage rights to 60% of the storage capacity of the proposed storage area.	*SB 498* Mineral Rights have primacy.	*SB 498* Bill does not impede or impair EOR operations, including the right to sell emission reduction credits associated with EOR.	*SB 498* Prior to a transfer of the title, operator must demonstrate that reservoir will maintain structural integrity and will not allow CO_2 to move out of the injection formation into another stratum or pollute drinking water supplies.
US - Illinois	Presumed to be surface owner, however, apart from legislation specific to FutureGen, no CCS-specific legislation to clarify.	Not addressed in present regulations. See comments on CCS Legislative Commission in *Section 6.4.5* below.	Not addressed in present regulations. See comments on CCS Legislative Commission in *Section 6.4.5* below.	Not addressed in present regulations. See comments on CCS Legislative Commission in *Section 6.4.5* below.
US - Colorado	Presumed to be surface owner, however, no CCS-specific legislation to clarify.	Not yet regulated.	Not yet regulated.	Not yet regulated.

Country - Jurisdiction	Porous Space Rights Ownership	Interaction with mineral rights	Interaction with hydrocarbon rights	Interaction with groundwater rights
US – New Mexico	Presumed to be surface owner, however, no CCS-specific legislation to clarify. During the 2009 legislative session, a comprehensive bill to regulate CO_2 storage, *HB 208*, did not pass due to no action taken by the House prior to adjournment.	The 2009 Bill addresses mineral rights and states that minerals likely belongs not to the mineral interest but to the surface owner, who would have the sole power to grant storage rights for the purpose of sequestering carbon dioxide.	The 2009 Bill addresses oil and gas rights and states that New Mexico retains a preference for the majority view that the mineral estate includes only the oil and gas native to the formation, and not rights to the formation or the pore space itself, unless the conveyance or severance of the mineral estate explicitly states otherwise.	The 2009 Bill addresses groundwater rights and states that one possible liability scheme could include some or all of the following: - Statutorily imposed strict liability for extraordinary occurrences, e.g. for contamination of protected groundwater sources.

5.3 *EUROPEAN UNION*

In the EU, ownership of deep subsurface pore space is generally vested in individual Member States and not in private individuals. Therefore, for onshore CCS projects deployed in EU Member States to date, pore space rights issues have been addressed by specific contracts between national governments and CCS operators at the start of the development of each project for the injection and post-injection phases.

Nonetheless, there is still a need to deal with agreements between storage operators and mineral interest owners, where the latter may own the geologic formation or at least retain a property right to extract minerals from the subsurface. An example of this is the RECOPOL (59) project in Poland where access and property rights have been granted to the project proponent by the Polish Government under the Polish Mining Law as a coal bed methane (CBM) concession.

5.3.1 *United Kingdom*

In the UK, The Crown is held to be the ultimate owner of all real property and therefore ownership of the subsurface is also ultimately vested in the Crown. This system effectively bars private ownership interests in deep subsurface - and approval for storing CO_2 (with a view to avoiding conflict with oil, gas and mineral interests) therefore falls under the control by the state.

In the UK's Government 'Response to the Consultation on the Proposed Offshore Carbon Dioxide Storage Licensing Regime' (August, 2010), it is noted that several respondents had requested clarification on the processes which the Crown Estate will conduct to evaluate competing interests in a given storage site. The Response indicates that the Crown Estate is 'developing guidance on this aspect of their leasing role and will publish that guidance in due course'.

The Response also clarifies that it would not be possible to give a Crown Estate lease to a third party in relation to storage activities in a formation still in use for petroleum production (irrespective of whether the storage activities are to be combined with EOR) (60).

(59) RECOPOL is an acronym for 'Reduction of CO2 emission by means of CO2 storage in coal seams in the Silesian Coal Basin of Poland'. The RECOPOL project is an EU co-funded combined research and demonstration project to investigate the possibility of permanen

(60) Government Response to the Consultation on the Proposed Offshore Carbon Dioxide Storage Licensing Regime (DECC, August, 2010)

5.4 UNITED STATES

5.4.1 Pore space rights

Under the US legal regime, CCS storage operators probably will need to acquire the rights to the pore space into which the CO_2 will be injected. Generally, in the US, property ownership issues associated with CO_2 injection and storage are matters of individual state law.

The ownership of storage spaces in the US for the purposes of CCS can be generally divided into either:

- ownership of pore space in geological formations where there are other defined assets such as minerals, oil and gas; or
- ownership of deep pore space where there are no other defined subsurface assets

The key subsurface ownership questions that require clarification in the US relate to:

1. Competing interests for pore space ownership in geological formations where there are other defined assets; and
2. Ownership of deep pore space where there are no other defined resource assets, (residual ownership).

These are discussed further below.

Pore space ownership where there are other defined assets

Because surface estate ownership in the US generally also entails ownership of subsurface strata, if a third party seeks mineral rights they will usually require a mineral severance grant from the government to obtain rights to the mineral estate. In the case of CCS, the question of who owns the pore space in a mineral estate (the mineral estate owner, or the surface owner) has been subject to debate. The most widely accepted interpretation of case law precedent across various states is that the mineral estate owner does not own the pore space, and the rights to use the pore space are generally reserved for mining extraction activities only. The exception would be where a surface estate owner sells the surface estate but reserves the subsurface mineral rights (61).

Where mineral severance has occurred, however, common law generally regards the mineral estate as the "dominant estate" and the surface estate as the "servient estate" in order to allow the mineral estate owner rights to access the surface for reasonable activities necessary to develop the mining estate (62).

(61) Duncan I., Anderson S., and Nicot, J.P., 'Pore space ownership issues for CO2 sequestration in the US' Energy Procedia, Volume 1, Issue 1, February 2009, Pages 4427-4431.
(62) The dominant estate being, in legal terms, the estate to which a servitude or easement is due.

In accordance with common law, a number of states have introduced CCS regulation which clarifies the dominance of the mineral estate (see *Table 5.1)*.

Pore space ownership where there are no other defined assets

Surface estate ownership rights to deep subsurface pore space (or 'residual ownership') where CO_2 would be stored have been eroded to some extent in the US by hazardous waste case law precedent from various states. Such case law, whilst not revoking the rights of a surface owner to deep subsurface pore space, has made it incumbent on surface owners to demonstrate that subsurface invasion has interfered with a reasonable and foreseeable use of their deep subsurface pore space in order to prevail in a trespass claim.

This common law precedent may have the effect of limiting the risk of trespass-related actions against a CO_2 storage proponent in the event of lateral subsurface invasion of CO_2. In addition, a number of states have also introduced CCS-specific legislation which declares undertaking geological sequestration of CO_2 to be in the public interest. Such statutory clarification infers that the pore space will be subject to 'eminent domain', separated from the surface estate, and vested in the state [(63)]. This would also further reduce the trespass liability risk by enabling storage operators to circumvent private ownership interests.

Nonetheless, a comprehensive state by state analysis of liability risk for lateral subsurface trespass is still required. To date there has been more emphasis on resolving the issue of ownership between surface and mineral estate owners in pore space where there are other defined assets, as described above.

Groundwater ownership arrangements in such reservoirs and how they might complicate CCS operations represents another complex legal issue requiring further clarification on a state-by-state basis.

5.4.2 *Statutory remedies*

As shown in *Table 5.1* several states in the US are developing CCS-specific statutes to clarify subsurface ownership issues and facilitate the implementation of CCS operations.

The Interstate Oil and Gas Compact Commission (IOGCC) developed the IOGCC Task Force in 2002 with a mandate to investigate and help address legal and regulatory issues related to CCS. Phase II of its mandate included the development in 2007 of a model "cradle to grave" legal and regulatory framework for CCS following a detailed investigation of CCS-related legal and regulatory issues.

In January 2008, the IOGCC released the document 'CO_2 Storage: A Legal and Regulatory Guide for States' which outlines model Statutes and Regulations

(63) Outside of the US eminent domain is often referred to as 'compulsory acquisition'.

for geological storage of CO_2. The report was developed by the IOGCC Geological CO_2 Sequestration Task Force and funded by the US DOE and its National Energy Technology Laboratory (NETL).

A key conclusion of the report was that it would be most logical that individual states be charged with the regulation of CCS given their experience and expertise in the regulation of oil and natural gas production and storage. The most important component of the report was to develop a model statute and accompanying model rules and regulations for the storage of CO_2. This model, referred to by the IOGCC Task Force as the 'Model Statute for the Geological Storage of Carbon Dioxide' has therefore provided a basis to guide the development of CCS-related rules, regulations and statutes in individual states, and also to standardise the regulatory approach between states.

Several states in the US have used the IOGCC model statute to help develop their state legal and regulatory frameworks for CCS. For example, the development of North Dakota's CCS legal framework was first informed by a working group comprising a number of key legal, regulatory and industry bodies (64) which used the IOGCC model as an important guidance document before introducing a CCS-related bill into the 2009 legislative session. However, the experience of other states, such as Washington, has been that existing laws (in this case water quality laws) have required that the state address some aspects differently to the way promoted in the IOGCC model rules.

Despite this, the IOGCC model has generally been accepted as a useful guide for states in developing standardized frameworks. With reference to the IOGCC's models, and other guidance, the following states are currently developing or have adopted CCS-specific legislation:

- California
- Illinois
- Indiana
- Kansas
- Louisiana
- Michigan
- Montana
- New Mexico
- New York
- North Dakota
- Ohio
- Oklahoma
- Texas
- Utah
- Virginia
- West Virginia.

(64) Lignite and oil and gas industries, PCORP, the North Dakota Industrial Commission, and the Attorney General's Office.

5.5 *CANADA*

In Canada, case law precedent from various provinces does not provide a clear indication of whether ownership of the surface estate also entails exclusive ownership of subsurface pore space (65). However, in general, mineral rights are reserved for the Crown, as they are recognised as strategic commodities which should be owned by the state.

At present, there is no specific property rights legislation in relation to CO_2 storage, either at the provincial or federal level. There are therefore a number of outstanding issues to be resolved including:

- acquisition of sub-surface storage rights
- interactions with pore space ownership
- transfer of the right-to-store; and
- surface access

In order to resolve these issues it is likely that existing legislation governing oil, gas and water activities will be extended to cover CO_2 storage property rights and the associated regulatory responsibility will remain within the existing oil and gas regulatory agencies, due to their experience in dealing with similar subsurface activities (i.e. natural and acid gas storage).

The following Provinces are currently developing or have adopted CO_2 legislation:

- Alberta
- British Colombia
- Nova Scotia; and
- Saskatchewan

5.5.1 *Alberta*

In Alberta most of the subsurface is owned by the state. The mineral rights owner is either the Alberta Crown (Alberta Energy) or Freehold (private ownership). Clarity on pore space ownership has been identified by the Canada/Alberta ecoENERGY Carbon Capture and Storage Task Force as an important step to help deployment of early CCS projects.

Current legislation governing ownership of storage rights relate mainly to oil and gas production and related activities and it remains unclear as to whether these rights extend to permanent disposal of CO2. Consequently, the Alberta Carbon Capture and Storage Development Council have recommended that legislation be enacted to provide clarity with respect to disposal rights (66).

(65) Edwards v. Sims' is the only case law precedent which deals with the exclusivity of a land owner to deep subsurface strata. The case was a split decision and dealt more with equity rather than with surface rights.
(66) Accelerating Carbon Capture and Storage Implementation in Alberta', Alberta Carbon Capture and Storage Development Council, Final Report, March 2009

5.5.2 *Ontario*

In Ontario no specific legislation has or is being developed to facilitate CCS deployment. This is mainly due to the fact that Ontario has limited CO_2 storage prospects given the unsuitability or unavailability of storage sites across the Canadian Shield (which covers most of Ontario and Quebec). In addition, the focus of Ontario's climate change policy is on renewable energy rather than CCS. Property and pore space rights issues have therefore not been addressed, given that short-term development of CCS projects is unlikely.

5.6 *AUSTRALIA*

5.6.1 *Overview*

Under the Australian constitution, all mineral (or sub-surface) ownership rights are expressly vested in the Crown (i.e. the state). Whilst there is very little statutory or case law regarding the ownership of deep subsurface pore space where extractive resources are *not* involved, it is generally accepted that the ownership of the deep-subsurface and associated property rights is also vested in the Crown.

Because of the lack of case law precedent regarding ownership of deep subsurface pore space, various state CCS acts have sought to clarify the matter by express reference to the issue in statute. An example of this is the Queensland 'Greenhouse Gas Storage Act 2009', governing onshore sequestration. This Act deems the pore space to be the property of the State on all land, whether freehold or not. The Act also stipulates that all grants of rights relating to land, whenever made, are taken to reserve to the State ownership of reservoirs.

After the exploration permit has been granted (see *Section 3.6*), granting of the injection and storage lease to the CCS operator confers exclusive rights to store a CO_2 stream in the reservoir. According to the Act, on surrender of the lease, all property is owned by the State (67).

Whilst CCS projects in Australia will still be subject to Australian common law liabilities (68), access and property rights for CCS projects will likely not be complicated by private ownership interests. Access and property rights will be regulated by specific project contracts between the storage proponent and the government at the start of each project for CO_2 injection.

Regarding the possible migration of CO_2 across jurisdictional boundaries, in States like Victoria which have a comprehensive framework for onshore and offshore greenhouse gas storage, a storage operator may be required to

(67) Part 4. 'Greenhouse Gas Storage Act 2009', Government of Queensland, Reprinted as in force on 23 February 2009.
(68) Negligence, nuisance, trespass and breach of statutory duty.

acquire tenure for CO_2 storage under more than one scheme. Specifically, depending on the spatial dispersion characteristics of the injected CO_2, tenure might be required for all three schemes in a worst case scenario (Federal offshore, State offshore, and State onshore). Liability for accidental leakage will be a particularly interesting question in these situations because post-injection liability currently differs between the State-level and Federal schemes. This issue is further discussed in *Section 6.6.*

A discussion of the pore space rights situation at the State level follows.

5.6.2 Victoria

Victoria has made considerable progress in developing a CCS legislative framework. In terms of pore space ownership, the Greenhouse Gas Geological Sequestration Act 2008 expressly clarifies that subsurface ownership of underground formations is vested in the Crown (see *Box 5.1*) [(69)]. Similarly, for offshore storage, the Victoria Offshore Petroleum and Greenhouse Gas Storage Act 2010 clarifies that the Crown owns all underground storage formations within Victorian waters [(70)].

Box 5.1 Victoria Greenhouse Gas Geological Sequestration Act 2008

PART 2—OWNERSHIP AND CONTROL OF GREENHOUSE GAS SUBSTANCES AND UNDERGROUND GEOLOGICAL STORAGE FORMATIONS

14. Underground geological storage formation is the property of the Crown

(1) The Crown owns all underground geological storage formations below the surface of any land in Victoria.
(2) Subsection (1) does not apply in relation to any land (other than Crown land) to the extent that the underground geological storage formation is within 15·24 metres of the surface of the land.
(3) Subsection (1) applies despite any prior alienation of Crown land.
(4) The Crown is not liable to pay any compensation in respect of a loss caused by the operation of this section.

15. The Crown retains Crown land rights

In conferring any grant, lease, licence or other tenure of any Crown land after the commencement of this section on any person, the Crown retains all rights that it has in relation to any underground geological storage formation below the surface of that land, unless otherwise stated in the document by which the grant, lease, licence or other tenure is conferred.

Source: Greenhouse Gas Geological Sequestration Act, Parliament of Victoria, Act No. 61 of 2008.

(69) The Greenhouse Gas Geological Sequestration Act 2008 (Vic) (GGGS Act), Section 14.
(70) Offshore Petroleum and Greenhouse Storage Act 2010, Part 1.5

In a further effort towards completing its regulatory regime for CCS, the Victorian Government released an exposure draft of the Greenhouse Gas Geological Sequestration Regulations in 2009. Overall, the regulatory framework establishes a "level playing field" for pre-existing interests (petroleum or CO_2 storage) by providing priority to the first (in terms of time) user. Both Acts provide protection for pre-existing petroleum interests (71) by giving to titleholders the "right of veto" over activities such as CO_2 storage that could interfere with the existing licensed activity.

However, the Act allows flexibility for parties representing competing interests to be able to enter into commercial agreements to resolve conflicting issues if they so wish.

5.6.3 Queensland

In Queensland, the Greenhouse Gas Storage Act 2009, deems that pore space ("GHG storage reservoirs") is the property of the State, on all land, whether freehold or not, and irrespective of any geological sequestration tenement being granted. Regulations detailing interactions with competing subsurface interests (e.g. mining, petroleum) has not yet been stipulated in existing legislation.

5.6.4 Western Australia

Although there is currently no comprehensive CCS legislation in place in Western Australia, the State Government has made clear its commitment to CCS development. In the absence of a comprehensive framework, Western Australia has adopted project-specific legislation to address the state's largest CCS project, the Gorgon Gas Project, through the Barrow Island Act 2003. All government approvals have been granted and project construction is ongoing, with first storage expected in 2012.

At this stage, it appears most likely that a legislative approach would involve amending the State's existing petroleum legislation. This approach would be similar to South Australia's, but would contrast with the approach taken in Victoria and Queensland where stand-alone legislation has been enacted.

5.6.5 New South Wales

In New South Wales subsurface ownership is generally vested in the Crown, although there are a small number of estates under 'Old System' title, whereby surface owners are granted ownership rights to some forms of minerals. Little progress has been made in New South Wales to develop a legal framework for CCS, and to date no legislation has been developed which expressly clarifies pore space ownership arrangements for CCS operations.

(71) i.e. in existence prior to the passage of the relevant GHG legislation

6 LIABILITY ISSUES

6.1 INTRODUCTION

CCS projects can potentially expose project developers and other stakeholders to significant risks and liabilities across the entire project chain. There are two key types of liabilities associated with CCS projects, depending on the phase of the project:

- Liabilities associated with capture, transport and injection activities during the **operational phase** of the project; and
- Liabilities associated with the storage site during the **post-closure period** (elements of which are referred to as 'long-term liability' – see below).

The type of liabilities that an operator might face can also be broadly categorised by the nature of the damage that can result from CCS activities. These are summarised in *Table 6.1*.

Table 6.1 CO_2 Storage liabilities by type of damage

Damage to	Description
Environment	Potential damages from CCS activities to the environment arise mainly in relation water resources. When CO_2 mixes with water it forms carbonic acid and over time, acidification could mobilise organic or inorganic compounds such as minerals, naturally occurring metals or contaminants that could further damage groundwater resources. Releases of CO_2 to the atmosphere and oceans can have a range of effects on exposed ecosystems and the presence of impurities in the CO_2 stream could further exacerbate the above impacts.
Human health	Improperly operated injection activities or ineffective long-term storage have the potential to impact human health as at high concentrations and with prolonged exposure, CO_2 can be an asphyxiant.
Property and third party assets	This category relates to general liabilities an operator may face in relation to potential damages to property and third party assets.
Global environment	This type of damage relates to migration of the CO_2 stream to the atmosphere, and resulting liability for carbon credit or other loss associated with climate change regulations.

Liabilities during the operational phase and the post-closure period associated with decommissioning, injection and post-closure monitoring, are well understood and can mainly be covered by contract and traditional risk transfer. Furthermore, analogous activities such as EOR demonstrate that operational environment, health and safety risks can also be managed successfully.

However, **long-term liabilities** associated with geological leakage of stored CO_2 and major loss of containment are less well understood and pose difficult management issues, due to the lengthy timeframes that extend beyond the life of the project's assets or even the operator itself.

This section provides a review of the operational, post-closure and long-term liability frameworks as they exist or are being developed within the studied jurisdictions, with a particular focus on the latter.

There first follows a brief discussion of long term liability and financial responsibility.

Long Term Liability

There are several issues associated with long-term liability that are still to be resolved in a number of the jurisdictions reviewed as part of this study. These include, for example:

- What does the liability include?
- Who is liable, and for how long?
- Is the liability transferred at some point to the State or another entity?
- Is the liability transferred partially or wholly?
- What conditions should be met for the liability transfer to take place?
- Are there any financial requirements for covering costs associated with the liability during the time it remains with the storage site operator?

Table 6.2 provides a summary of the extent to which these issues have, or are being, addressed in the US, Canada, EU and Australia. The table provides information in relation to the definition, timing and conditions of long-term liability transfer to the state as well as any associated financial security requirements. These are discussed in further detail for each jurisdiction later in this section.

Table 6.2 Overview of long-term liability frameworks

Jurisdiction	Liability type(s)	Transfer	Timing	Conditions of Transfer	Financial Security	Regulation/Agency
European Union	Environmental liabilities (land, water, protected species and natural habitats) for costs associated with preventative and remedial actions.	Does not provide option for transfer of responsibility	N/A	Does not provide option for transfer of responsibility. Exceptions from liability only include: Act of war (including terrorism) and Act of God.	The Directive does not oblige operators to put in place financial security provisions, such as insurance, to cover their potential insolvency. However, Member States are required to encourage operators to make use of such mechanisms and must promote the development of such services.	Environmental Liability Directive (72) (ELD) transposed in the UK as "The Environmental Damage (Prevention and Remediation) Regulations, 2009".
	Liabilities associated with health and property damage.	Subject to Member State law which may (or may not) address the issue.	Subject to Member State law. In the UK, DECC is planning further regulation specifying the arrangements for transfer of responsibility to the State.	Subject to Member State law. In the UK, DECC is planning further regulation specifying the arrangements for transfer of responsibility to the State.	Subject to Member State law. In the UK, DECC is planning further regulation specifying the arrangements for transfer of responsibility to the State.	Subject to Member State law. In the UK, health and safety aspects regulated by the Health and Safety Executive (HSE). Environmental aspects are largely regulated by the Environment Agency (EA).
	Long-term monitoring and all other liability relating to CO_2 storage (incl. liability under EU-ETS)	Transferred to the Member State.	Transfer of liability: Minimum 20 years after closure.	Evidence that CO_2 is safely contained for the indefinite future.	Contributions and financial security provisions (Trust funds, bonds, guarantees or similar) required to cover all possible liability (incl. EU-ETS allowances for potential leakage). Financial contribution should cover the anticipated cost of monitoring for a period of at least 30 years.	EU CCS Directive & Member State Competent Authorities (for UK – Department of Energy and Climate Change).

(72) Directive 2004/35/CE 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

Jurisdiction	Liability type(s)	Transfer	Timing	Conditions of Transfer	Financial Security	Regulation/Agency
USA	Long-term monitoring and liabilities associated with Underground Source of Drinking Water (USDW) – regulated at federal level	Requirements allow for the transfer of appropriate monitoring, well plugging and other actions needed following cessation of injection. However under current provisions responsibility for potential impacts to USDWs ultimately remains with the owner or operator of the site indefinitely.	EPA is tentatively proposing a post-injection site care (monitoring) period of 50 years with the option to lengthen or shorten the 50-year period if appropriate based on site performance.	Evidence (i.e. pressure, fluid movement, mineralization, and/or dissolution reactions) that movement of the plume and pressure front have ceased and the injected CO_2 does not pose a risk to USDWs.	Requires financial responsibility in relation to endangerment of USDWs from improper plugging, remediation, and management of wells after site closure. May include performance bonds, letters of credit or a corporate guarantee. Does not extend to financial responsibility for activities unrelated to protection of USDWs (e.g., coverage of risks to air, ecosystems, or public health unrelated to USDW endangerment)	Federal Requirements Under the Underground Injection Control Program for Carbon Dioxide Geological Sequestration Wells under Safe Drinking Water Act (SDWA) (73) / USEPA
	Long-term monitoring of storage site – to be regulated at state level	To be developed at state level (see *Table 6.6*)	To be developed at state level (see *Table 6.6*)	To be developed at state level (see *Table 6.6*)	To be developed at state level (see *Table 6.6*)	To be developed at state level (see *Table 6.6*)
Canada - Alberta	Long-term liability for damages arising from CO_2 storage activities	Transfer of long-term liabilities to the state	Alberta is working on resolving timing issues (likely 2011)	ERCB acceptance of liability cost estimates provided by licensee. Additional requirements outlined in Directive 001 and Directive 006	Where liabilities deemed to exceed assets, licensee must establish security deposit equal t o the difference	Directive 001 (Requirements for Site-Specific Liability Assessments in Support of the EUB's Liability Management Programs, 2005); Directive 006 (Licensee Liability Rating (LLR) Program and Licence Transfer Process, 2009). Regulated by ERCB (Energy Resources Conservation Board).

(73) Safe Drinking Water Act (SDWA), 42 U.S.C. § 300f

Jurisdiction	Liability type(s)	Transfer	Timing	Conditions of Transfer	Financial Security	Regulation/Agency
Australia – Federal (federal offshore waters)	Long term liability for damages arising from CO_2 storage activities	All liability transferred to the Commonwealth (including common law liabilities) as defined in *Offshore Petroleum and Greenhouse Gas Storage Act* upon granting of a site closure certificate (SCC)..	Minimum 15 years after closure.	Minster must be satisfied that the stored GHGs do not pose any significant risks (evidence that CO_2 is acting as predicted), & no further injection has taken place.	Long-term monitoring and verification of storage sites is at expense of storage proponent but the responsibility of the Commonwealth Government.	Offshore Petroleum and Greenhouse Gas Storage Act (2006).
Australia – Victoria	Long term liability for damages arising from CO_2 storage activities	Common law liabilities will remain with the storage proponent but statutory liability ceases upon surrender of licence. However, Victorian Government recently indicated it may consider taking on comprehensive liability (like Commonwealth Act) in certain cases, particularly for demonstration and early mover projects.	Statutory liability ceases upon surrender of licence.	Demonstration that injected GHG is likely to be contained in the storage formation. Financial security arrangements also required (see right)	*Offshore*: Insurance and royalty provisions apply. Long-term monitoring and verification of storage sites is at expense of storage proponent but the responsibility of the Victorian Government (s. 620 - s.694). *Onshore*:, Insurance, rehabilitation bond and royalties provisions apply. Long-term monitoring and verification of storage sites is at expense of storage proponent but the responsibility of the Victorian Government (s.128, s.220, s.224, s. 174, s. 112).	Offshore: *Offshore Petroleum and Greenhouse Gas Storage Act 2010* Onshore: *Victorian Greenhouse Gas Geological Sequestration Act 2008*

Financial responsibility

Regulatory frameworks for CCS need to ensure that adequate funds are in place to cover anticipated CCS project activities such as decommissioning, closure and post closure monitoring (e.g. in case of operator insolvency) as well as any damages resulting from unanticipated events (e.g. leakage/seepage). In the latter case, any leaked CO_2 will need to be reconciled against the use of carbon credits, where these apply to CCS activities.

Developing financial provision for long-term impacts has occurred in other sectors such as mining, waste management and nuclear power where risks associated with an operator's activities could conceivably occur at some point in the future and over long periods of time. In such cases, an obligation is typically placed on an operator to ensure that activity risks are covered through the use of a number of financial security instruments.

Where long-term responsibility for a storage site is transferred to the state, the regulatory framework may reduce the financial exposure of the relevant authority by requiring the operator to contribute to the costs associated with long-term stewardship of the site. The requirement of a financial contribution to post-closure stewardship, aims to prevent the state adopting the financial burden associated with long-term liability.

A number of financial security instruments can be employed to address the risks and liabilities associated with the operator's activities, whether during the operational phase, in the immediate future or spanning longer periods.

These instruments can take different forms, but can be summarised into three broad categories.

1. Third-party instruments which include specified funds, Letters of Credit (LOCs), bonds and insurance products
2. Self-insurance, namely e.g. through the application of the corporate guarantee
3. Private and/or public frameworks in the form of trust funds and compensation funds

Implementation of each type of instrument is best suited to a target array of activities in each case, and depending on the stage or category of CCS-related liability, these tools can be amalgamated to address the risks involved. No one approach can adequately address all the key risks/liabilities associated with CO_2 storage. As such, and in view of the fact that all risks/liabilities need to be addressed in order for commercial-scale CCS to be funded, a combination of means may likely be required.

Table 6.3 presents an overview of the different financial instruments and other means that could be used for addressing CCS operator financial responsibilities associated and ***Table 6.4*** presents a blank matrix that can be used for the determination of their potential suitability.

Table 6.3 Overview of Financial Instruments for addressing risks and liabilities

Instrument	Description
Cash flow	Cash flow refers to the cash stream into and out of a project or business. In the case of CCS activities, the portion of the cash flow being introduced into these practices and being put up as a means to address risks and liabilities could act as a testament of the operator's financial responsibility. Cash flow could potentially be a suitable method of dealing with monitoring costs during the injection process, but may not be the best solution to address most other risks and liabilities linked to CCS activities.
Corporate Guarantee	The corporate guarantee is a self-insurance financial instrument that is established upon the operator's financial solvency, i.e. no third party guaranteeing payment is involved in this process. The prospective advantage of such a system would stem from the fact that preventive measures and the overall act of mitigating potential environmental risk would be managed by the companies themselves. Lower costs could hence be incurred by operators when they retire their assets, additionally so, because under most corporate guarantee policies, operators are usually instructed to set funds aside for eventual closure and post-closure during the active life of the facility (74).
Letter of Credit	As a testimony of its financial responsibility, it is possible for an operator to address certain risk categories through a Letter of Credit. This is a document issued by a financial institution or other such issuers to a third party with the aim of making an eventual payment on behalf of the operator in accordance with set conditions. Remedial action and tasks such as post-injection monitoring are typical instances that could benefit from the demonstration of financial responsibility of the storage facility operator through this instrument (75).
Bond	The bonding mechanism is another such system that could act as evidence of the operator's financial responsibility. When applied to CCS, a bond equates an amount presented upfront by the issuer – central government, corporate body, public sector entity – as security, and as proof of the accountability of the operator in the event of performance failure, and this collateral is made immediately available under such circumstances. Bonds are most effective when the transaction costs involved are low and the bond value advanced is not significant when contrasted against the operator's assets. Compliance is also best ensured when the environmental effects considered are not irreversible. The bond system could thus be applied to a range of CCS-related activities, from addressing monitoring costs during injection to dealing with minor leakages post-injection. However, bonds might not be well-adapted to situations involving major leakages and monitoring costs arising after handover to the state (76).

(71) World Resources Institute, Liability and Financial Responsibility Frameworks for Carbon Capture and Sequestration (2007)
(72) US Carbon Sequestration Council, Carbon Capture and Storage: On Your Mark,! Get Set! Go? (2010)
(73) Gerard, D. & Wilson, E.J. Environmental Bonds and the Problem of Long-Term Carbon Sequestration, *Journal of Environmental Management* (2009)

Instrument	Description
Insurance	To mitigate the risk associated with CCS activities, insurance can be acquired in the form of a policy that is fundamentally a pledge from the insurer to provide assistance in compliance with the terms and regulations of the policy in exchange for the payment of a premium. The insurance mechanism revolves around the core concept of underwriting, which includes the assessment, management and transfer of risks linked with CCS activities. Generally, the insurance mechanism could be recommended for the operational stages of CCS deployment, while modified insurance products could also be directed towards closure and post-closure risks[(77)].
CCS Fund	The establishment of a dedicated CCS Fund could be a way of potentially addressing a plethora of liabilities associated with a range of CCS activities, from attending to remediation costs during injection to monitoring costs following handover to the state. Evidently, the type and level of fund created would influence the type of risk that can be covered. The initial design of the CCS Fund would therefore be vital in determining the activities that can be supported by this instrument, as the conditions stipulated and guarantees provided prior to the creation of the fund would ensure that money is dispersed only for the purposes originally assigned to the programme[(78)].
Government funding	Where CCS projects are seen to be of strategic significance to a specific country, it may be more suitable to apply financial instruments in the form of direct government loans, grants and guarantees, often through designated bodies. In certain scenarios, it may be necessary for the state to provide financial assistance during the preliminary phases of CCS activities in anticipation of the creation of an adapted CCS Fund. Governmental financial backing of risks and liabilities could therefore be the preferred option in situations involving major leakage during or post-injection, and through monitoring costs following handover to the state.

(74) Zurich Financial Services Group, The Climate Risk Challenge: The Role of Insurance in Pricing Climate-Related Risks (2009)
(75) Peña, N. & Rubin, E. S. Coal Initiative Reports, White Paper Series, A Trust Fund Approach to Accelerating Deployment of CCS: Options and Considerations (2008)

Table 6.4 Matrix for Determining Potential Suitability of Different Financial Instruments for addressing risks and liabilities [79]

Nature of liability or risk to be provided for	Cash flow	Corporate Guarantee	Letter of Credit	Bond or Cash Deposit	Insurance	CCS Fund	Government assumes liability
Monitoring costs during injection							
Remediation costs during injection							
Minor leakage during injection (purchase of carbon credits)							
Major leakage during injection (purchase of carbon credits)							
Decommissioning							
Premature decommissioning							
Monitoring costs post-injection							
Remediation costs post-injection							
Minor leakage post-injection (purchase of carbon credits)							
Major leakage post-injection (purchase of carbon credits)							
Monitoring costs post-handover to the state							

The current financial responsibility requirements for CCS storage activities in each jurisdiction are presented in further detail in the remainder of this section.

6.2 *OVERVIEW*

Within the **EU**, the CCS Directive provides the overarching regulatory framework for dealing with liabilities associated with CO_2 storage in Member States. The Directive will be transposed into individual Member State law by 2011. Under the EU Environmental Liability Directive, the operator is liable for any environmental damages associated with the CCS activities; liabilities associated with health and property damage fall within Member States regulation. In the context of the ETS, storage operators would, in the event of a CO_2 leak, have to surrender emissions allowances to match released volume.

In the **US**, the proposed Class VI UIC requirements (within the SDWA UIC Program) address key liability issues such as well operation, post-injection site care and financial responsibility. In addition, operators may be liable for any releases from a CO_2 storage site under CERCLA (Superfund), presenting a significant barrier to CCS deployment until and unless the nature and extent of such long-term liabilities is defined in law. A growing number of states have also developed laws related to liability for CCS.

In **Canada** a process of reviewing and amending existing legislation to address liability issues is underway. In **Australia**, comprehensive legislation has been put in place at the federal level to cover CCS offshore and, in a number of states to cover CCS onshore. However, long-term liability arrangements differ between Commonwealth and State schemes in Australia, suggesting a potential conflict of liability arrangements.

In addition to government efforts, the following non-regulatory organisations have developed their own proposed approaches to addressing long-term and financial liabilities associated with CCS:

- Interstate Oil & Gas Compact Commission (IOGCC)
- World Resources Institute (WRI)
- International Risk Governance Council (IRGC)
- CCS REG project

The remainder of this section presents in more detail the manner in which operational and long-term liability issues are managed, and also the current or proposed types of financial security required by regulators in Europe, the US, Canada, and Australia.

6.3 EUROPEAN UNION

6.3.1 *Operational liability*

Under the EU CCS Directive, those liabilities which a CCS storage site operator is likely to bear in the event of CO_2 leakage are categorised as follows:

1. **Liability for damage to health and/or property**. CCS operator liability for local damage to health or property is subject to the national civil and common law claims for harm to persons and property of individual Member States.

2. **Liability for damage to the local environment**. CCS operators in the EU are liable for any damages to local the environment under the Environmental Liability Directive (ELD) (80). The ELD provides detailed provisions on the remedial measures to be taken in case of events causing local environmental damage. The ELD does not provide an option for transfer of responsibility and does not oblige operators to take out a financial security, such as insurance, to cover their potential insolvency, However, Member States are required to encourage operators to make use of such mechanisms and must promote the development of such services.

3. **Liability for damage to the global environment**. Associated with CO_2 re-emitted into the atmosphere, thus reducing the efficacy of the project in mitigating climate change. CCS operators are liable for damages to the global environment. More specifically, in the event of a leak, operators would have to surrender emissions allowances under the Emission Trading Scheme Directive (81) to match the released volume.

6.3.2 *Long-Term Liability*

According to the CCS Directive, a CCS operator remains liable for monitoring the CO_2 storage site, and for any necessary response action, until the moment when the Member State competent authority determines that the injected CO_2 is safely contained for the indefinite future, at which point responsibility is transferred to the state.

Article 18 (Transfer of responsibility) of The Directive specifies that a series of conditions must be met before the transfer can be concluded:

1. All available evidence indicates that the stored CO_2 will be completely and permanently contained;
2. A minimum period, to be determined by the competent authority has elapsed, that minimum being no shorter than 20 years, unless the

(80) Directive 2004/35/ECCE 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
(81) Directive 2003/87/EC

competent authority is convinced that the condition specified above has been met before the end of this period;

3. Financial obligations, concerning a mandatory contribution towards post-transfer costs, have been fulfilled; and
4. The site has been sealed and the injection facilities have been removed.

It should be noted that the operator still remains liable in cases where there has been fault, including cases of deficient data, concealment of relevant information, negligence, wilful deceit or failure to exercise due diligence even after the transfer of responsibility.

The CCS Directive also allows EU Member State authorities to recover any associated costs incurred from the former operator (Article 17).

6.3.3 Financial Responsibility

Two types of financial responsibility requirement are stipulated in the CCS Directive:

1. Article 19 requires that a ***financial security provision*** should be in place before commencement of CO_2 injection, in the form of a financial security product sufficient to cover all obligations arising under the storage permit, including closure and post-closure requirements, as well as any obligations for corrective measures in case of leakages or significant irregularities. Possible forms of security include trust funds, surety bonds, bank guarantees, insurance, deposits, or some combination thereof.

2. Article 20 requires that a ***financial contribution*** should also be made available by the operator to the Member State competent authority, before the transfer of responsibility takes place. This financial contribution should cover the anticipated cost of monitoring for a period of at least 30 years. To help ensure a harmonised approach to interpretation of the CCS Directive, the actual level of the financial contribution will be determined on the basis of guidelines to be adopted by the Commission by the end of 2010.

   An issue that arises from the 'financial security provision' requirement is the large theoretical liability that an operator might be exposed to in the event of a major CO_2 release into the atmosphere. Furthermore, there is considerable uncertainty about the future price of EU Allowances (EUA) within the EU ETS at the time of (future) potential leakages, indicating that an operator's exposure could in theory be unlimited - as there is no existing or planned cap on the price of EUAs.

The relevant EC draft guidance document relating to financial responsibility (82) states that the Member State competent authority can use any of the following three scenarios to determine the appropriate level of financial security required:

1. The most expensive scenario
2. An average value across scenarios
3. The least expensive scenario

It is therefore the decision of Member States as to which scenario to use in determining the amount of financial security required, and approaches may vary between Member States.

Although a release under the worst case scenario (i.e. the one associated with the maximum amount that can be released from a formation) will, in most cases, be much less than 100% of the total CO_2 amount stored, it can be expected that the cost of holding a financial security to cover the most expensive liability scenario is likely to impose a prohibitive economic burden on the operator. For example, a medium-sized 500-MW coal-fired power plant that emits approximately 3 million tonnes of CO_2 per year, even at current low EUA prices, could generate a theoretical multibillion euro liability in a worst case scenario over its operational lifetime.

Options identified in the guidance for resolving this situation (i.e. prohibitive financial exposure) may include:

- Introducing a "force majeure" clause for major CO_2 release events (i.e. very low probability/high impact) to be excluded from the financial security obligations
- Removing or capping liabilities under the EU ETS (i.e. the need to surrender allowances)
- Predefining a level of financial security that is related to the expected value of a store-specific risk scenario, proposed by the operator

UK Response to Consultation

The UK Government's Response to the Consultation on the Proposed Offshore Carbon Dioxide Storage Licensing Regime (August, 2010) acknowledges that long-term liabilities, in respect to financial requirements under both the EU ETS and CCS Directives pose a significant barrier to CCS deployment. The Response indicates that, in light of discussions ongoing at an EU level, DECC will 'publish additional guidance on financial security requirements' in the autumn of 2010 and 'welcomes further views' from stakeholders.

(82) Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 4 on Article 19 'Financial Security' and Article 20 'Financial Contribution', 18 June 2010

In respect of long-term liability and transfer to the State, the Response indicates that 'DECC plans to lay down further regulations under section 31 of the Energy Act 2008 specifying the arrangements for the termination of the Licence and the transfer of responsibility to the State. DECC will be issuing guidance on the criteria to be met before such a transfer can take place' (83).

6.4 UNITED STATES

Long-term liability and stewardship issues currently remain unresolved in the US. However, while there is no comprehensive framework in the US which specifically addresses long-term liability for CCS activities, there are a number of Federal and state regulations with a bearing on long-term liability.

At a Federal level in the US, the EPA intends to regulate CO_2 injection and storage under the Safe Drinking Water Act (SDWA) Underground Injection Control (UIC) programme. The EPA has proposed federal requirements under SDWA for storage of CO_2 which are currently under consultation (84), and has further addressed liability issues with their discussion paper 'Approaches to Geologic Sequestration Site Stewardship after Site Closure'.

Under current provisions in the federal requirements, the liability for potential impacts to Underground Sources of Drinking Water (USDWs) remains with the owner or operator of the storage site indefinitely. The EPA has recognised this issue as problematic and has compiled information on a variety of alternative instruments not currently available under the SDWA. The EPA has not determined whether any of the models are appropriate for CO_2 storage wells, but has acknowledged that they may contain important concepts for future strategies in addressing the issue of indefinite liability.

Efforts are being made by the EPA to address the issue at a federal level, but it is not clear how these emerging federal rules will interact with different regulations already established at a state level where several states have already implemented stewardship regulations. Generally, in most states operational liability lies with the operator, while long-term liability is expected to require some level of public involvement.

There are also issues and uncertainty in relation to liability for operators that store in geological formations that lie between two or more states (e.g. Tuscaloosa formation, Illinois Basin that includes Illinois, Kentucky and Indiana, Permian Basin etc.). In such cases operators may have to to provide the permitting State (where the injection takes place) the assurance that all potential migration pathways have been investigated.

(83) Government Response to the Consultation on the Proposed Offshore Carbon Dioxide Storage Licensing Regime (DECC, August 2010)
(84) Federal Register / Vol. 73, No. 144 / Friday, July 25, 2008 / Proposed Rules

6.4.1 *Operational liability*

At a federal level, operational liability to health, property and environmental issues has not been specifically regulated under separate legislation, and is therefore subject to common law. Those states that have regulated or otherwise addressed operational liability issues through separate legislation are presented in *Table 6.5*.

Table 6.5 Operational Liability at a State Level

State	Legislation	Notes
Louisiana	HB 661	Liability remains with operator, capped at $500,000 per occurrence
Montana	SB 498	Liability remains with operator
Illinois	SB 1704	State liability (specific to FutureGen project)
North Dakota	SB 2095	Liability remains with operator
Oklahoma	SB 610	Liability remains with operator, unless otherwise provided by contract
Missouri	HB 2038	Liability remains with operator, but with limited liability in event of personal injury or death

6.4.2 *Long-term liability*

As mentioned earlier, a comprehensive legal framework that deals with long-term liability and transfer of responsibility for CO_2 storage activities does not currently exist in the US.

Provisions included in the EPA draft rule address some long-term liability issues such as general requirements for financial responsibility. However, there are no provisions to allow for transfer of liability to the government (unless where project specific legislation is enacted, as was the case with the FutureGen project; see *Table 6.5*) or to cover potential risks to atmosphere, ecosystems, or public health. This is because the EPA does not have authority under the Safe Drinking Water Act (SDWA) to regulate long-term liability or authorise transfer of responsibility from an operator to another entity. Such a framework will therefore need to be developed either at a federal level - or else left to individual states to regulate at a state level.

In order to address the issue of long-term liability, the EPA has published a paper [85] which describes potential models for site stewardship options and different approaches that could be adopted as a basis for developing a long-term liability regime. These include the possible use of financial trust funds and insurance products. An overview of the document is provided in *Annex B* to this report.

(85) Approaches to Geologic Sequestration Site Stewardship after Site Closure, USEPA, Office of Water (4604M), EPA 816-B-08-002, July 2008

The CCS Regulatory project (CCS REG), which aims to harmonise liability regulations at a federal level (86) has proposed, under its Model statute (The Carbon Capture and Sequestration Regulatory Act of 2010) the establishment of a Federal Geologic Sequestration Board that would assume long-term liability and the use of a Carbon Sequestration Trust Fund, funded by risk-based fees paid by operators on a per tonne CO_2 basis. Under the proposed arrangements, long-term liabilities would be transferred to the Board 10 years after storage operations cease, and the conditions of transfer would include demonstrating that the storage reservoir is reasonably expected to retain mechanical integrity (87).

Another option for addressing CCS long-term liability is the development of regulation at a state level. Certain US states, such as Louisiana, Illinois, Kentucky, Michigan, Virginia, Kansas, Montana, Wyoming and Texas, have already started to address long-term liability issues. More details can be found in *Table 6.6.*

6.4.3 *Financial responsibility*

In relation to financial responsibility requirements, under the draft rule the EPA proposes a general duty on storage operators to obtain financial responsibility acceptable to the permitting authority for a Class VI Well permit. The financial responsibility requirements would oblige owners and operators to demonstrate and maintain financial responsibility during operation, closure, and the post-injection site care period.

Financial assurance in the US is typically demonstrated through two broad categories of instruments:

1. Third party instruments, including surety bonds, financial guarantee bonds or performance bonds, letters of credit, and irrevocable trust funds; and
2. Self-insurance instruments, including the corporate financial test and the corporate guarantee

The EPA is considering updating mechanisms for demonstrating financial responsibility for CO_2 storage projects, and intends to provide guidance at a later date that will describe recommended types of financial mechanisms that owners or operators can use to meet this requirement.

Table 6.6 presents an overview of legislation considering long-term liability and financial responsibility obligations at a US state level.

(86) http://www.ccsreg.org/
(87) http://www.ccsreg.org/pdf/CCS_Draft_Leg_05192010.pdf

Table 6.6 Overview of treatment of CO_2 storage liability at US state level

State	Short term	Long term	State assumes	Rights and interests also transferred to the state?	Legislation	Fund established?	Financing for long-term stewardship funds: Application Fee	Annual Fee	Per ton Fee
Illinois*	State	State	All liabilities	Yes	SB 1704	N/A	N/A	N/A	N/A
Kansas	Operator	Operator	Monitoring and remediation		HB 2419 (2007)	yes	$4,500 + $100/well	$1,000/well	$0.05
Kentucky	Operator	State	All liabilities	Yes	HB 491 (pending)	yes	TBD	TBD	TBD
Michigan	Operator	State	All liabilities		SB 775 (pending)	yes	TBD	TBD	TBD
Missouri	Operator – limited **	Not addressed			HB 2038				
Montana	Operator	State	All liabilities	Yes	SB 498 (2009)	yes	TBD	TBD	TBD
North Dakota	Operator	State	All liabilities		SB 2095 (2009)	yes	$150 + actual processing costs	0	$0.07
Oklahoma	Operator	Operator	Monitoring and limited remediation	Yes	SB 610, SB 1765	yes	TBD	TBD	TBD
Texas	Operator	State	Monitoring and limited remediation.		SB 1387 (2009)	yes	$75,000	$50,000 for each year post-injection	$0.10
Virginia	Operator	Commonwealth	All liabilities		SB 247 (pending)				
Wyoming	Operator	Operator	Monitoring		HB 17 (2010)	yes	TBD	TBD	TBD

* Specific to FutureGen project

**Limitations to operators' liabilities $50,000 per occurrence: Louisiana: liability capped, Missouri: limited liability to personal injury or death

6.5 *CANADA*

In Canada, environmental damages associated with a CO2 release would be covered by existing environmental legislation, and tort law would apply to civil liabilities. Groundwater protection falls under the authority of the environment protection agencies and it is expected that the provincial agencies will address this issue as part of the environmental impact assessment (EIA) process on a project-by-project basis.

However, the long-term liability of CO2 storage has not been addressed in Canada at a Federal level, including a clear assignment of transfer of responsibility to the state, and any related financial security arrangements. It is expected that this will be regulated at a Province level; although at present only Alberta has taken steps to address long-term liability.

Other provinces will therefore need to follow in the development of appropriate long-term liability frameworks so as not to hinder CCS deployment.

6.5.1 *Alberta*

There are two types of liability recognised within the legal framework in place for CCS activities in Alberta: legal liability and remedial liability ( ).

In Alberta, liabilities associated with the operational phase of a project, will be the responsibility of the permit holder and be governed primarily through existing oil and gas regulations by the Energy Resources Conservation Board (ERCB), and Alberta Environment. However, this liability regime will not be applied to the long-term liability associated with CCS activities.

Under existing arrangements, the licence required for CO_2 storage contains the need to complete a site-specific liability assessment. If the assessment meets all the requirements detailed in the ERCB Directive 001(Requirements for Site-Specific Liability Assessments in Support of the EUB's Liability Management Programs, 2005) [(88)] and all forms are provided to the ERCB for review and acceptance of the site-specific liability cost estimate, the licence holder may then apply for the transfer of the liabilities. When liabilities are deemed to exceed assets, the licensee is required to establish a security deposit equal to the difference.

In November 2011, Alberta introduced new legislation that will enable the province to accept the long term liability associated with sequestration. At the end of the life of a project, if an operator can satisfy the Crown that predetermined performance criteria have been met, they can apply for a closure certificate and formally liability transfer can take place.

(88) http://www.ercb.ca/docs/documents/directives/directive001.pdf

Alberta is also proposing to establish a new fund, the Post-closure Stewardship Fund, which would require a CCS operator pay a levy per tonne of CO2 injected over the life of the project. These funds would then be available to Alberta to cover the ongoing monitoring or any necessary remedial costs once the Province issues a closure certificate.

In 2011, Alberta will undertake a CCS regulatory review which will help to identify and resolve any remaining gaps associated with their overall regulatory framework for CCS. Identifying the appropriate performance standards necessary for site closure and building the regulatory process to obtain a closure certificate are two areas of focus that will be examined in detail. The results from this review are expected at the end of 2011.

6.6 *AUSTRALIA*

6.6.1 *Operational liability*

Although a number of CO_2 storage schemes have developed across Australia's state jurisdictions, all present a consistent approach in relation to treatment of liability during the operational period.

Consistent with current practice for industrial facilities and contaminated sites in Australia, CO_2 storage operators are deemed liable for all aspects of a CCS project during the life of the project until a closure certificate has been issued following the operational period. This includes common law and statutory liability throughout the operational period for adverse impacts constituting offences from CO_2 leakage or migration upon:

- the public (human health)
- surface owners (property)
- the environment; and
- competing interests

Liabilities cover all aspects of the CCS project operation, including capture, transport, injection and storage, monitoring, verification and decommissioning.

6.6.2 *Long-term liability*

The '*Carbon Dioxide Capture and Geological Storage – Australian Regulatory Guiding Principles'* were published in 2005 by the Ministerial Council on Mineral and Petroleum Resources (MCMPR) with a view to facilitating a nationally consistent approach to the application of CCS projects in Australia [89]. Regarding liability, the Guiding Principles promoted the principle of "polluter pays" whereby the person who generates pollution

(89) The Guiding Principles were endorsed by the Ministerial Council on Mineral and Petroleum Resources (MCMPR) in 2005, and recently complimented by the Environment Protection and Heritage Council (EPHC)'s Environmental Guidelines for Carbon Dioxide Cap

should bear the cost of containment, avoidance or abatement, and includes legal liability or other agreements throughout the post-injection period [90].

A nationally consistent approach to long-term liability has, however, not been achieved. Most notably, there is a clear difference between long-term liability arrangements that have been stipulated in Commonwealth offshore legislation and state-level offshore and onshore legislation. This key difference can be explained largely by the fact that the Commonwealth Government, with a Senate minority, did not have support for its original policy position of not transferring long-term liability to the Crown. Subsequently, the Commonwealth legislation that was passed by the Senate did not represent the preferred policy position of the Commonwealth Government. The difference creates uncertainty for prospective storage proponents in Australia. These differences, and their implications, are discussed further below.

Commonwealth offshore

At a Federal level in Australia, long-term liability is governed by the Offshore Petroleum and Greenhouse Gas Storage Act (OPGGS). According to the Act, the first step towards relinquishing responsibility to the Commonwealth post-injection involves the GHG storage authority holder (the storage operator) to submit a Site Closure Certificate (SCC). Storage operators remain "on risk" until a SCC is issued by the Commonwealth. A SCC must be granted or declined within 5 years of an SCC application being submitted by the GHG storage authority holder. The application for a SCC must be accompanied by information including the behaviour of the stored GHG (i.e. the injected CO_2) and its expected migration pathways, and it must be established that there is no significant risk of an adverse effect.

The period between the submission of the certificate and the transfer of the liability to the Commonwealth can be no less than 15 years, during which time it must be established that the injected CO_2 is acting as was predicted, and that the stored CO_2 does not pose any significant risks. In other words, the storage operator remains "on risk" for at least 15 years following the granting of a SCC. This period is deemed to be the "Closure Assurance Period". During the Closure Assurance Period, storage proponents must demonstrate that they have met stringent closure requirements and demonstrate to the Commonwealth that there will be negligible risk associated with damage or nuisance arising from any misconduct or negligence on the part of the storage operator. Furthermore, the legislation stipulates that storage proponents should bear the Commonwealth's costs associated with post-closure monitoring and verification. After the SCC is issued, transfer of the liabilities from a storage operator to the Commonwealth, including common law liabilities, would then ensue.

The amendment to the original Act now requires the Commonwealth to assume comprehensive long-term liability of any licence-holder (i.e. the

(90) MCMPR, 'Carbon Dioxide Capture and Geological Storage Australian Regulatory Guiding Principles', 2005, p 11.

storage operator) who has ceased to exist. The current approach to long-term liability therefore does not strictly accord with the "polluter pays" principle promoted by the Guiding Principles (although it must be noted that this principle was not promoted in the Commonwealth Government's original position) [(91)].

State offshore

Treatment of long-term liability in offshore **Victoria**, as legislated under the Victorian 'Offshore Petroleum and Greenhouse Gas Storage Act 2010', differs fundamentally from liability in the Commonwealth offshore domain. The key difference is that in Victoria's offshore domain (i.e. Victorian waters), common law liability remains with the GHG authority holder, even after a GHG injection and monitoring authority has been surrendered. This clearly presents a problematic issue in terms of a storage operator understanding and managing the liability risk(s) for offshore storage activities in Victoria.

State onshore

In **Victoria**, long-term liability for onshore storage is legislated under the Victorian 'Greenhouse Gas Geological Sequestration Act 2008'. Provisions under the Act stipulate that CCS operators would be required to surrender their GHG lease upon completion of the operational period, and that monitoring responsibilities and property ownership in stored GHG would ultimately be passed to the Crown. However, common law liability would still remain with the operator indefinitely following surrender of the GHG lease [(92)]. Common law liability would include negligence, nuisance, trespass and breach of statutory duty which may adversely affect the public, surface owners, the environment and competing interests.

Onshore storage in **Queensland** is legislated under the 'Greenhouse Gas Storage Act 2009'. As in Victoria, under the Queensland scheme, GHG leases can be surrendered on completion of the operation, provided that the operator satisfies the Minister that risks associated with CO_2 storage have been minimised as far as possible. Following surrender of a GHG lease, property in the stored GHG and any ongoing monitoring requirements would be transferred to the Crown.

However, there is no explicit reference in the Act indicating that at the point of lease surrender liability would be transferred to the state. As such, it is expected that under the Queensland Act (as with Victoria), common law liability would remain with the CCS operator indefinitely following the surrender of the GHG lease. Common law liability would similarly include negligence, nuisance, trespass and breach of statutory duty which may

(91) Without a majority in the Senate, the Federal Labour Government was forced to change its original policy position on long-term liability in order for the legislation to be passed through the Senate with the support of the opposition.
(92) Common law liability could arise from damage or nuisance arising from misconduct or negligence on the part of the operator of the operation. Common law liabilities exist in perpetuity.

adversely affect the public, surface owners, the environment and competing interests.

In **Western Australia**, a project-specific agreement was reached for the Gorgon LNG project and there is still no state-wide legislation introduced that deals with long-term liability for other CCS projects. The agreement reached between the Western Australian and the Federal Government commits that both the State and Federal Governments will accept joint long-term liability arising from storage of CO_2 gases in geological formations under Barrow Island. Details of the exact timeframe and conditions for liability release are still pending and will need to be endorsed by Parliament through a variation to the Barrow Island Act 2003.

It is anticipated that Gorgon will be injecting CO_2 for 60 years or more. For at least 15 years after the cessation of gas production, the operator will be required to manage and monitor the injection site. An indemnity would only be provided to the operator once it has satisfied both Governments that the site can be closed. The operator is responsible for all costs associated with the project up to the point of closure (93).

In **South Australia**, CCS operations are regulated under the Petroleum Act 2000 (SA). Under the Act, the licensee may bear significant liability for damages incurred relating to CCS activities undertaken pursuant to their GHG license. Common law liabilities also apply in the long-term. According to the Act, the following specific provisions are stipulated regarding licensee liability:

Licensees are liable for any damage caused by authorized activities, and will be made to bear reasonable costs incurred by the State for the purpose of rehabilitating an area of land following environmental damage (94). Licensees may be required to follow Ministerial direction to undertake specific actions for the purpose of minimizing or preventing environmental damage. Where damage has occurred, the licensee may also be required to rehabilitate that land themselves and to bear the costs of rehabilitation (95).

For CO_2 storage operators, these specific liabilities may be limited or excluded, subject to the following:

1. The licensee commissions and submits an independent expert report to the Minister, detailing the inherent risk associated with the regulated activity, and also risk mitigation measures; and
2. Based on this report, an agreement may be entered into between the licensee and the Minister, which may include provisions to limit liability, provided that specific risk mitigation conditions are adhered to.

(93) Government of Western Australia, 2010.
(94) Petroleum and Geothermal Energy Act 2000 Division 6, Section 111.
(95) Ibid, Division 12, Section 89

Potential conflict of liability arrangements

As described above, long-term liability arrangements differ between Commonwealth and State schemes in Australia. Therefore, in situations where storage operators inject CO_2 into reservoirs that may migrate across both state and Commonwealth jurisdictions, such operators will be faced with inherent uncertainty in regards to their long-term liability exposure.

In Victoria's offshore waters, it is conceivable that injected CO_2 might cross jurisdictional boundaries. Specifically, the subsurface geological characteristics of storage reservoirs in the Bass Straight (offshore from Victoria) are such that CO_2 originally injected into a reservoir located in the Commonwealth offshore jurisdiction may eventually migrate into Victorian waters. In some cases, CO_2 may even eventually migrate into subsurface pore space beneath the Victorian landmass. In such situations, storage operators would need to seek tenure under the Victorian onshore, offshore and Commonwealth offshore schemes.

Because of the different long-term liability arrangements in place under these various jurisdictions, liability for trespass from unexpected leakage of injected CO_2, that being either the private party (under Victoria legislation) or the Commonwealth (under Commonwealth legislation) may be a point of considerable legal contention.

An overview of the various liability frameworks in Australia is presented *Table **6.7***.

Table 6.7 Overview of CCS liability arrangements in Australia

Jurisdiction	Short term	Long term	State assumes	Rights and interests also transferred to the Crown?	Legislation	Provisions for long-term financial responsibility
Commonwealth (Federal Level)	Operator	Commonwealth	All liabilities	Formation and property ownership in stored GHG transferred to Crown	Offshore Petroleum Amendment (Greenhouse Gas Storage) Act 2008	Conditions of a GHG injection license may include 'insurance against expenses of complying with directions relating to the clean-up or other remediation of the effects of the escape of a greenhouse gas substance'.
Victoria	Operator	State	Common law liabilities remain with the operator, statutory liabilities cease upon surrender of licence.	Formation and property ownership in stored GHG transferred to Crown	Offshore: Offshore Petroleum and Greenhouse Gas Storage Act 2010 Onshore: Greenhouse Gas Geological Storage Act 2008	Onshore: Under the GGS Act 2008, the operator must obtain insurance, rehabilitation bond, pay royalties and long-term monitoring and verification costs (s.128, s.220, s.224, s,112 & s.174)
Queensland	Operator	State	Common law liabilities remain with the operator, statutory liabilities cease upon surrender of licence.	Formation and property ownership in stored GHG transferred to Crown	Onshore: Greenhouse Gas Storage Act 2009	Government is currently seeking advice on financial security arrangements that will be put in place.
South Australia	Operator	State (subject to risk mitigation procedures)	Common law liabilities remain with the operator (subject to risk mitigation procedures).	The Petroleum Act 2000 does not address ownership of injected CO_2 at the termination or expiry of a licence.	Onshore: Petroleum Act 2000	Not specifically addressed. However, licensee to bear liability for any 'reasonable costs' for rehabilitation, with liabilities limited or excluded subject to specified risk mitigation procedures.
Western Australia	Operator	State & Commonwealth joint liability through amendment of the Barrow Island Act 2003. Provision of a post closure indemnity not expected to occur for at least 75 years and would only occur after the GJV has satisfied Government closure requirements.	All liabilities (note: current provisions do not cover liabilities associated with a future emissions trading scheme).	Formation and property ownership in stored GHG transferred to Crown	Barrow Island Act 2003 – currently used specifically for the Gorgon Gas Project. Onshore legislation (planned)	Not addressed.

6.6.3 *Financial Responsibility*

Federal level

The Commonwealth Offshore Petroleum Amendment (Greenhouse Gas Storage) Act 2008, stipulates a process for managing financial responsibility that can be tailored individually to each site to address their long-term financial risk profile. Specifically, for operations in Commonwealth offshore waters, the Act stipulates that greenhouse gas titles may include a condition that the registered holder maintain, as directed by the responsible Commonwealth Minister from time to time, insurance against:

(f) expenses; or
(g) liabilities; or
(h) specified things;

arising in connection with, or as a result of:

(i) the carrying out of work under the permit, lease, licence or authority; or
(j) the doing of any other thing under the permit, lease, licence or authority;

including insurance against expenses of complying with directions relating to the clean-up or other remediation of the effects of the escape of a greenhouse gas substance (96).

State level

Financial responsibility for CCS activities is regulated in the state of **Victoria** under the Greenhouse Gas Geological Sequestration Act 2008.

Under the Act, the CCS operator must:

- Obtain insurance (s.218)
- Obtain a rehabilitation bond before carrying out any injection & storage activities (s.220)
- Pay royalties (s.224)
- Pay long-term monitoring and verification costs (s. 112 and 174) as set out in the approved injection and monitoring plan, in annual instalments of a fixed percentage of the total estimated cost set by the Minister.

The specific requirements relating to long-term monitoring and verification costs are shown in *Box 6.1*.

(96) Amendment 193, Schedule 1.

Box 6.1 Long-term financial costs under the Victoria GGGS Act 2008

112 Payment of long-term monitoring and verification costs

(1) It is a condition of an injection and monitoring licence that the holder of the licence must pay an annual instalment of the estimated long-term monitoring and verification costs set out in the approved injection and monitoring plan.
(2) The annual instalment amount is to be a percentage fixed by the Minister of the total estimated cost.
(3) The licence holder must pay each instalment by the date that it is due to be paid.

174 Payment of long-term monitoring and verification costs

(1) If the Minister consents to the surrender of an injection and monitoring licence, the licence holder must, before surrendering the licence, pay the remaining cost of carrying out long-term monitoring and verification as detailed in the long-term monitoring and verification plan approved under section 170(2) and which has not already been paid in accordance with section 112.
(2) If the licence holder has paid more than the cost estimated in the long-term monitoring and verification plan, the licence holder is entitled to a refund of the difference between the amount paid and the cost estimated in the approved plan.

Source: Greenhouse Gas Geological Sequestration Act, Parliament of Victoria, Act No. 61 of 2008.

7 *MONITORING, REPORTING & VERIFICATION REQUIREMENTS*

7.1 *OVERVIEW*

The development of robust monitoring, reporting and verification (MRV) standards and guidelines is a central component of the CO_2 storage regulation, required to satisfy two main purposes:

1) in relation to safety of operations, subsurface license area and potential breach of permit conditions, third-part interests and potential trespass, and public acceptance of CO_2 storage; and
2) in relation to emissions accounting frameworks

These two purposes give rise to two slightly different objectives of monitoring and reporting for CO_2 storage, although in practice significant overlap can be expected in terms of the technologies and approaches to be employed. Because of the potential for overlap, one of the main challenges in regulatory design is the avoidance of double regulation.

A number of efforts have been made to articulate monitoring and reporting guidelines at international and national levels. The following sections provide a brief overview of the requirements set down in various frameworks including:

- The Intergovernmental Panel on Climate Change (IPCC)
- The European Union
- The United States EPA

Guidelines on monitoring and reporting of emissions from CO_2 storage have developed by the IPCC. The guidelines, set out in Volume 2, Chapter 5 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories set down an overarching framework for the collection of data on greenhouse gas emissions from CO_2 storage activities for compilation in countries national greenhouse gas inventories as submitted to the United Nations Framework Convention on Climate Change. Various other components are included across the full suite of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories to accommodate capture and transport of CO_2, including broad guidelines on CO_2-EOR. Where countries are employing CCS as a means to reduce emissions, emissions from point sources which are captured, transported and stored in geological reservoirs which are monitored in accordance with the rules set down in Volume 2, Chapter 5, countries may report the emissions as not emitted to atmosphere for the purpose of their national greenhouse gas inventory.

As these set down an international set of rules for all UNFCCC signatory Parties, they logically form a basis to develop national level guidelines. As they are reasonably high-level in their approach – although they do propose a

"Tier 3" methodology which means project specific approaches are required – more detailed articulation of Monitoring and Reporting guidelines (MRGs) has taken place to meet the two objectives described above as follows under:

- The EU ETS Directive, due to the inclusion of CCS in the scheme via modifications to the rules for Phase III (2012-2017). Part of this inclusion involves the introduction of monitoring and reporting guidelines for CCS ("EU ETS M&R Guidelines");
- The US EPA GHG reporting rule
- The EU CCS Directive
- The US EPA SDWA Well Class VI proposed model rule

All require, at varying levels, the development of a monitoring plan outlining a suite of monitoring tools and methods. For the purpose of compliance under the EU ETS Directive, the monitoring and reporting guidelines there under also cover capture and transport installations in order to accurately account for any emissions of CO_2 across the CCS chain as included under the scheme.

All four legal documents establish minimum reporting requirements to be undertaken by storage site operators, along with timelines in relation to the reporting and approval process within the monitoring plan. However, they do not include specific technical requirements in relation to techniques employed.

In the **EU**, a storage operator is obliged to monitor and report under both the EU CCS Directive and the EU ETS Directive (or to be precise, in accordance with the Decision outlining the EU ETS M&R Guidelines thereto). The focus of monitoring and reporting requirements under the EU ETS is on measuring emissions from capture, transport and storage operations (including emissions from associated CCS activities such as fuel combustion at compressor stations) as these sites are now included as qualifying installations under the scheme. Under the CCS Directive, the focus is on measuring the success of CO_2 storage and detecting leakage - as well as any other adverse effects on health or third-parties and the environment as described previously. However, in practice the two requirements will need to be harmonised and complemented to avoid double regulation.

In the **US,** the EPA is proposing to include CO_2 injection sites under its mandatory GHG reporting rule. Under this rule, data collected from CO_2 storage sites would enable the EPA to track the amount of CO_2 that is injected and in some cases would require a monitoring strategy for detecting potential emissions to the atmosphere. The EPA is also proposing to require all facilities in the reporting system to provide information on their corporate ownership [97]. The reporting and monitoring requirements in the proposed rule are not linked to a permit, and storage site operators will therefore also

(97) Under the proposed rule, covered sources would have to begin collecting emissions data on January 1, 2011 and their first annual report would have to submitted to EPA by March 31, 2012

have to conduct monitoring and reporting in accordance with the UIC Class VI well permit requirements (see *Section 3.4*).

In **Canada,** regulation of CCS M&R will be informed by work on a standard jointly CSA Standards and the International Performance Assessment Centre for Geologic Storage of Carbon Dioxide (IPAC-CO2) announced in June 2010 [(98)]. Further details relating to the standard will be made known in late 2011. However, detailed guidance already exists at a Province level, and a number of CO_2 storage monitoring R&D projects are currently receiving government funding [(99)].

In **Australia**, the Environment Protection and Heritage Council (EPHC) 'Environmental Guidelines for Carbon Dioxide Capture and Geological Storage 2009' require CO_2 storage operators (until experience determines otherwise) to implement comprehensive monitoring regimes, including air, groundwater and soil chemistry, in-hole geochemical monitoring, geophysical, including seismic, monitoring and modelling of the CO_2 plume, although further detailed specifications are not provided.

Although specific accuracy requirements, units, and quality assurance are not mentioned in the EU CCS Directive and US EPA GHG reporting rule, it is anticipated that monitoring plans would need to specify monitoring accuracy, units of commerce and data quality assessment protocols according to best practice.

The remainder of this section presents a comparative overview of the existing and emerging guidelines relating *specific to CO2 storage* across the studied jurisdictions, with a view to understand similarities and differences in relation to:

Monitoring, with respect to:

- baseline, scope and boundary
- accuracy of measurement
- metering
- timelines

Reporting, with respect to:

- minimum reporting requirements
- units of commerce
- QA/QC and reporting and documentation procedures

Verification, with respect to:

- verification procedures
- chain of custody and credit application

(98) IPAC-CO2: IPAC-CO2 and CSA - Development of Standard for Geologic Storage of CO2, 16 June 2010 http://www.ipac-co2.com/IpacCo2/Pages/Projects.aspx
(99) Natural resources Canada: Carbon Dioxide Capture and Storage: A Compendium of Canada's Participation, 2006

- data disclosure and confidentiality issues

This section considers these components of MRV in the context of ongoing requirements. Provisions and requirements under the licensing/permitting phase (e.g. storage site characterisation) are considered in *Section 3*.

The section concludes with a brief discussion of the technology choices associated with MRV of CCS activities.

An overview of guidelines or regulations addressing MRV for CCS activities, along with their key provisions, can be found in *Annex D* to this report.

7.2 MONITORING

7.2.1 Baseline, scope and boundary

One of the initial stages of monitoring plan design is the establishment of the boundaries and baseline for monitoring and reporting.

Scope and boundary

The boundaries set down the areal and vertical extent of storage operations as well as any surrounding components of a storage complex relevant to storage – including surface facilities, thus delimiting the areas within which monitoring should take place. These boundaries are subject to revision in the event that migration or leakage occurs and CO_2 moves outside of these predefined limits.

The **EU CCS Directive** sets down boundary setting processes under Annex I as part of site characterization. These boundaries are used to determine the extent of storage operations. Annex II sets down procedures for monitoring plan design within the determined boundaries, and beyond where necessary.

In the **EU ETS M&R Guidelines**, the boundary definition for the CO_2 storage complex monitoring area is set according to the delineation determined in fulfilling the CCS Directive requirements described in the previous paragraph. For surface components, the monitoring boundaries are determined according to the standard process of identifying relevant emission sources at an installation, and then setting the monitoring procedures down in the monitoring plan.

In the **US**, the proposed model rule for well class VI under SDWA UIC rules require the determination of an 'Area of Review', which is essence the same as the boundary described under the EU CCS Directive. As for the EU CCS Directive, it is based on multiphase computational modelling, and sets out rules stipulating that best available models must be used and that results should be verified by a third party. The EPA proposed model rule on GHG reporting for geological sequestration sets down conditions for boundary setting based on identifying all potential emissions sources within a geological sequestration (GS) facility. The precise approach, set down in the proposed rule, are unclear, and may extend well beyond the boundary of existing facilities. Presently the EPA is seeking further guidance from operators on its proposals.

In **Australia**, only a general rule exists stating that monitoring should include regional scale monitoring beyond the actual CCS injection site (100).

Baseline monitoring

Baseline monitoring is required to assess the baseline conditions before any CO_2 injection and storage takes place. The results of these tests can be used to inform regulators in the event of subsequent environmental damage caused by leakage or migration, to establish restorative conditions, and also for the calibration of monitoring results, as required for some techniques (e.g. soil gas analysis; micro-seismic surveys). These activities are likely to be carried out in the initial stage during the assessment of the appropriateness of the storage site for CO_2 injection. As emission reductions and potential leakage estimations will be assessed against the baseline monitoring results, it is essential for robust monitoring to take place at this stage.

Under the **EU CCS Directive**, baseline monitoring should be considered as an integral part of the initial monitoring plan submitted at the time of storage permitting. Baseline surveying will also have to be carried out as a part of Environmental Impact Assessment, as applicable to CCS through amendments in the CCS Directive. According to the draft Guidance document on the implementation of CCS directive (101), baseline measurements consist of:

- Monitoring of formation gas and fluid characteristics in the storage reservoir, surrounding complex and formations that might be affected by potential leakage, including aquifers;
- Background CO_2 emissions at surface or sea floor;
- Surface and near surface environmental surveys;
- Seabed, surface or near surface baseline surveys to define any pre-existing leakage indicators such as pock marks; and
- Ground surface surveying, e.g. where ground movement monitoring is expected to be beneficial, and/or in areas of ground movement risk.

In **Australia**, what constitutes a baseline is not legally defined. However, the 'Offshore Petroleum and Greenhouse Gas Storage Act' mentions that the geological surveying tasks could serve as a basis for establishing a baseline.

(100) Environment Protection and Heritage Council (EPHC), Guidelines for Carbon Dioxide Capture and Geological Storage – 2009

(101) Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 2 on Site Characterisation, CO_2 Stream Composition, Monitoring and Corrective Measures, 17 June 2010

In **US**, the proposed EPA model rule for well class VI under sets down requirements to collect baseline data. This includes gravity surveys, baseline geochemical data, baseline geological surveys, surface air quality data etc. These are all intended for the purpose of calibrating monitoring results during project operation and post closure. The EPA proposed model rule on GHG reporting for geological sequestration activities sets out a range of monitoring and reporting steps which operators must undertake on a site-specific basis. This includes*: Step 3 – Strategies for Establishing Pre-Injection Environmental Baselines*, which sets out data against which monitored data will be compared. These data must be in suitable format (e.g. diurnal, seasonal, annual) in order that any leakage be discernable from environmental background levels of near-surface atmospheric CO2 concentration. It does allow for derogations to be implemented or pre-existing geological sequestration sites.

In **Canada**, the regulatory frameworks do not currently prescribe any obligatory baseline monitoring activities. In Canada, further guidelines can be expected as part of the CSA standard under development (see *Section 7.1* above).

Storage operators should be aware of potential delays in intended injection commencement caused by the need to establish a robust baseline in the very early stages of the project.

7.2.2 *Accuracy of measurement*

None of the authorities within the jurisdictions studied in this report currently specify requirements in relation to the accuracy of measurement of baseline and boundary data. These are likely to be determined on a case by case basis, according to the prescribed CO_2 storage complex characterisation procedures and any sensitivity analysis there under.

However, some specific aspects of monitoring and reporting do set down accuracy requirements.

In the **EU**, the M&R Guidelines under the EU ETS Directive specify uncertainty levels for fugitive emissions from capture and transport, and also for the transfer of CO_2 between different installations across the chain of capture, transport and storage. In these contexts, the M&R Guidelines prescribe the following requirements:

- For capture of CO_2, the overall uncertainty of estimated CO_2 generation at the facility should be within the limits for the specific installation/activity/tier of reporting as prescribed in the EU ETS monitoring and reporting guidelines (Decision 2007/589/EC);
- For transfer of CO_2 from a capture installation to a pipeline installation, ±1.5%;
- For fugitive emissions from CO_2 transport networks, a maximum uncertainty of ±7.5% across a CO_2 transport network;

For transfer of CO_2 from a pipeline installation to a storage installation, ±1.5%;

- For leakage of CO_2 from storage complexes, emissions should be measured with a maximum overall uncertainty of ±7.5%.

Some aspects of this may be challenging to meet, for example measuring mass flows of CO2 under high pressure potentially with multi-phase flows to an accuracy of ±1.5% may be challenging. Also, detection limits for CO_2 leakages depend on the technology used. For 3D seismic surveys, detection limits have been reported to be between 2500 – 7500 tonnes of CO_2 [(102)].

7.2.3 *Metering*

Metering requirements will be determined according to the required level of accuracy prescribed under a particular scheme. It will be dependent on the tolerable levels of uncertainty for a particular part of the chain, for example, ±1.5% for transfers of CO_2 between different installations under the EU ETS M&R Guidelines.

Overall uncertainty is a measure of both metering accuracy, and error propagation across secondary instrumentation (e.g. temperature and pressure correction) and the use of multiple meter data to e.g. calculate amounts of CO_2 shipped. Meeting a ±1.5% uncertainty threshold will be particularly challenging, although given that mature CCS chains will likely involve the transfer of custody between different components, it is probable that contracts may well specify accuracy levels to fiscal metering standards similar to oil and gas custody transfer standards.

7.2.4 *Timelines*

In the **EU**, the CCS Directive requires that measurements be made continuously for the following during a site's operational phase:

- Mass of injected CO_2 (volumetric, pressure and temperature at injection wellheads);
- Fugitive emissions of CO_2 at the injection facility;
- Chemical analysis of the injected material; and
- Reservoir temperature and pressure.

For other non-continuous/non-passive techniques, the frequency of application should be proposed by the operator and subject to specific approval by the competent authority. As such, the time intervals over which other monitoring activities should be conducted are not prescribed in the EU and are to be performed based on industry good practice. For example, 3D seismic surveys used to detect leakages are usually repeated at intervals of

(102) Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 2 on Site Characterisation, CO2 Stream Composition, Monitoring and Corrective Measures, 17 June 2010

several years [103]. In practice, the determinations will be made on a case-by-case basis subject to the operator proposing a monitoring and reporting plan, and the competent authority approval of that plan most likely based on the specific circumstances present at the site (e.g. geological media, risks present etc.).

In terms of post-closure monitoring, the EU CCS Directive sets down a minimum term of 20 years of operator responsibility for a storage complex post-closure. Over this period, the operator is obliged to undertake post-closure monitoring activities in accordance with the requirements set down in Annex II of the Directive. The length of this period may be shortened where a competent authority is convinced that all available evidence indicates that stored CO_2 will be completely and permanently contained.

In the **US**, the proposed model rule for well class VI under UIC, envisage continuous monitoring and semi-annual reporting under the Class VI Well permit. It is not yet specified which activities will need to be monitored continuously, although the monitoring and reporting activities should continue across a 50-year (or more) post-injection site care period.

In **Canada** and **Australia**, regulations regarding the level of detail that would prescribe monitoring frequency and timelines of particular CCS storage related activities, do not yet exist. They will likely follow regulations and existing practices present in the Oil and Gas sector and also provisions within the European CCS regulatory framework.

However, at state and province levels, regulations might be more detailed, deriving mostly from previously existing oil and gas operational regimes. For example, in Canada, the Saskatchewan Instruction Directive I.D. ER-219 2008 06 requires injection well operators (including those injecting CO_2) to report monthly on basic injection parameters, including the injected volumes.

7.3 *REPORTING*

7.3.1 *Minimum reporting requirements*

There are a number of minimum reporting requirements defined in MRV guidelines in different jurisdictions. A comparative overview of the existing guidelines is presented in Table 7.1

(103) Ibid

Table 7.1 Comparison of mandatory reporting requirements

	IPCC Guidelines for National GHG Inventories	**EU ETS monitoring guidelines for CCS**	**EU CCS directive**	**US EPA GHG reporting rule (EOR)**	**US EPA GHG reporting rule (CO_2 sequestration)**
The mass of CO_2 transferred onsite from offsite sources (imports)	x			x	x
The mass of CO_2 transferred offsite (exports)	x				
The source of the CO_2	x	x		x	x
Background CO_2 measurements	x				
Other baseline data		x	x		
Chemical composition of the injected material		x	x		
Injected CO_2 volumetric flow	x		x	x	x
Injected CO_2 pressure and temperature			x	x	x
Injected CO_2 mass	x		x	x	x
Sequestered CO_2 mass (cumulative mass of stored CO_2)			indirectly indirectly		x
Fugitive emissions of CO_2 from the transport	x	x			
Fugitive emissions of CO_2 at the injection facility	x	x	x		x
The mass of CO_2 emitted to the surface from the subsurface	x				x
Isotopic analysis of CO_2 leakage	x	For on-shore			
Reservoir temperature and pressure			x		
Modelling updates		x	x		
Third party verification			x		
Copies of associated permits			x		
Reporting frequency		Annually	Min Annually	Annually	Annually
Revising the monitoring plan frequency			Min 5 years	Not prescribed	Not prescribed
Additional requirements		Also including emissions from CCS activities. Prescribed level of uncertainty for each measurement	Corrective measures plan. Comparison with the simulated pressure-volume behaviour.	Risk assessment	Risk assessment

7.3.2 *Units of commerce*

The IPCC Guidelines on National Greenhouse Gas Inventories 2006 require reporting of CO_2 in gigagrammes (Gg). Other guidelines do not specifically mention mandatory units, but tonnes, kilotonnes, lbs. or gigagrammes are likely to be used, depending on the prevailing units of measurements employed in individual countries.

Emissions under the EU ETS are reported in tonnes of CO_2 (tCO_2) which is commensurate with the minimum level of tradable amount (European Union Allowance) as used in the EU's Emissions Trading Scheme.

7.3.3 *QA/QC and reporting and documentation procedures*

The IPCC Guidelines specify site-specific QA/QC and reporting and documentation procedures for national inventory compliers as well as more general national reporting and QA/QC. Given the detailed nature of the Tier 3 methods (for estimating and reporting emissions from CO_2 storage sites under the IPCC Guidelines) extensive site specific documentation is anticipated. However as this is likely to be required by any regulatory regime, and given the fact that these sites are likely to be large and represent significant financial investments this is not considered to be a significant additional burden.

In the **EU**, the EU ETS M&R Guidelines under the EU ETS includes guidance on documentation as part of the monitoring of CO_2 emissions from installations.

As well as providing general guidance on reconciling data inconsistencies across the CCS chain, specific requirements set down in the additional M&R Guidelines for CCS indicate that the following additional information shall be retained for CO_2 capture, transport and geological storage activities:

- where applicable, documentation of the amount of CO_2 injected into the storage complex by installations carrying out geological storage of CO_2;
- where applicable, representatively aggregated pressure and temperature data from a transport network;
- where applicable, a copy of the storage permit, including the approved monitoring plan, pursuant to Article 9 of Directive 2009/31/EC;
- where applicable, the reports submitted pursuant to Article 14 of Directive 2009/31/EC;
- where applicable, reports on the results of the inspections carried out pursuant to Article 15 of Directive 2009/31/EC; and
- where applicable, documentation on corrective measures taken pursuant to Article 16 of Directive 2009/31/EC."

The EU requires that all information be made publically available through the European Pollutant Release and Transfer Register (E-PRTR).

7.4 VERIFICATION

The periodic verification of monitoring plans is a typical component of regulatory approaches for CCS activities. It consists of two components:

- Inspections by competent authorities; and
- Verifications by accredited third-parties.

Inspections of records and activities provide assurances to regulators that storage operators are acting within the terms of the permitting framework. Third-party verification of quantified estimates of transferred CO_2, fugitive emissions and leakage, where relevant, also help to build confidence amongst market participants regarding the integrity of any emissions trading programmes linked to CCS.

7.4.1 *Verification procedures*

In the **EU**, verification procedures are established, both under CCS Directive and the EU ETS Directive. The verification processes are different and independent for the two purposes, and are discussed further below.

In **Canada**, the verification programme for CCS projects will form part of the CCS standard currently under development.

EU CCS Directive

Under the EU CCS Directive, the Member State competent authorities are responsible for routine inspections of all related surface installations and the checking of relevant records. Inspections will be carried out at least once a year until three years after installation closure, and every five years until transfer of responsibility has occurred.

Non-routine inspections shall be carried out *ad hoc* or in the case of suspected CO_2 leakages, or irregularities and insufficient compliance. The latter may be the result of complaints by members of the public, operators' own findings or can be carried out when the competent authority deems appropriate.

In addition, the evaluation of overall performance in terms of safety and environment will be carried out on the basis of monitoring and inspection results. According to the guidance, these should include targets relating to the timing, frequency and accuracy of monitoring programme elements, as well as definitions of normal alert and threshold values for key monitoring elements.

EU ETS Directive

Under the EU ETS, the operator is responsible for arranging independent third party verification on annual basis linked to the compliance periods and deadlines prescribed under the EU ETS Directive. The verification criteria are outlined in Annex V of the ETS Directive, covering strategic, process and risks analysis as well as the minimum competency requirements for verifiers.

7.4.2 *Chain of custody and credit application*

In the **EU**, Member States are required to develop appropriate regulations concerning the responsibility for the long-term preservation of monitoring data, as this is not regulated directly at the EU-level (through either the CCS or EU ETS Directives).

It is likely that the development of Member State regulation on this topic will compel site operators to retain both raw monitoring data and processed data for specific periods of time. The operating history established via collected monitoring and operational data will be sought when applying for transfer of responsibility to the competent authority (104).

In the **US**, the EPA has developed general rules regarding the chain of custody for agencies at the state level, but does not hold any information specific to CCS (105).

No specific chain of custody protocols have been identified in **Canada** or **Australia**.

7.4.3 *Data disclosure and confidentiality issues*

Data collected at the national level is reported to the UNFCCC Parties via national communications and national inventory reports, which required annually for Annex I Parties to the UNFCCC.

In the **EU**, the CCS Directive states that there are no specific provisions for data retention and ownership, but that each Member State may choose to develop appropriate policies, laws and regulations concerning those actors entitled to access and rights to use the monitoring data, with a view to address developers' rights to retain proprietary data as well as the public need for transparency. Reported data under the EU ETS is publically disclosed via the E-PRTR.

In the **US**, those data elements requiring confidentiality and those that should be reported under the EPA's Greenhouse Gas Reporting Program will be determined by the Proposed Confidentiality Determination, signed on June 28, 2010, which is currently under public consultation (106).

(104) Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 2 on Site Characterisation, CO_2 Stream Composition, Monitoring and Corrective Measures, 17 June 2010
(105) http://www.epa.gov/apti/coc/
(106) EPA **Proposed Confidentiality Determination for the Mandatory Greenhouse Gas Reporting Rule and Proposed Rule Amendment Specifying Procedures for Handling Part 98 Data, 2010**
http://www.epa.gov/climatechange/emissions/ghgrulemaking.html

In **Canada** and **Australia**, no further guidance specifically addressing confidentiality issues are known to exist at present.

7.5 *MONITORING TECHNOLOGIES*

The choice of technology for monitoring CCS activities is generally not mandated by legislation, and therefore lies with the operator. The only exception is wellhead flow and pressure monitoring during injection, which is clearly implied as being necessary in both the EU CCS Directive and US EPA GHG monitoring rule.

The IPCC has reviewed and listed some possible methodologies likely to be used by regulators as guidance when assessing the suitability of operators' CCS monitoring plans (see *Box 7.1*).

Box 7.1 Monitoring technologies reviewed in the IPCC GHG inventory guidelines

DEEP SUBSURFACE MONITORING:
2D, 3D and 4D and multicomponent seismic reflection surveys
Crosshole seismic profile Images velocity distribution between wells
Vertical seismic profile
Microseismic monitoring
Wellhead pressure monitoring during injection, formation pressure testing
Gravity surveys

SHALLOW SUBSURFACE MONITORING
Sparker:
Deep towed boomer:
Sidescan sonar
Multi-beam echo-sounding (Swath bathymetry)

FLUXES FROM GROUND OR WATER TO ATMOSPHERE,
Groundwater and surface water gas analysis.

LEAKAGE DETECTION at small scale (ground)
Portable personal safety oriented hand-held infrared gas analyzers
Airborne infra-red laser gas analysis

LEAKAGE DETECTION at small scale (satellite)
Satellite or airborne hyperspectral imaging
Satellite interferometry

Source: IPCC GHG National Inventory Guidelines

7.5.1 *Technologies for Monitoring CO_2 Stream Purity*

The IPCC guidelines do not address the purity of the CO_2, which features as a requisite for the reporting process in the EU (with continuous monitoring being recommended). However, it is hard to reliably determine the CO_2 content in the captured stream, as analytical devices e.g. non-dispersive infrared spectrometer (NDIR) are mechanically not able to cope with the typical; pressures in pipelines or at the wellheads. Therefore, continuous emission monitoring is currently not possible for all monitoring parameters.

Batch measurements may be possible by providing a gas tap at wellheads for sampling of CO2 being injected. It will be critical for operators of geological storage sites in the EU to measure CO2 purity as part of the CO2 acceptance criteria set down in the CCS Directive. This will also apply in any London Protocol signatory country, where requirements are set down for overwhelmingly CO_2 without any added substances.

7.5.2 *Technologies for Detecting Leakage*

For detecting off-shore leakages, the North Sea Basin Task Force has proposed monitoring approaches which consists of seismic data used for the detection of gas chimneys or sea-bottom echo-sounding for the detection of pockmarks. Subsequently, sampling of these leakage areas for direct CO_2 detection needs to be taken repeatedly and, based on the sampling profiles, an estimate of the leakage rates over time for the area can be made. These standards may be adopted by operators in the EU as part of their overall CO_2 monitoring plan development.

Current CO_2 leakage detection techniques for on-shore storage at surface as recommended by the draft Guidance document on the implementation of CCS directive [(107)], include the following:

- Sampling the uptake of CO_2 by plants during photosynthesis;
- Root respiration;
- Microbial respiration in soil;
- Deep natural out-gassing of CO_2; and
- Exchange of CO_2 between the soil and the atmosphere in combination with isotope analysis.

Although unlikely to yield useful information outside of target depth, 3D seismic surveys have also proved useful in some circumstances in the detection of leakages for on-shore storage.

(107) Implementation of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide, Draft Document for Consultation, GD 2 on Site Characterisation, CO_2 Stream Composition, Monitoring and Corrective Measures, 17 June 2010

Annex A

CCR compliance elements and Implications for Developers

A1.1 SPACE AVAILABILITY IN THE PROXIMITY OF THE PLANT

In relation to space availability, authorities will most likely require key conditions to be met. ***Table Table*** A.1 below presents some of the most widely anticipated conditions that will be placed by regulation.

Table A.1 CCR Basic and Additional Space Requirements by Technology

Basic Space Requirements	Additional Space Requirements for Oxyfuel	Additional Space Requirements for Post Combustion
Enough area identified for: • CO_2 cleaning and compression equipment (scrubbers, CO_2 compressors) • Improved cleaning of flue gas and additional flue gas cooling where necessary • Extension of cooling water systems (up to 30%) • Safety barrier zones • Pipe work and tie-ins to existing equipment	Space is also required for the flue gas recirculation ductwork and the air separation units.	Space is also required for the absorbers and regeneration towers.

In addition to the requirements described above, the IEA also highlights special requirements for storage of equipment and materials and for access to the existing plant during construction.

Size

In the UK, a conservative appraisal is mandated in terms of determining necessary space requirements, and applicants must submit plans and supporting documents to prove space availability. Similar procedures are required to obtain the TÜV certification. The size of the space depends on the type of capture technology chosen. The size/number of the power generating units etc. is generally not prescribed, but rather is determined on a case by case basis. Whilst this may be a reasonable approach, since CCS will likely require progressively less space as technology matures, in the UK, the approximate minimum land footprints for some types of CO_2 capture plants are defined.

The UK regulations also highlight that the use of hazardous substances, such as oxygen, hydrogen and amine solvents will have additional spatial requirements that must be considered when making a plant CCR. In particular, the use of these hazardous substances may necessitate that buffer zones are placed around a particular site to avoid land use conflict with neighbouring land uses, and may require consultation with local planning authorities.

The consultation distance will depend upon the type and quantity of the hazardous substance. The developer must be aware of its effect on the land-use planning around the facility and subsequent loss of value of the land, which might be of consideration to the developer or bring conflicts with other landowners. Some other jurisdictions outside EU may not follow UK in this requirement due to differences in hazardous substance regulations that would be in place.

Depending on how prescriptive CCR requirements prove to be in the future, some jurisdictions may also require spatial availability for some uses linked indirectly to CCS, such as the additional space for the construction phase.

Proximity

In the UK, CCR requirements indicate that the additional space required to make a plant CCR should be close to the proposed power plant. Exceptions are possible if enough support documentation is provided. It may be for example possible to transport the flue gases, liquid or pressurised oxygen via ductwork to the capture plant several hundred meters away from the plant. Units for the CO_2 compression plant may be along the CO_2 pipeline, etc.

The European Power Plant Suppliers Association (EPPSA) specify distance away from the plant at which some parts of carbon capture could be carried out – flue gases in post capture CCS can be transported for several hundred meters, whereas pressurised oxygen for oxyfuel plant can be transported several kilometres. Developers must be aware however, that such separations come with financial and efficiency costs.

Timeline

TÜV Nord certification requires proof of space availability from 2018 onwards. By that it is meant that space does not necessarily need to be made available now, but must be made available by 2018. This time concession will likely facilitate plant operators to meet CCR compliance obligations. To demonstrate, space currently occupied by a part of the plant scheduled for decommissioning can count towards the space necessary for the carbon capture facility. This sort of timeline tolerance is not mentioned in other regulations and standards.

The UK DECC CCR Guidelines do not specifically mentioned when the spatial availability must be in place but as a minimum it is expected that space would need to be available at the time of construction. Because the Guidelines are non-specific, it cannot be ruled out that developers might still be successful in arguing for time tolerance if they can justify why it is required, citing also TÜV Nord certification as a reference. Specifically, as the regulations in the UK are based on the "no perceived boundaries" principle, [(1)] the developer could argue that a space that is currently occupied will be available by the time that CCS becomes viable and therefore the lack of space in the present does not present a "boundary" to CCS installation.

(1) i.e. the applicants would be asked to demonstrate that there are no known technical or economic barriers which would prevent the installation and operation of the CCS technologies

The UK's CCR Guidelines and the current draft GCCSI definition both stipulate a requirement for continued provision of evidence to justify that space availability is maintained after the construction of the plant.

Ownership of the land

While exceptions can be allowed on a case by case basis, the UK's CCR requirements are unique in that operators are required to own (or otherwise retain control) of the additional space on or near the site. It is expected that this approach could set a precedent that might be adopted by other regulatory authorities in EU and around the world.

A1.2 TECHNICAL FEASIBILITY OF CARBON CAPTURE

The aim of the technical feasibility study is to demonstrate to that the plant has been designed in such a way as to enable the subsequent retrofit of carbon capture equipment without affecting the proposed capacity of plant.

The level of detail required for the design of the capture facilities will likely vary from country to country or even on a case by case basis and is to some extent left to the discretion of the operator and the regulator.

In the UK where CCR is and Australia where CCR can be requirement, it is the IEA 'CO_2 Capture Ready Plants' report that is the key reference document for assessing technical feasibility.

Operators are expected to provide the following to demonstrate compliance with the UK CCR Guidelines:

- A clear identification of the most appropriate capture technology.
- Percentage of CO_2 emissions that will be captured.
- A preliminary design containing "sufficient technical detail" for capture facilities and their integration into the plant.

For the TUV Nord certification, the operators must show on the layout plan the interfaces and contacts between the respective installations (boilers, FGD, gasification plants etc.) and the carbon capture facility.

The UK's Environment Agency has produced advisory checklists for applicants to guide them on technical feasibility issues that they need to consider [1]. The checklists and documents on the feasibility study will be updated as technologies develop.

A1.3 ECONOMIC FEASIBILITY

The economic feasibility requirement of the CCR policy stipulates that operators must provide evidence they have taken costs of the capture technology into account in reasonable scenarios. The core of the economic

(1) DECC: CCR guidance, Annex 1A-C.

feasibility requirement is to necessitate that a study be undertaken to develop a comparison with paying full carbon allowances.

In the UK, the developer will be obliged to submit a single economic assessment on the full range of costs and benefits from instalment of CCS. If the government determines on the basis of this document that it is unlikely that there will ever be a business case for CCS implementation, the developer will not be allowed to proceed with the development.

A1.4 *SPECIFIC PRE-INVESTMENTS*

Specific pre-investments, which would make the later instalment of CCS easier and cheaper, are listed in the IEA 'CO_2 Capture Ready Plants' report as presented in A.2.

Table A.2 ***Possible specific pre-investments for CCS***

post-combustion capture:	**oxy-combustion**	**Natural gas combined cycle plants**
• Oversized pipe-racks • Low SOX and NO2 concentrations feed gas to post combustion CO_2 scrubbers • Flue gas desulfurization (FGD) meeting the flue gas purity requirements of CO_2 capture or the ability upgrade the FGD • Amine scrubbing and steam turbine related investments • Ultra-supercritical steam cycle	• Oversized pipe-racks • Minimised in-leakage of air into the boiler and its ancillaries • Air ducts and fans should be designed to enable them to be re-used for flue gas recycle • Adaptable FGD plant • Ultra-supercritical steam cycle	• Oversized pipe-racks • Ultra-supercritical steam cycle

These specific pre-investments are not mandatory under the UK's CCR guidance, provided that their absence is not perceived as a barrier to CCS retrofit in the future. Since what can be perceived as a barrier in a future planning scenario can be open to interpretation and will be assessed on a case by case basis, it is possible that some of the listed pre-investments (for example ultra-supercritical steam cycle) might be requested by the regulatory authority as a form of demonstration of best practice from operators.

A1.5 *TRANSPORT*

In relation to the transport, it is likely that operators would need to identify a viable CO_2 transport option for the project (e.g. by onshore/offshore pipeline, ship or road).

Under the UK CCR requirements, the proposed route must be well defined within the 10 km proximity of the plant and after that only loosely outlined. The requirements do not dictate that a completely empty space needs to be available nor that other development is prohibited within the transportation corridor, however major obstacles must be identified.

Joint transport arrangements between multiple developments are possible in the UK. [1] In the UK, and in countries where CO_2 pipeline networks are likely to be developed at a national level, the developer will likely be expected to determine the route and feasibility of the connecting pipeline route from the plant to the backbone pipeline.

A1.6 *STORAGE IDENTIFICATION*

In the UK, CO_2 storage areas are pre-identified by the government with the aim to fast track the application and approval process; In cases where a different storage area is proposed, it will up to the developer to demonstrate storage site suitability. Canada has also undertaken storage mapping and feasibility studies [2], which can be used by the developers in their CCR applications. Australia has already enabled the CO_2 underground injection under the Offshore Petroleum Amendment (Greenhouse Gas Storage) Bill [3]. The applicant for the CCR would have to address some storage related provisions coming from the Act (for example the interaction with petroleum rights).

For storage the technical feasibility requirements typically include:

- A short, reasoned, written justification of their proposed storage area, demonstrating that no known barriers exist to its use for CO_2 sequestration if chosen among the designated areas.
- A simple map of the proposed storage area.

A1.7 *STORAGE QUANTIFICATION*

In the UK, applicants are expected to include information on the amount of CO_2 that is to be captured and stored. The CO_2 amount will be assessed against previous applicants that intent to store or already store CO_2 in the same formation in order to determine whether it has sufficient capacity. Applicants that identify sites which do not appear to hold enough capacity will need to propose alternative storage options. Issues in relation to timing projects may arise in certain cases. This can be demonstrated by a hypothetical scenario where:

- ***Project A*** and ***Project B*** are in the proximity of the same ***storage area X***.
- ***Project A*** applies for CCR first and proposes ***storage area X*** as its designated storage space which is granted.
- ***Project B*** also applies, for the same storage area at a later stage but is not allowed to use it as there is not enough capacity and selects ***storage area Y***

(1) DECC: CCR guidance.
(2) Hegan L.,Natural Resources Canada (2008) Canada Update: CCS Legal and Regulatory Developments
(3) Offshore Petroleum Amendment (Greenhouse Gas Storage) Bill

which makes the project less economical mainly due to additional CO_2 transport costs associated with the distant ***storage area Y***.

- Capture technology becomes economic for **Project B** before **Project A and decides to** install before Project A.

In such a scenario, it is unclear if and how ***Project B*** will be allowed to use the storage area, since it has been allocated to ***Project A.***

Annex B

Options for financial liability as discussed in considered by EPA

US EPA has in 2008 issued a discussion paper "Approaches to geologic sequestration site stewardship after site closure". The paper lists some existing models that could potentially be applied for long term liability for carbon storage. The models were either developed specifically for CCS by organizations interested in promoting CCS or derived from existing US regulation for dealing with liabilities in other sectors such as the Nuclear, Chemical and Oil & Gas sector.

The models can be broadly categorised in three groups:

B1.1 TRUST FUNDS

- Suggested by the Interstate Oil and Gas Compact Commission
- Existing examples: Oil Spill Liability Trust Fund and CERCLA Superfund.

A trust fund for a potential cleanup would be funded by an injection fee. State collects the funds and the liability for the site transfer to the state after post-site-closure period. The model is relatively easy to implement, however the varying degree of risk across carbon storage sites is not addressed.

Existing examples:
The Oil Spill Liability Trust Fund is funded from various sources (oil tax, interest on fund principal, cost recovery from responsible parties and penalties), that covers for the responsible party's liability above a certain limit, unless the incident is caused by gross negligence or wilful misconduct or is the result of violation of an applicable federal regulation.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) has a similar funding mechanisms, however the funds are distributed differently, based on eligibility criteria which target the most seriously contaminated sites, with the responsible parties still being accountable unless the release was permitted.

2) PERFORMANCE STANDARDS BASED LIABILITY TRANSFER TO STATE

- Suggested by the WRI
- No existing examples.

State assumes liability if the site is operated in compliance with Performance-based standards. The operator would be required to re-assume financial responsibility if they failed to maintain prescribed standards at set monitoring periods over time. State would need to be assure that adequate funds are readily accessible. This approach avoids imposing excessive barriers to projects that have public benefits, but WRI sees a danger of public subsidizing private development and the possibility that the liable person will not be able to be identified when damages arrive (in far future).

3) PRIVATE INSURANCE COMBINED WITH FEDERAL INDEMNITY:

- existing examples: nuclear power in US, National Flood Insurance Act

This is a combination when the government steps in if the damages are too high to be bared by the private insurer. In the case of Nuclear three-tiered coverage system it has proved very successful, as no claim have been made even on Tier II level (industry-pooled liability insurance). However the flood found is suffering big loses.

Existing examples:

Three-tiered coverage system, as exists for nuclear power in US (Price-Anderson Nuclear Industries Indemnity Act of 1957) which requires licensed facilities to maintain both site-specific liability insurance (Tier 1) and industry-pooled liability insurance (Tier 2) and in the event that the private claims against a licensee exceed the amounts available in both the site-specific, federal government covers (Tier 3).

Pooled insurance model, as exist in National Flood Insurance Act of 1968. Insurers issue insurance policies for flood coverage to eligible property owners. Premiums collected under these policies are deposited into the National Flood Insurance Fund. Any claims made under these policies (as well as any administrative costs) are paid from the Fund.

Annex C

Requirements for site closure under UIC:

The 2008 proposed Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO2) Geologic Sequestration (GS) Wells require the following procedure for site closure.

The operator must submit a post-injection site care and closure plan with the application for the Well Permit (which can later be revised). Post-injection site care starts after Well plugging. Well plugging must follow set requirements. Post-injection site care would last 50 years as the basic time reference, which may be shortened or lengthened depending on the plume stabilization (to the discretion of the permitting authority).

The permitting authority would determine that the post-injection site care period has ended and authorize site closure after:
information required of the post injection site care and site closure plan has been submitted;
data demonstrates there is no threat of endangerment to USDWs.

Once the Director approves site closure, the owner or operator is required to submit a site closure report within 90 days, with documentation of injection and monitoring, well plugging, notifications to State and local authorities that may have authority over future drilling activities in the region and records reflecting the nature, composition, and volume of the injected carbon dioxide stream.

Annex D

Overview of Guidelines or Regulations Addressing M&R for CCS activities

D1.1 *IPCC Guidelines for National Greenhouse Gas Inventories (2006)*

The IPPC has covered CCS, especially the storage stage, in Chapter 5 of their 2006 Guidelines for National Greenhouse Gas Inventories. General guidance is given on how to plan monitoring, what to monitor and how to report on results. The methodology and type of monitoring are prescribed or recommended in order to achieve meaningful and comparable GHG inventories. The recommendations in the document are drawing upon the IPPC (2005) Special Report on Carbon Dioxide Capture and Storage. Subsequent regulations (GHG rule and the EC CCS Directive were based on these guidelines, but omitted some and added other recommendations as the minimum obligatory content of the reporting).
The key features of what the monitoring programme should include according to IPCC are presented in ***Box*** D.1

Box D.1 Key Features of CCS Monitoring Programme

- Measurement of background fluxes of CO2 (Geological storage sites may have a natural background flux of emissions prior to injection that should not be included in the estimate of annual emissions) - isotopic analysis is recommended, to help distinguish between natural and injected CO2.
- Continuous measurement of the mass of CO2 injected at each well. Continuous monitoring of the injection pressure recommended.
- Monitoring to determine any CO2 emissions from the injection system.
- Monitoring to determine any CO2 (and if appropriate CH4) fluxes through the seabed or ground surface, through wells and water sources such as springs.
- Periodic investigations of the entire site.
- Periodic monitoring the distribution of CO2 in the subsurface recommended. Leakage to the seabed should be considered as emissions to the atmosphere.
- Periodic monitoring the distribution of CO2 in the subsurface recommended. Leakage to the seabed should be considered as emissions to the atmosphere.
- Post-injection Monitoring: In accordance to forward modelling of CO2 behaviour.
- Incorporating improvements in monitoring techniques/technologies over time.
- Periodic verification of emissions estimates.

The goal of the IPPC reporting guidance is to develop tier I and tier II emission factors that would simplify the GHG reporting for CCS operations in the future, however those are currently not available.

Guidelines also point out the complications in monitoring when the emissions from the sire arise in a different jurisdiction to the injection. Also in cases where CO_2 capture occurs in a different country from CO_2 storage, arrangements to ensure that there is no double accounting of storage should be made between the relevant national inventory compilers.

Units in the reports are Gg (gigagrams) with no further comment given to accuracy or rounding. The ability to measure the distribution, phase and mass of CO_2 in a subsurface reservoir will be site-specific.

D1.2 *EU ETS Monitoring & Reporting Guidelines (MRG)*

CCS was added to listed activities under EU ETS when the Directive 2009/29/EC amended EU ETS Directive (Annex I). CCS has therefore been included in the monitoring and reporting of greenhouse gas emissions with a decision on 8 June 2010. The decision adds specific CCS monitoring provisions to the Monitoring & Reporting Guidelines as annexes XVI-XVIII.

The key features of the EU ETS monitoring guidelines for CCS are presented in DBox D.2:

Box D.2 *Key Features of EU ETS M&R Guidelines for CCS*

- Covers all three stages: capture, transfer and storage
- Determination of emissions by calculation or continuous emission monitoring systems measurement (CEMS) if it reliably results in a more accurate determination of annual emissions. Since there are no emission factors yet established for majority of CCS activities, CEMS is the prevailing option for CCS.
- Monitoring plans must be approved by Competent Authority (as for EU CCS Directive)
- The emissions for the accompanying activities must be included must be included– for example fuel use at the booster stations.
- Obligatory third party verification
- Competent authority discretion to allow simplified emission reports in relation to closed storage installations.

For the **capture** element, the emissions must be calculated by using CEMS on the transfer routes with the maximum uncertainty of 2.5%.

For the **transport** element, emissions can be calculated either on mass balance from the CEMS at two ends or as a sum of the potential emissions (vented, fugitive, leakage events and at installations). Overall uncertainty must not exceed 7.5%

For the **storage** element, the M&R has four components in relation to:

- Emissions from fuel use at the injection site that are to be calculated and reported using standard stationary combustion methods
- Vented and flared emissions that must be monitored by CEMS
- Fugitive emissions that must be either calculated or measured by industry best practice with a maximum uncertainty of 7.5%.
- Leakage emissions that must be either calculated or measured by industry best practice with a maximum uncertainty of 7.5%.

The directive is linked to the EU CCS Directive in terms of boundaries of the sites, permits, etc. and the monitoring of fugitive emissions.. For example, the pursuant can use data for fugitive emissions, collected under the requirements of the UE CCS Directive, for ETS reporting.

Monitoring plan submitted at the permit application is the same for both Directives and need to be approved by both authorities. A part of EU ETS reporting are copies of monitoring plans, reports, and permits as required by EU CCS Directive.

D1.3 *EU CCS DIRECTIVE*

Monitoring of the injection facilities, storage areas and the surrounding environment is obligatory under EU CCS Directive. Detailed monitoring requirements are laid down in Annex II. Monitoring plans must be approved by the competent Authority. Plans must be updated at least every five years and submitted to the authority for re-approval. The results of monitoring must be submitted at least every year.

The Directive mandates that an operator should monitor the storage site before commencement of operations (to establish the environmental baseline) , during injection and post-closure.

The requirement to monitor the storage site for several years before the commencement of the operation could in some cases cause delays, especially for operators that intent to inject CO_2 to formations with limited or no pre-existing site information.

Monitoring must encompass a comparison between actual and modeled behavior of CO_2 and detect any significant irregularities, migration and leakage of CO_2 and any adverse effects of the surrounding environment and reporting should as a minimum include the quantities and properties of injected CO_2 streams.

In addition to the monitoring plan, a corrective measures plan must also be submitted during permit application and additional monitoring must also be implemented if any corrective measurements were required.

An assessment of the safety and integrity of the storage complex must be undertaken and updated.

After the transfer of responsibility all monitoring responsibility lies with the competent authority.

D1.4 *US EPA GREENHOUSE GAS REPORTING RULE*

In US, CO_2 storage activities reporting will be mandatory under the proposed EPA Greenhouse Gas Reporting Rule [(1)]. The rule applies to facilities (a well or a group of wells) that inject carbon dioxide in subsurface geologic formations for the purposes of geologic sequestration or enhanced oil and gas recovery either on or offshore. The enhanced oil and gas recovery facilities will have to provide only basic information and the sequestration facilities some further data.

The proposal is being conducted under Clean Air Act (CAA) section 144, which allows EPA to request information from regulated entities. The informational nature of the authority makes the rule not require control measures, remediation, or other actions that would aler the operations of the facility – the facility would not be expected to shut down or delay its operations in order to develop, gain approval of and implement its MRV plan.

Both types of facilities will have to provide basic information on CO_2 injected underground:

- The mass of CO_2 transferred onsite from offsite sources.
- The source category of the CO_2
- The mass of CO_2 transferred onsite from offsite sources using mass or volumetric flow meters and based on the CO_2 concentration in the flow.
- The mass of CO_2 injected using mass or volumetric flow meters and based on the CO_2 concentration in the flow.

In addition to the reporting requirements listed above, geologic sequestration facilities that inject CO_2 for the purpose of long-term containment in subsurface geologic formations (but not the ones that only conduct enhanced recovery) would be required to develop and later implement a monitoring, reporting, and verification (MRV) plan. They will be required to develop the MRV themselves to be approved by EPA. It must include the following:

- An assessment of the risk of CO_2 leakage to the surface.
- A strategy for detecting and quantifying any CO_2 leakage to the surface.
- A strategy for establishing pre-injection environmental baselines.
- A summary of considerations made to calculate site-specific variables for the mass balance equation.

They must also annually report:

- The mass of fugitive and vented CO_2 emissions from surface equipment at the facility.
- The mass of CO_2 produced with oil or gas, if applicable.
- The mass of CO_2 emitted to the surface from the subsurface, if applicable.
- The mass of CO_2 sequestered in the subsurface geologic formation.

The rule does not touch upon the issues such as the accuracy of measurement, units of metering etc and they are left to the discretion of the operator when submitting the monitoring plans. It's not clear at the moment whether EPA will provide further guidance on the form and content of the MRV to address these gaps.

([1]) US EPA: Mandatory Reporting of Greenhouse Gases: Carbon Dioxide Injection and Geologic Sequestration (EPA-HQ-OAR-2009-0926) 2010

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