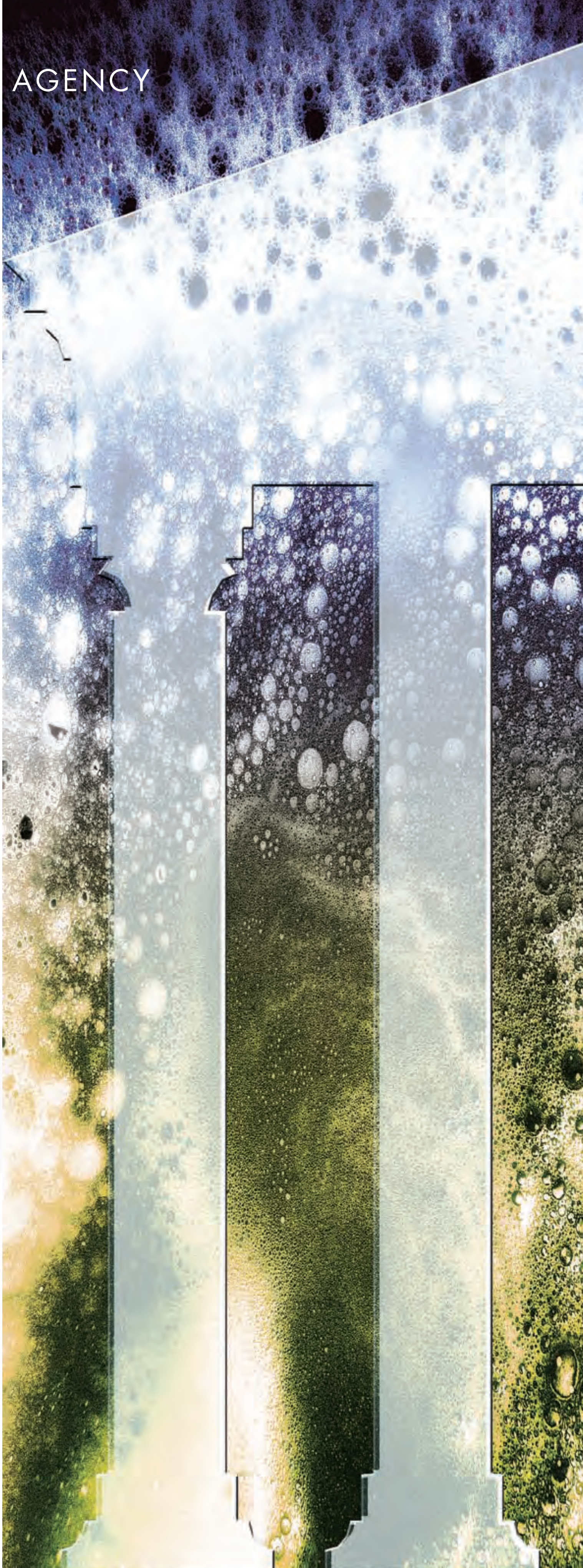
INTERNATIONAL ENERGY AGENCY



LEGAL ASPECTS OF STORING CO_2

Update and Recommendations

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OECD

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- To maintain and improve systems for coping with oil supply disruptions.
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- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To assist in the integration of environmental and energy policies.

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The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.
The European Commission takes part in the work of the OECD.

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FOREWORD

There is a strong and growing global interest in advancing carbon dioxide (CO_2) capture and storage as a greenhouse gas mitigation strategy. Recent IEA analysis confirms that coal and other fossil fuels will continue to play a key role in providing our energy in the future. CO_2 capture and storage (CCS) will allow us to continue using these resources while we simultaneously pursue energy efficiency, renewable, and nuclear energy opportunities. The energy challenges we face are great; all of these technologies must play roles to achieve a sustainable future.

The first IEA *Legal Aspects of CO_2 Storage* Workshop in 2004 started an important body of work analysing legal issues surrounding CO_2 storage in domestic and international law. The second workshop, held in October 2006, made significant progress by collecting case studies and sharing legal and regulatory developments from around the world that advance the viability of CCS. This book thus provides a compilation of essential information regarding the legal, policy and regulatory principles for CCS.

While this progress is to be commended, much more work needs to be done at the local, national and international levels to facilitate large-scale CO_2 storage demonstration projects to lay the groundwork for expansion of this important greenhouse gas mitigation option. Several new major CCS projects have been recently announced, and require clear guidance on key issues like monitoring and verification requirements and long-term liability. There is an urgent need for governments to develop "fast track" regulatory approaches to speed implementation of these projects, as they will provide important data on CO_2 retention to guide the development of much-needed standards, as well as increase public acceptance and understanding of this important technology.

I am delighted that the IEA continues to provide value to the international CO_2 capture and storage community, and hope that this latest publication paves the way for future work to improve the investment security for continued progress this important technology.

Claude Mandil
Executive Director

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The IEA thanks the Carbon Sequestration Leadership Forum for co-sponsoring the 2nd IEA/CSLF Workshop on Legal Aspects of Storing CO_2, and the French Ministère de l'Industrie for hosting the event.

Finally, the IEA would like to thank all of the speakers and panellists at the Paris workshop for their contributions: Clare Haley, Alexandra Neri, Barry Worthington, Ian Hayhow, Robert Sussman, Tania Constable, John Torkington, Simon Read, Jill Barrett, Caroline van Dalen, Amparo Agrait, Andy Greaves, Tim Dixon, Paul Zakkour, Tore Andreas Torp, Jeff Logan, Mette Karine Gravdahl Agerup, Magnus Pettersson, David Reiner and Paal Frisvold.

TABLE OF CONTENTS

KEY MESSAGES

Carbon dioxide (CO_2) storage demonstration projects must rapidly expand to guide future legal developments.

- To achieve a variety of legal and policy goals related to increasing the use of CO_2 storage – including developing CO_2 monitoring frameworks, increasing public acceptance and levelling the playing field for CO_2 capture and storage (CCS) relative to other greenhouse gas (GHG) mitigation options – effective CO_2 storage needs to be demonstrated rapidly at a wider variety of sites. Additional demonstration is essential to better understand and validate CO_2 storage retention in different geologic formations and to develop criteria to select and rank appropriate sites. Expanded demonstration will provide critical data to enable the development of guidance for CO_2 storage monitoring and verification practices. That, in turn, will accelerate the deployment of CCS, and allow it to move from the current level to the one required for stabilized emissions levels.

A number of national legal and regulatory issues merit attention; however, the near-term priority should be spurring additional demonstration projects.

- The development of an effective regulatory system – without overlap and confusion among and between different organisations – is a key first step toward developing industry and community confidence in CO_2 storage activities. Projects should be subject to scrutiny based on the relative risk posed to the environment and community. CO_2 storage project investors require rules that establish clear rights and responsibilities relating to access to the property and that clarify their responsibilities pre- and post-closure. Finally, intellectual property rights do not appear to present significant issues. Future work should focus on outreach and capacity-building efforts to enhance intellectual property regimes in developing regions.

Additional guidance is needed to advance CO_2 storage incentives, including participation in emissions trading schemes.

- While important work is underway to establish methods for including CO_2 capture and storage in the United Nations Framework Convention on Climate Change additional work may be helpful to advance CO_2 capture and storage in the Kyoto Protocol context as well as in national and regional emissions trading systems. Work is needed to develop baselines, monitoring, reporting and verification guidelines, and to address leakage. Additionally, governments should explore "fast-track" regulations and a variety of other research, development and demonstration incentives to advance near-term projects.

Rapid progress has been made in the past three years to address CO_2 storage; harmonised international guidance is required for further progress.

- International marine environment protection instruments are taking important steps to guide the advancement of CO_2 storage. For example, the recent amendment to the London Convention now provides a basis in international environmental law to regulate CO_2 storage in sub-seabed geologic formations, subject to licensing by governments. The next step is to provide governments and CO_2 storage project proponents with internationally agreed-upon guidance for monitoring and verification that will demonstrate the integrity of a proposed storage site with monitoring and mitigation safeguards in place.

INTRODUCTION

In 2004, the International Energy Agency (IEA) Working Party on Fossil Fuel jointly organised a workshop with the Carbon Sequestration Leadership Forum (CSLF) on the legal aspects of CO_2 storage. This workshop, held in Paris, was the first international event to systematically examine the legal issues affecting the storage of carbon dioxide (CO_2) as a greenhouse gas (GHG) mitigation strategy. The workshop concluded by highlighting the urgent need for appropriate regulatory and legal frameworks to facilitate the successful uptake of CO_2 storage, with a particular emphasis on the need to facilitate large-scale demonstration projects.

The subsequent IEA publication, *Legal Aspects of Storing CO_2* (IEA, 2005), provided an overview of the main legal and regulatory issues. The publication noted **five important areas that merited further work and analysis. The five areas were:**

- **Increase the number of CO_2 storage demonstration projects,** including CO_2 enhanced oil recovery (EOR), focusing on long-term storage and monitoring aspects in order to establish criteria for optimal siting, verifying the results and assessing the environmental impact of carbon storage, establish monitoring benchmarks and risk management practices. Increase public-private partnerships to achieve these goals, and explore contractual rights and responsibilities related to CO_2 storage projects including intellectual property rights.
- In the short-term, **governments should ensure that there is an appropriate national legal and regulatory framework for storage demonstration projects.** In the interest of time, and given the diversity of institutional setups and policy processes between States, working at the national and/or provincial/state level using existing legal frameworks might be the preferred route. Longer term national frameworks should be formulated on the basis of adequate empirical knowledge about the conditions and risks of long-term storage.
- Contracting parties to international instruments should **take a proactive approach to clarifying the legal status of carbon storage in the marine environment protection instruments,** taking into consideration not only their marine environment protection objectives, but also their objectives regarding climate change mitigation, energy security, sustainable economic development and poverty reduction.
- Governments should **create a level-playing field for CO_2 storage with other climate change mitigation technologies** in the various climate change mitigation instruments, including market-oriented emission trading schemes.
- Both the public and private sectors should **increase public awareness and work on gaining public acceptance of CO_2 storage** by increasing the transparency of their activities and making information about on-going projects available to the public.

In October 2006, the IEA and the CSLF revisited these themes at a follow-on workshop, the 2nd IEA Workshop on *Legal Aspects for Storing CO_2* in Paris, France. Legal developments in the carbon capture and storage arena had proceeded at a rapid pace between the two workshops, and participants came together to share case studies and highlights of policies and regulations in these and other areas. As a way to stimulate discussion, participants prepared a background paper highlighting these developments, along with relevant national and international case studies.

The second workshop explored the five issue areas in greater detail, asking whether these five areas merited further international attention. Workshop participants also examined additional gaps and barriers to the deployment of CO_2 capture, and identified recommendations to guide further development of appropriate legal and regulatory frameworks. The workshop benefited from the participation of over 120 government, industry and non-governmental legal practitioners that offered insights and experiences gained from developing legal systems to govern CO_2 storage.

Structure of this report

This publication summarises the discussions and developments related to the IEA/CSLF October 2006 workshop, and reorganises issue areas to reflect changed priorities. It also includes recommendations for priorities for future work in this critical area. Each chapter is designed to provide an overview of key legal aspects of CO_2 storage, and include relevant case studies where appropriate. The chapters are arranged as follows.

Background information

This chapter provides an overview of carbon capture and storage (CCS) components and the associated technologies, including CO_2 storage in the context of climate change; an explanation of the stages of a CO_2 storage project; costs and the potential for cost reductions in the future; challenges for future deployment; and international experiences and cooperation.

National legal and regulatory frameworks

This chapter is a key area for legal developments related to CO_2 storage. It highlights the issues that are typically covered under national regulations or policies, including:

- The goals of regulation and jurisdictional issues;
- Property rights issues, including ownership and liability at storage sites and intellectual property rights;
- Monitoring and verification requirements;
- Incentive programs to advance CO_2 storage, including emissions trading schemes; and
- Ensuring stakeholder participation in review of proposed CO_2 storage sites.

International marine environment protection instruments

This chapter provides an inventory of existing international marine protection instruments and their current and planned treatment of CO_2 storage activities. Two frameworks – the London Convention and the OSPAR Convention – have had considerable legal developments related to CO_2 storage in the past two years.

Recommendations for further work

This section concludes the publication with recommendations for further work.

Annexes

The Annexes include background information on technology costs, demonstration projects, intellectual property rights, case studies of CO_2 storage public awareness efforts, and background information (including relevant treaty provisions) from international marine environment protection and climate change instruments.

1. BACKGROUND INFORMATION

Overview of carbon capture and storage

CCS and climate change

The world cannot continue to use fossil fuels at the rate needed to satisfy energy needs without adversely affecting the Earth's climate and the environment. Despite important steps taken by government and industry to mitigate GHG emissions, CO_2 emissions have increased by over 20% over the past decade. If the future is in line with present trends as illustrated by the *World Energy Outlook 2006* Reference Scenario (IEA, 2006), CO_2 emissions will continue to grow rapidly over the next 25 years. This is after taking account of energy efficiency gains and technological progress that can be expected under existing policies, including the United Nations Framework Convention on Climate Change, the Kyoto Protocol and related national efforts to implement these instruments. The carbon intensity of the world's economy is expected to increase dramatically due to greater reliance on coal for power generation and increased emissions from transportation, among other things. As a result, CO_2 emissions are forecast to be almost two and a half times the current level by 2050 (IEA, 2006).

This alarming outlook can, however, be changed with a portfolio of existing and emerging mitigation technologies. These technologies not only reduce CO_2 emissions, but also improve economic efficiency, competitiveness, and local environmental quality. Energy efficiency, renewable energy, advanced bioenergy, advanced hydrogen production for transportation, nuclear power generation and CO_2 storage are all key aspects of a global response to address climate change.

With appropriate carbon capture, CO_2 storage technologies can significantly reduce CO_2 emissions from power generation, industry and the production of synthetic transport fuels. In the IEA *Energy Technology Perspectives* Accelerated Technology Scenarios, which model technologies which exist today or which are likely to become commercially available in the next two decades, CCS technologies contribute 20-28% of total CO_2 emission reductions below the expected baseline by 2050 (IEA, 2006a). That makes it the second largest contributor to emissions reduction, after energy efficiency improvements (see Figure 1.1). However, in order to achieve substantial emissions reductions, CO_2 storage needs to be deployed on a large scale – estimated to be 3 600 times the CO_2 that is currently being stored at the Sleipner project in the North Sea (MIT, 2007).

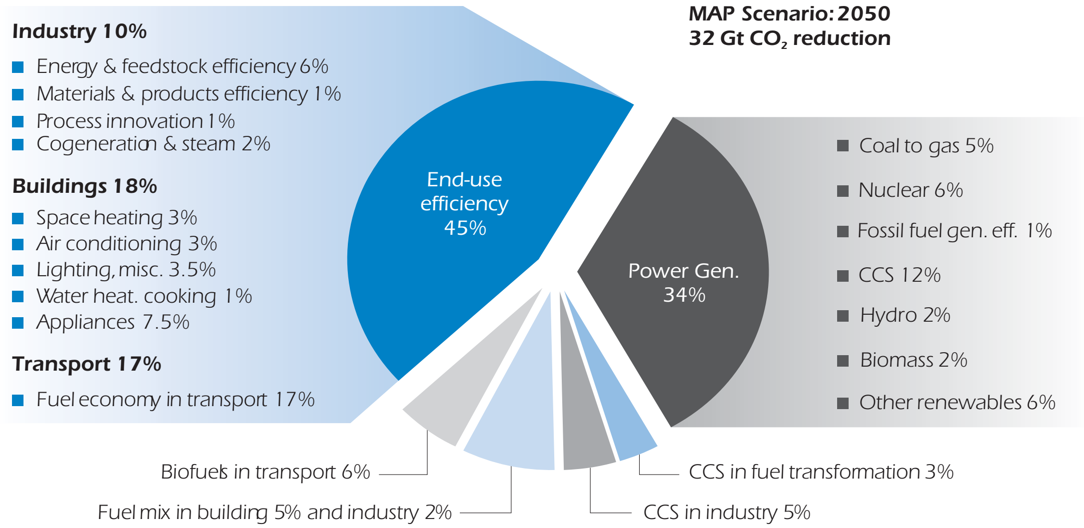
Carbon capture and storage technologies: an overview

While the focus of this publication is on the legal aspects of CO_2 storage, storage cannot be considered in isolation from CO_2 capture and transport. These technologies and practices are discussed here briefly; a number of recent publications include a detailed discussion of those technologies (IPCC, 2005; Wilson and Gerard, 2007), and applications prospects (IEA, 2004).

Carbon capture and storage involves three distinct stages (Figure 1.2):

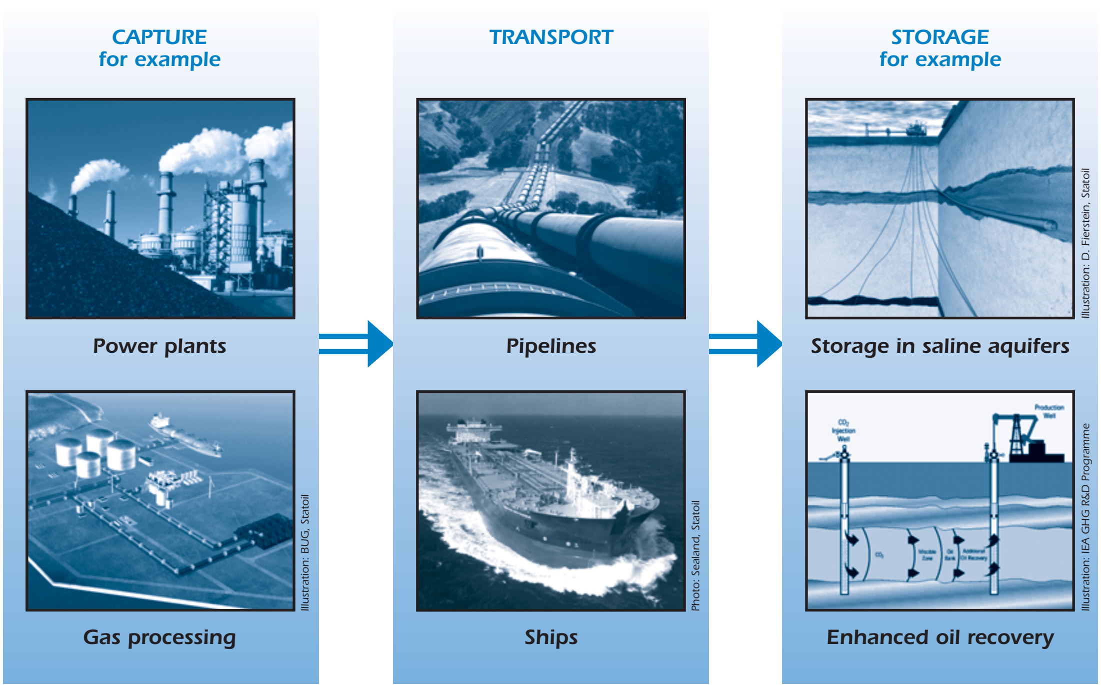
- Capturing CO_2 from power plants, industrial processes or fuel processing, conditioning and compression;
- Transporting the captured CO_2 by pipeline or by other means, such as ships, (unless the anthropogenic source is collocated with the reservoir or sink); and

Figure 1.1: Emission reduction by technology area



Source: IEA, Energy Technology Perspectives (2006).

Figure 1.2: CO_2 capture, transport and storage



Source: IEA, Energy Technology Perspectives (2006).

- injecting (storing) and monitoring CO_2 underground in different geologic formations, including deep saline aquifers, depleted oil and gas reservoirs or un-mineable coal seams. The technologies that are needed have been in use for decades, albeit not in combination with the purpose of reducing CO_2 emissions.

CO_2 capture

While carbon dioxide separation has been widely applied in industrial processes and for natural gas processing, their use for commercial-scale power plants needs to be demonstrated. A number of demonstration projects for coal- and gas-fired power plants and fuel separation with CO_2 capture are in various stages of development (see Figure 1.5). CO_2 can be captured either before or after combustion using a range of existing and emerging technologies. In conventional processes, CO_2 is captured from the flue gases produced during combustion (post-combustion capture). It is also possible to convert the hydrocarbon fuel into CO_2 and hydrogen, remove the CO_2 from the gas stream and combust the remaining hydrogen-rich gas (pre-combustion capture). In pre-combustion capture, physical absorption of CO_2 is the most promising option. In post-combustion capture, options include processes based on chemical absorption or oxy-fuelling. If oxygen is used for the combustion process, a nearly pure CO_2 flue gas is generated without requiring further separation. In the long term, gas separation membranes and other new technologies may be used for both pre- and post-combustion capture. Captured CO_2 must generally be pressurised to 100 bar or more for transportation and storage. This pressurisation adds to the energy intensity of the overall process.

In electricity generation, CO_2 capture appears to make economic sense only in combination with large-scale, high-efficiency power plants. For coal-fired plants, a promising technology is integrated gasification combined-cycle (IGCC) fitted with physical absorption technology to capture CO_2 at the pre-combustion stage. Other alternatives may emerge, including coal-fired ultra-supercritical steam cycle plants fitted with post-combustion capture technologies or various types of oxygen-fuelling (oxy-fuelling) technology (including chemical looping, where the oxygen is supplied through a chemical reaction instead of air separation). For natural gas-fired plants, promising options include oxy-fuelling (including chemical looping), pre-combustion gas shifting and physical absorption in combination with hydrogen turbines, or post-combustion chemical absorption. At a later stage, fuel cells may be integrated into high-efficiency gas and coal-fired power plants fitted with capture technologies. Capturing CO_2 from plants that cogenerate electricity and synthetic fuels could also reduce cost.

In fuel processing, a gas stream containing a high content of CO_2 is already the result of the production process, and this contributes to the low cost for CO_2 capture from these processes. For example, sour natural gas (gas that contains CO_2 and/or hydrogen sulphide) has to be "sweetened" (the CO_2 and hydrogen sulphide have to be removed to market specifications), usually using amine-based systems, before the gas can enter the collection and distribution pipeline system. Similarly, hydrogen plants in refineries and tar sands upgrading plants produce a very high-purity CO_2 stream whose capture cost is quite low. For this reason, it is more likely that the first large-scale CO_2 storage operations will be associated with fuel processing plants rather than with power plants.

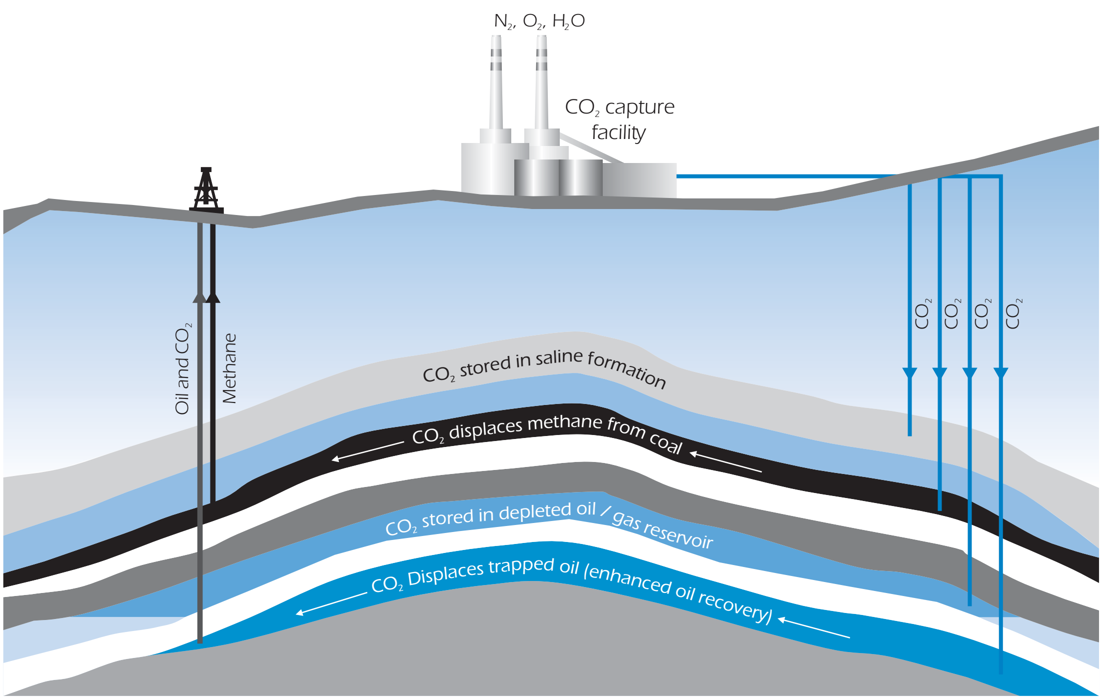
CO_2 storage

A number of geologic reservoirs appear to have the potential to store thousands of gigatons of CO_2 (IPCC, 2005; MIT, 2007). Geologic structural and stratigraphic traps have demonstrated the ability of reservoirs to seal and store hydrocarbon liquids and gases for millions of years. Large, long-standing geologic occurrences of CO_2 and other non-hydrocarbon gases are also known. The mechanisms that initially trapped these materials remain intact as fluids are extracted from or injected into these reservoirs. The prospects for ocean storage in the water column are hampered by a number of environmental risks, and above-ground storage would likely be quite costly and the technology is immature (IPCC, 2005).

As illustrated in Figure 1.3, geologic storage venues include:

- Depleted oil and gas reservoirs;
- Producing oil reservoirs, utilising CO_2 injection for enhanced oil recovery and later long-term final storage;
- Enhanced gas recovery;
- Unmineable coal seams suitable for enhanced coal bed methane recovery; and
- Deep saline formations.

Figure 1.3: Geologic venues for CO_2 storage



Source: IPIECA, 2007.

Prior to injection, CO_2 must be compressed to enable injection at reservoir conditions. CO_2 can be stored in dense phase natural geologic formations at a depth of more than 600 metres. At depths below 800-1 000 metres, the ambient pressures and temperatures in the reservoir will usually result in CO_2 being in a liquid or supercritical state. Since the liquid or supercritical CO_2 at reservoir conditions occupies a much smaller volume than the gaseous state at atmospheric conditions, this provides the potential for more efficient utilisation of underground storage space and improves storage security.

CO_2 is retained in geologic formations by a combination of physical and geochemical trapping mechanisms, with the proportion of exact mechanisms depending on the formation type and fluid properties, as well as the time scales. These trapping mechanisms include dissolution in water, trapping by capillary forces in small pores and long-term mineralisation. In oil reservoirs, CO_2 may dissolve in oil, but a portion will remain in the reservoir. For saline formations without distinct geologic traps, the presence of an impermeable caprock above the reservoir, residual or capillary trapping, and the geochemical mechanisms of solubility and mineral trapping are important. The formation water saturated with CO_2 is denser than water without the CO_2; therefore, the formation water containing CO_2 will sink slowly to the bottom of the storage formation. Enhanced coal bed methane recovery through the injection of CO_2 is also possible due to the preferential adsorption of CO_2 over methane onto the coal matrix. In this case, the CO_2 is expected to remain trapped so long as pressures and temperatures remain stable (IPCC, 2005, Bachu and Celia (2006)).

The steps to determine if a geologic formation is suitable for long-term CO_2 storage include:

- Site characterisation – confirming the appropriateness of a site for CO_2 storage through evaluations of surface area land use, the site's geology and hydrogeology, its capacity to store the desired amounts of CO_2, flow characterisation in the injection reservoir and the underlying layers, and identifying possible pathways for leakage.
- Risk assessment – determining the potential risks of physical leakage from the geologic formations, using models to predict movements of CO_2 over time and identifying specific locations where leakage might occur.

The injection of CO_2 in deep geologic formations involves many of the same technologies that have been developed in the oil and gas exploration and production industry; including well drilling, fluid injection, computer simulation of storage reservoirs and monitoring.

It is likely that most CO_2 storage will occur in saline formations, because of their large storage potential and broad distribution (IPCC, 2005). CO_2 storage in combination with enhanced oil recovery has been demonstrated at the Weyburn project in Canada, where about 2 million tonnes of CO_2 per year has been injected since 2001. At Weyburn and other projects, important progress has been achieved in the understanding and monitoring of CO_2 behaviour underground. So far, no leakage has been detected; monitoring these sites will continue to offer important data that will facilitate additional demonstrations at a wider variety of sites (PTRC, 2004).

A priority for governments should be to undertake bottom-up capacity assessments for CO_2 storage, taking into account specific concerns for each type of geologic storage. For example, at depleted hydrocarbon fields, the incremental costs necessary to ensure well or field integrity need to be assessed. For saline formations, key issues involve mapping potential permeability fast-paths out of the reservoir, accurate rendering of subsurface heterogeneity and uncertainty, and appropriate geo-mechanical characterisation. For unmineable coal seams, the issues are more substantial: demonstration of understanding of cleat structure and geochemical response, accurate rendering of sealing architecture and leakage risk, and understanding transmissivity between fracture and matrix pore networks. For these reasons, the regulatory framework will need to be tailored to different classes of sites (MIT, 2007). The CSLF has recently reviewed the applicability of methodologies for estimating CO_2 storage capacity to various assessment scales (CSLF, 2007).

All options–including CO_2 EOR and enhanced coal bed methane recovery–that enhance fossil fuel production can create revenue that may offset part of the capture, transportation and injection costs. Indeed, these projects can generate revenue from the sale of CO_2, jump-starting technology commercialisation. Encouraged by the promising results so far, a number of underground storage demonstration projects have been started or are planned. All the individual elements needed for carbon capture and storage have been demonstrated, but there is an urgent need to expand on current projects with other integrated full-scale demonstration plants. It is likely that several technologies can co-exist, but all options require further improvements to cut costs before they can be applied on a commercial scale, a process which is likely to take several years. Research and development (R&D) is needed for emerging options such as chemical looping, while demonstration projects are needed for other pre- and post-combustion processes. This development must be accelerated if carbon capture and storage is to play a substantial role in mitigating greenhouse gas emissions.

Prospects for CO_2 capture technologies

More than 60% of the carbon capture potential in 2050 is related to power plants, while the remaining is associated with industry and fuel transformation (IEA, 2006a). We focus here on capture from power plants, given the rapid pace of deployment of coal-based plants in developing economies. Assessment of capture costs from medium-scale units is currently being made by the IEA Greenhouse Gas R&D Programme.

Cost and potential for cost reductions from power plants

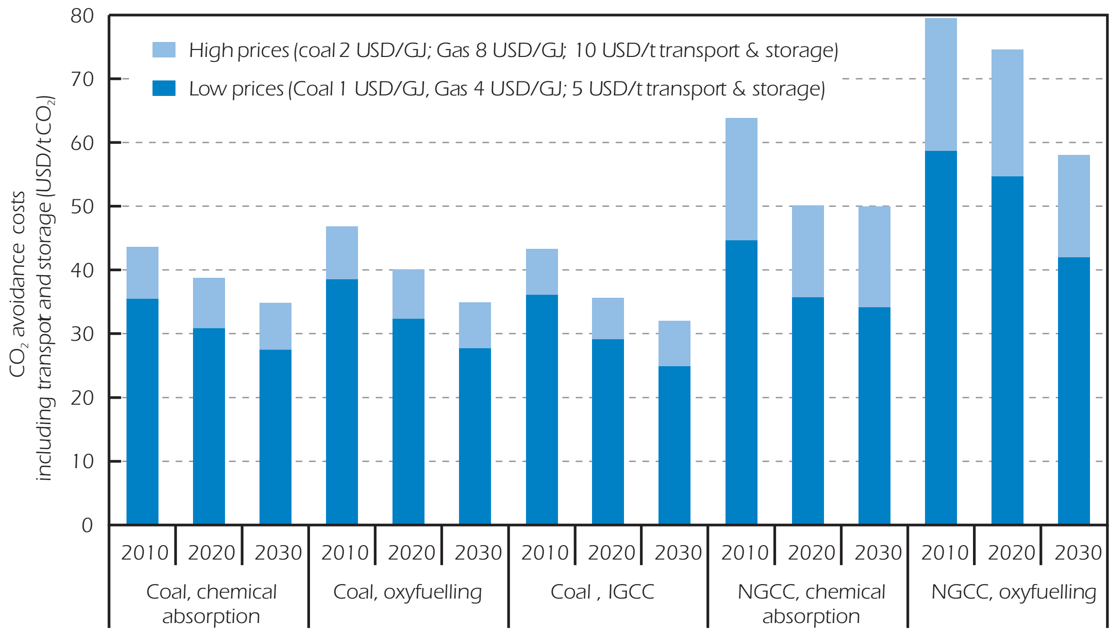
The bulk of project costs are associated with carbon capture. The cost of carbon capture from power plants generally ranges between USD 40 and USD 90 per tonne of CO_2 captured and stored, but is highly dependent on the power plant fuel and the technology used (see Figure 1.4 below; see also Annex 1). For the most cost-effective technologies, capture costs are USD 20 to USD 40 per tonne. In certain cases, depending on factors such as oil price, extraction economics and reservoir performance, the benefits from enhanced oil recovery can offset part or all of the capture, transportation and injection costs. By 2030, costs could fall to below USD 25 per tonne of CO_2 captured for coal-fired plants, provided sufficient R&D and demonstration efforts are put in place (IEA, 2004).

Using carbon capture and storage with new natural gas and coal-fired power plants would increase electricity production costs by USD 0.02 to USD 0.03 per kilowatt hour (kWh). By 2030, cost could fall to USD 0.01 to USD 0.02 per kWh. The costs of pipelines for CO_2 transportation depend strongly on the volumes being transported and, to a lesser extent, on the distances involved. Large-scale pipeline transportation costs range from USD 1 to USD 5 per tonne of CO_2 per 100 kilometres (IEA, 2004).

The cost of CO_2 storage depends on the site, its location and method of injection chosen, as well as the cost of monitoring. In general, at around USD 1 to USD 2 per tonne of CO_2, storage costs are marginal compared to capture and transportation costs. As a result, longer-term costs for monitoring and verification of storage sites are of secondary importance. Revenues from using CO_2 to enhance oil production could be substantial. The level of EOR can range from 0.1 to 0.5 tonne oil per tonne of CO_2. At an oil price of 45 USD/barrel, this translates into USD 30 to USD 160 per tonne of CO_2. This would offset all or a significant share of the capture cost; at higher oil prices, such projects could be revenue positive.

The future cost of capturing, transporting and storing CO_2 depends on which technologies are used, how they are applied, how far costs fall as a result of research, development and demonstration and market uptake, and fuel prices. Since capture requires more energy use and leads to production of more CO_2, the cost per tonne of CO_2 emission reduction is higher than the

Figure 1.4: CO_2 capture and transport costs



Source: IEA Analysis.

per-tonne cost of capturing and storing CO_2. The gap between the two narrows as CO_2 capture energy efficiency increases.

Efficiency and retrofitting

Carbon dioxide capture from power plants with low efficiency is not economically viable. The higher the efficiency of electricity generation, the lower the cost increases per kilowatt-hour of electricity. Therefore, investing in high-efficiency power plants is a first step. It may be possible to retrofit capture installations to high-efficiency power plants. Such capture-ready plants constitute a new concept that is currently being developed.

In a case study of a new gas-fired power plant in Karstø, Norway, two capture systems were compared. The first was an integrated system, where steam was extracted from the power plant, and the second a back-end capture system with its own steam supply designed for retrofit after the power plant had been built. The analysis suggested an efficiency penalty of 3.3 percentage points for the retrofit option but similar investment costs (IEA, 2004). This efficiency penalty is modest and therefore investments in capture-ready plants may make economic sense if natural gas prices are sufficiently low and the need for CO_2 capture is uncertain.

Since most coal-fired power plants have a long life span, rapid expansion of CO_2 capture in the power sector would mean retrofitting. New capacity will still be needed to offset the capacity de-rating caused by CO_2 capture. In the case of new coal-fired IGCC plants, the initial design could allow for retrofit at a later stage. This would require space for a shift reactor, physical absorption units, air separation unit, expanded coal handling facilities and larger vessels. Also, CO_2 capture would involve changes in the gas turbine, as the gas composition would change. Pulverised coal-fired plants could also be retrofitted. Oxy-fuelling retrofits are being proposed for projects in Germany and Australia.

Experiences with CO_2 storage

A number of CO_2 storage projects are currently being carried out around the world. Figure 1.5 shows the location of the main CO_2 storage monitoring projects (see Annex 2 for a current table of major demonstration projects). Additionally, there are around 70 CO_2 EOR sites globally, all operated by major and independent oil companies; the majority is in North America where approximately 40 million metric tonnes of CO_2 are injected annually. Others are planned or already operating in Australia, the United Arab Emirates, North America, China and parts of Europe.

Below is a brief summary of four major CO_2 storage projects: the operational projects Sleipner in the North Sea; Weyburn in Canada; In Salah in Algeria; and the planned Gorgon project in Australia. The projects inject or plan to inject CO_2 into a variety of geologic formations, including depleted hydrocarbon reservoirs, coal seams and saline formations, using varying amounts of CO_2. The Sleipner project injects 20 M tonnes of CO_2; the Gorgon project has the potential to inject up to 120 million tonnes. All projects involve the long-term storage of CO_2 and no venting is expected after project completion. In the Weyburn project, CO_2 is separated from recovered oil and re-injected along with the anthropogenous stream.

Sleipner

Sleipner is a private sector project that stores CO_2 from industrial sources into the subsurface beneath the North Sea in Norway. The lead organisation managing the project is Statoil. The project began injecting CO_2 in 1996. Sleipner was the first industrial-scale CO_2 storage project in the world, and the operators have established extensive monitoring procedures, including models to predict long-term movement of CO_2. While the original saline aquifer CO_2 storage project ended in 2002, project activities continued under the EU-funded CO_2STORE project from 2003-06, and continue today under the CO_2 ReMoVe effort (IPCC, 2005). Use of time-lapse seismic monitoring has provided a significant insight to the migration of CO_2, and a comparison with numerical reservoir simulation (SACS, 2002).

Weyburn

In May 1999, PanCanadian Resources, a Canadian oil company, broke ground at the Weyburn enhanced oil recovery project in southeastern Saskatchewan, Canada. This EOR project takes approximately 5 000 tonnes per day of CO_2 from a coal gasification plant in North Dakota, USA, and uses it to recover incremental oil. A pipeline transports the CO_2. The first CO_2 was injected in 2001. The field covers 50 000 acres; the amount of oil in place is estimated at 1.3 billion barrels, and with EOR, the amount of recoverable oil will be enhanced significantly. At the conclusion of the project, some 19 million tonnes of CO_2 will have been sequestered. Monitoring is carried out by Saskatchewan Energy and Mines, EnCana and the Petroleum Technology Research Centre, with of the University of Regina with the assistance of the IEA Greenhouse Gas R&D Programme EU participation. The monitoring includes all aspects of the fate of the CO_2, including its reactions with the formation and formation fluids and its movement at the well bore and within the reservoir (IPCC, 2005).

In Salah

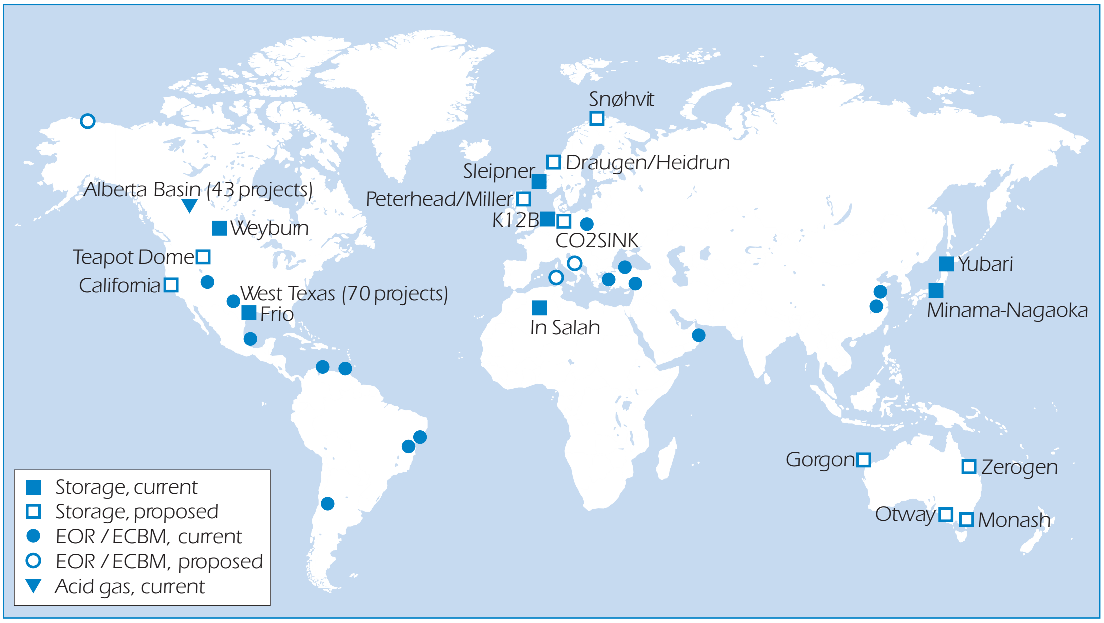
In Salah is a private sector project located in central Algeria that was designed to test the commercial viability of CO_2 storage as a CO_2 mitigation option. Is it a joint venture between BP, the state oil and gas company Sonatrach, and Statoil. The project began in 2004, and involves the injection of up to 4 000 tonnes per day of CO_2. The project includes a facility that removes

CO_2 from the natural gas produced from the field followed by the reinjection of the CO_2 into the aquifer that underlies a gas reservoir, with a planned total storage of 17 million tonnes of CO_2 (IPCC, 2005).

Gorgon

Gorgon is a planned commercial project that will inject CO_2 into a saline formation beneath Barrow Island off the coast of Western Australia in 2011. Chevron is the lead organisation within the Gorgon Joint Venture Group, which also includes ExxonMobil and Royal Dutch Shell. The CO_2 injection project is part of a large natural gas processing facility that is planned to be built. Once the injections begin, it will be the largest-scale CO_2 storage project in the world, with an intended injection rate of up to 10 000 tonnes of CO_2 per day. The project proponents plan to inject CO_2 contained in the reservoir's natural gas after it is removed as a routine part of the gas processing. The project aims to inject approximately 2.7 million tonnes per year over a potential project lifetime of 40 years. A comprehensive environmental impact statement has been generated as part of the project's due diligence (IPCC, 2005).

Figure 1.5: current and proposed CO_2 storage projects



Source: IPCC, 2005.

Challenges to future deployment

The main challenges for the future adoption of CO_2 capture and storage technologies include technology and costs, legal and regulatory issues, international mechanisms, financing, and public acceptance. CO_2 capture and storage technologies are not expected to be deployed in the absence of a CO_2 incentive, except for cases with substantial benefits from enhanced oil recovery, ECBM, and related extractive techniques. As a result, EOR technologies are expected to play an important role in the commercial deployment of CO_2 storage technologies in the years ahead. However, the same reasoning applies to other low-carbon electricity production options with higher costs – including wider use of renewable and nuclear energy – and CO_2 capture and storage seems a relatively low-cost option to mitigate CO_2 emissions, especially in countries that rely heavily on coal for power generation.

A key challenge is the issue of underground retention of CO_2. All three storage options–deep saline aquifers, depleted oil and gas reservoirs, and unmineable coal seams – need more proof on a large scale to gain wider public acceptance. Monitoring and measurement systems which validate CO_2 storage activities and sites must also be implemented. Sufficient proof of a high degree of CO_2 retention will be essential for public acceptance. While projects involving natural gas storage and acid gas storage, which have similar characteristics as CO_2 storage projects, have worked well, more pilot projects are needed to better understand and validate the storage retention in various geologic formations and develop criteria to select and rank appropriate sites. Progress in modelling will allow increasingly accurate forecasts of the long-term fate of stored CO_2 which cannot be tested in practice.

International cooperation on carbon capture and storage

A number of international initiatives have been launched by the public and private sector to study, develop and promote CCS technologies. Several major on-going projects have a strong international collaboration component.

The International Energy Agency is involved in the development of a framework for carbon capture and storage through:

- IEA Implementing Agreements, in particular, the IEA Greenhouse Gas R&D Programme (GHG Programme) that has worked since 1991 on evaluation of technologies, promotion and dissemination of results and data from its evaluation studies and facilitating practical research, development and demonstration activities; the IEA Clean Coal Centre also works on CO_2 storage technologies;
- Working Parties, including in particular the IEA Working Party on Fossil Fuels (WPFF) that pursues the Zero Emissions Technologies for Fossil Fuels Initiative; the WPFF's Subcommittee on Legal Issues prepared this study and organised the 2nd *Legal Aspects of CO_2 Storage* Workshop;
- The IEA Coal Industry Advisory Board and its Zero Emissions Technologies Working Group; and
- The IEA Secretariat.

The Secretariat's work includes a response to the G8 request to accelerate the development and commercialisation of carbon capture and storage technologies. To accomplish this, in August 2006, IEA organised the first workshop on near-term opportunities for CCS together with the IEA WPFF, CSLF and industrial partners in San Francisco. Next workshops in the series on near-term CCS opportunities are planned in Oslo, Norway in June 2007 and Canada in late 2007. Work on a concept storage-ready power plant is being conducted by the IEA GHG Programme together with the IEA Secretariat (Gale, 2007). An update to the 2004 IEA publication on CCS is planned for the end of 2007.

The Carbon Sequestration Leadership Forum complements this work. CSLF is an international initiative under the auspices of the government of the United States bringing together 21 countries and the European Commission. The purpose of the CSLF is to facilitate the development of improved cost-effective technologies for the separation and capture of carbon dioxide for its transport and long-term safe storage; to make these technologies broadly available internationally; and to identify and address wider issues relating to carbon capture and storage. This could include promoting the appropriate technical, political, and regulatory environments for the development of such technology. The activities of the CSLF are conducted by the Policy and Technical Groups. Among other actions, seventeen major collaborative CO_2 storage projects have been already proposed by CSLF Members and recognised by the CSLF.

A major international project aimed at building a full-scale demonstration coal-fired plant is the FutureGen program launched by the United States. This demonstration will be based on coal gasification and pre-combustion capture. Similarly, the European Union's Zero Emissions Fossil Fuel Power Plant Technology Platform aims to have a zero emissions power plant commercially viable by 2020. To achieve this, the Commission has funded a portfolio of research projects in its fifth, sixth and seventh Framework Programmes is funding a portfolio of research projects aimed at advancing knowledge on CCS, including the CO_2 from Capture to Storage (CASTOR) project, Enhanced Capture of CO_2 (ENCAP) project, the in-situ research and development laboratory for geologic storage (CO_2-SINK), the Network of Excellence on Geologic Sequestration (CO_2GeoNet), and the CO_2ReMoVe effort, which aims to develop research and technologies for CO_2 storage monitoring and verification.

Related leading international efforts are CANMET, a pre-competitive collaborative R&D program supported by Natural Resources Canada, which is investigating the development of combustion and pollution abatement technologies for fossil fuels in oxygen and recycled flue gas atmospheres for the purpose of producing high-purity CO_2 streams that are capture ready for transport and storage; the Australian government's Cooperative Research Centre for Greenhouse Gas Technologies (CO_2CRC), which works collaboratively with industry to coordinate research efforts to advance the development and application of technologies to more effectively capture and store carbon dioxide; the Japanese Ministry of Energy and Technology support for CO_2 storage projects in a variety of geologic settings; and other European national programmes.

These various initiatives, among others, have contributed to the understanding of the existing international and national legal frameworks applicable to CO_2 storage, identifying legal and regulatory gaps in these frameworks and formulating recommendations for regulating CO_2 storage.

2. NATIONAL LEGAL AND REGULATORY FRAMEWORKS

The goals of regulation

There are a number of important goals guiding the establishment of legal and regulatory frameworks governing CO_2 storage. Governments are interested in promoting CO_2 storage as a climate change strategy while at the same time ensuring the protection of public health and the environment. These equally important goals can be accomplished through monitoring and verification requirements, establishment of liability schemes and ensuring robust public participation in planned projects. CO_2 storage project investors and developers also need rules that establish clear rights and responsibilities relating to property ownership and access, including specific guidelines on intellectual property. Governments are also looking to a variety of incentive schemes to speed demonstration of this important technology. This chapter will discuss these and other issues.

The development of an effective regulatory system is a first step toward developing industry and community confidence in CO_2 storage activities. Projects should be subject to scrutiny based on the relative risk posed to the environment and community. A regulator must have the power to direct certain actions, and ensure that effective risk assessment, monitoring and mitigation strategies are incorporated.

Due to the rapidly developing nature of CO_2 storage activities, there must be regular communications between technical research programs and regulators when developing and revising a legal and regulatory framework for CO_2 storage – a good example here relates to site assessment, where researchers are developing novel ways to identify CO_2 storage sites by predicting CO_2 storage pathways. It is widely accepted that additional large-scale demonstrations in a variety of geologic settings are needed to provide the technical basis for regulations. A first step some countries have taken in developing CO_2 storage regulations is to break down the project cycle into discrete stages, identifying specific legal and regulatory issues associated with these stages.

Australia: development of a regulatory framework

In 2005, the Australian Government consulted with all six States and two Territories to develop and agree a set of principles to achieve a nationally consistent framework for CO_2 storage activities. Through an extensive consultative process with government, industry, research organisations and non-governmental organisations, the *Regulatory Guiding Principles for Carbon Capture and Storage* (the principles) was endorsed by all Australian jurisdictions.

The principles cover assessment and approvals processes, access and property rights, transportation issues, monitoring and verification, liability and post-closure responsibilities, and financial issues. They were designed to provide industry with an investment climate that facilitates the uptake of CO_2 storage and enhance community confidence in the technology.

Although internationally it is accepted that there are three stages in the CO_2 storage lifecycle, that is capture, transport and storage, the Australian model identifies four stages as follows:

- Capture: capturing CO_2 from industrial processes, electricity generation, and hydrogen production to flue stack;
- Transport: transporting the CO_2 from the flue stack to the injection well;
- Injection stage: both pre-and post-injection activities; and
- Post-closure phase: incorporating storage, decommissioning and long-term responsibilities.

Source: Australian Government Department of Industry, Tourism and Resources.

Jurisdictional issues

One of the first questions a regulator must contend with in establishing a legal framework for CO_2 storage is the issue of jurisdiction. These large, long-term projects have the potential to interact with a variety of regulations and laws at the local, state/provincial, national and international levels (Vine, 2004). In addition, there are often multiple agencies with jurisdiction over aspects of CO_2 storage, including energy, environment and natural resource agencies. This can create challenges in developing nationally consistent rules for CO_2 storage. Some have suggested the creation of a high-level office be created at the Executive Branch (or equivalent national level) to facilitate an interagency process to sort out a jurisdictional framework for CCS (MIT, 2007).

Jurisdictional issues in Canada

Canada is a federal state (confederation) that comprises ten provinces and three territories. Given its federal structure, the federal and provincial governments have both exclusive and shared jurisdictions and responsibilities, and this is reflected also in the application of CO_2 storage and development of corresponding policies and regulations.

The federal government has jurisdiction over foreign affairs, including international treaties such as the London Convention and the Kyoto Protocol (Canada is a signatory to both), over the territories, which are administered directly by the federal government, over territorial waters, and over transboundary issues (interprovincial or international).

The provincial governments have exclusive jurisdiction over natural resources and economic development. Social issues and the environment are a shared responsibility between the two levels of government.

Within Canada, provincial governments may have different positions on CO_2 storage, which is to a certain extent a reflection of their primary energy mix, greenhouse gas emission profile, and potential for CO_2 storage. For example, the province of Alberta is a heavy user and producer of coal and is underlain by the Alberta basin, which has significant CO_2 storage potential. On the other hand, the province of Quebec, which derives almost all its power needs from hydroelectric energy and where about half of the CO_2 emissions are from transportation and buildings, has only limited potential for CO_2 storage, being almost entirely underlain by the Canadian Precambrian Shield.

Within governments at both levels, various aspects of CO_2 storage fall generally under the responsibility of two departments: Environment and its equivalents, and Resources, or Energy, and its equivalents. Within provincial boundaries, provinces have exclusive jurisdiction over the capture, transport and storage of CO_2 as long as the entire chain is contained within the respective province. In the CO_2 storage chain, the federal government would have jurisdiction over transport, and possibly storage, if any component of the CO_2 storage chain occurs in territorial waters or in the territories, or crosses a provincial or international boundary.

From a regulatory point of view, CO_2 storage implementation will likely fall under the authority and responsibility of regulatory agencies that regulate the energy industry (oil and gas, power generation). This will cover CO_2 capture, transportation (pipelines) and injection. However, groundwater protection falls under the authority of environment protection agencies, and in this case the two agencies usually coordinate their activities to address the potential for leakage and environmental impact assessments. As an example, the Alberta Energy and Utilities Board, which is the provincial regulatory agency in Alberta, will have jurisdiction over the CO_2 storage chain, but will coordinate with the Alberta Department of Environment in regard to groundwater protection, and with the National Energy Board (a federal agency) in regard to transboundary issues.

In Alberta, British Columbia (BC) and Saskatchewan there is a well-developed regulatory framework for oil and gas production which would handle CO_2 storage associated with enhanced hydrocarbon production (EOR, EGR and ECBM). Several EOR operations, including CO_2 flooding, are active in Alberta and Saskatchewan. Also, in Alberta and BC there are regulations in place for acid gas disposal in deep saline aquifers and depleted hydrocarbon reservoirs (there are more than 40 projects of this kind in Alberta and BC). While the individual scale of these operations is smaller than that needed for CO_2 storage implementation, their significance resides mainly in the fact that there is extensive technological and operational experience with the separation, capture, transportation and injection of these gases. Furthermore, in the federal and provincial jurisdictions there is already a regulatory framework in place dealing with the permitting, operation and abandonment of these operations. This regulatory framework could be adapted and focused toward CO_2 storage, but it will need to be expanded to cover the permanent storage and the post-abandonment stage of CO_2 storage operations, including monitoring and remediation. However, there are major issues that need to be addressed, such as ownership of the pore space from a legal and financial point of view (most, but not all, of the subsurface is government owned), liability, right of access, third party transfer, and incentives, among other things.

Given the nature of Canada's size, its diverse energy mix and its geology, it is most likely that regulatory solutions for CO_2 storage will be applied differently across the country. In this regard, the federal and provincial governments will need to focus their efforts toward producing a coherent policy, much of which already exists.

Source: Natural Resources Canada.

Threshold question: classification of stored CO_2

The definition of CO_2 and the process by which it is stored play a key role in determining jurisdiction. In general, stored CO_2 has been classified either as an industrial product, sometimes referred to as a resource, or as a waste product or pollutant. This distinction is important because industrial resource recovery projects are usually subject to regulation by existing oil and gas regulations while waste/pollutant disposal will fall under the jurisdiction of relevant environmental regulations.

In cases where CO_2 has been classified as a resource, this has largely been due to its commodity value for use in enhanced oil recovery. For example, enhanced resource recovery projects are allowed under international marine treaties because the purpose of the storage is not considered disposal, but rather a part of an industrial process. CO_2 storage projects that do not have a resource recovery component are in a legal grey area. In most jurisdictions, classifying stored CO_2 as a waste triggers the application of a set of rules that have been designed for other substances and might not be appropriate to CO_2.

Many of the domestic laws and international conventions relevant to CO_2 storage activities use defined terms to delineate their scope of coverage. Commonly used terms include: "pollution", "land-based pollution", "wastes", "hazardous wastes", "industrial wastes", "liquid wastes", "harmful substances", "dangerous substances", "dangerous activities", "operator", "ship", "sea", "dumping", "disposal" and "storage". These terms (and differences in their definitions and usage in different regimes and contexts) will determine whether a particular CO_2 storage activity is covered by a particular regime, and how it is to be regulated. Where it is not clear whether a CO_2 storage activity falls within or outside the scope of a defined term in a particular legal regime, this will likely need to be clarified to provide regulatory certainty. This may be done through amendments, policy guidance or the creation of regulations covering CO_2 storage activities.

Some regimes use positive lists to describe their scope of coverage, using annexed lists of substances, groups of substances, characteristics of substances, or categories of activities that are covered, with varying degrees of specificity. They may also refer to lists contained in other legal instruments, like the London Protocol's reverse list, or to regional or national lists. Other regimes use negative lists, in which everything is included unless it is expressly excluded. These lists permit the flexibility to add or delete regulated substances or activities. Still other regimes define their scope and coverage by the risks that a substance's handling, storage, shipment or accidental release may pose (*e.g.* trans-boundary risks, significant risks), or the risks that a particular activity may pose.

National efforts to classify CO_2 injection are less developed than international efforts and are likely to depend on the regulatory framework of each individual country. In the United States, for example, the majority of states have classified CO_2 as an industrial commodity for the purpose of enhanced resource recovery projects. In other jurisdictions, like in Alberta, Canada, CO_2 has been classified as a resource.

To date, initial demonstration projects have all classified CO_2 as a resource rather than as a waste, offering some guidance to regulators. Depending on the location of potential projects, national authorities should consult with neighbouring countries that may be impacted, as uniformity in this classification will be important due in cross-border CO_2 storage projects.

Existing CO_2 storage projects: defining stored CO_2

- The CO_2SINK project in Germany did not specify whether the injected CO_2 is an industrial commodity or a waste product, due to the small scale of the project;
- For the planned Gorgon project in Australia, the injected CO_2 will be considered a byproduct of gas processing operations under the *Barrow Island Act 2003;*
- For the In Salah project, CO_2 is defined as an industrial product under the Algerian Hydrocarbon Law;
- The CO_2 injected into coal seams for the RECOPOL project in Poland is defined as industrial product under the Polish Mining Law; and
- The CO_2 extracted from the Sleipner field is the result of industrial activities and it is therefore classified as an industrial commodity; however, there has been some dispute because of the project's design for long-term storage.

Source: IEA Research.

Relationship with existing oil and gas regulations

Countries with established resource extraction industries already have well-developed regulatory regimes covering such issues as resource conservation, groundwater protection, deep disposal of liquid wastes and/or acid gas, transport of gases by pipeline, storage and injection of gases as part of hydrocarbon production/recovery. These regimes can serve as a basis for developing the necessary legal and regulatory frameworks for CO_2 storage. In fact, a strategy governments have used to expedite initial CO_2 storage demonstration projects is to amend existing frameworks to allow for CO_2 storage demonstration projects . It appears that for those countries that have existing regulatory regimes, changes to existing regulation will likely present the most efficient way to regulate CO_2 storage in the near term, while the national authority undertakes longer-term comprehensive rules. However, current regulations typically address only the permitting, construction, operational and abandonment stages of such operations. Very little regulation exists for post-closure stages; this is recommended as a priority for future work.

The Netherlands: amending the Dutch Mining Act of 2003

The Netherlands is currently discussing the possibilities and issues associated with regulating CO_2 storage within its current legal and regulatory system.

The Netherlands has a substantial amount of mature gas reservoirs or reservoirs where production has ended that are still subject to a production licence. In order to store gas or CO_2 in any of these nearly empty gas reservoirs a storage licence is needed.

At the moment, a storage licence will not be granted if, at the time it becomes effective, the licence would cover an area for which another party already holds a production licence. This means that any third party that is interested in CO_2 storage activities cannot apply for a storage licence. The Netherlands is currently investigating how to amend the Dutch Mining Act of 2003 so that the government can withdraw, for instance, part of the production licence where there are no more activities taking place. This would promote and assist gas or CO_2 storage in the Netherlands.

The Netherlands is also considering issues regarding production licences where gas is still produced but where there is also an interest to store gas or CO_2. It is believed that the interest in storing CO_2 will in most cases come from the same operator that is currently producing the gas. One of the issues being investigated is to give the storage license to the holder of the production license or to give other persons the opportunity to submit applications for a similar licence for the same storage and for the same area, when an operator applies for a storage permit. However, if a permit is given to a different operator, problems may arise for the current operator relating to compensation for and assessment of gas that is still in the reservoir. Levies are imposed on the production of gas. If the gas will not be produced because of CO_2 storage, the operator is still required to pay a levy on an estimated amount of the gas that remains in the reservoir.

If CO_2 storage is regulated by an amended Mining Act, storage will have to be carried out according to a storage plan. The storage plan will be assessed and approved by the regulator, and must contain, among other things:

- Description of the quantity and the composition of the substances which are being stored.
- Specification of the data with regard to the structure of the deposit and the location of the deposit relative to other strata (with relevant geologic, geophysical and petrophysical studies and the uncertainty analyses used).
- Specification of the substances used when the substances are introduced into the subsoil.
- Inventory of the risks involved in the spreading of the substances that are stored in the subsoil, the occurrence of chemical processes in the subsoil and the damage to the mineral reservoirs present in the subsoil, or the composition of these minerals.
- Inventory of measures that will be taken to prevent these risks.
- Description of the way in which the deposit is abandoned following termination of the storage activity.
- Risk survey concerning soil movement and soil tremors as a result of storage.

Decommissioning under the Mining Act

Assuming the Mining Act is amended to incorporate CO_2 storage, after the CO_2 storage activity has been completed, a closure plan will have to be submitted to the regulator no later than one year after cessation of the activities. Approval can be granted subject to restrictions or regulations that may be prescribed with regard to the risk of damage. The manmade structure that is used for offshore CO_2 storage will have to be removed after completion of the activity.

Next steps

The government will examine in consultation with industry how the future availability can be secured. Furthermore the government wants to interest market parties in several demonstration projects for CO_2 storage. Currently there is one demonstration project involving the injection of CO_2 in an offshore gas reservoir.

In the near future the Netherlands government is expected to amend the Mining Act to facilitate CO_2 storage. Stakeholders are currently being consulted to identify problems and possible solutions.

Source: The Netherlands Ministry of Economic Affairs.

Access, ownership and property rights

CO_2 storage project investors require rules that establish clear rights and responsibilities relating to access to the property, liability pre- and post-closure, and intellectual property rights, among other things. Financial issues – including insurance requirements and the provision of funding for any post-closure obligations and/or liabilities – are also important considerations requiring guidance. This section covers these issues in more detail.

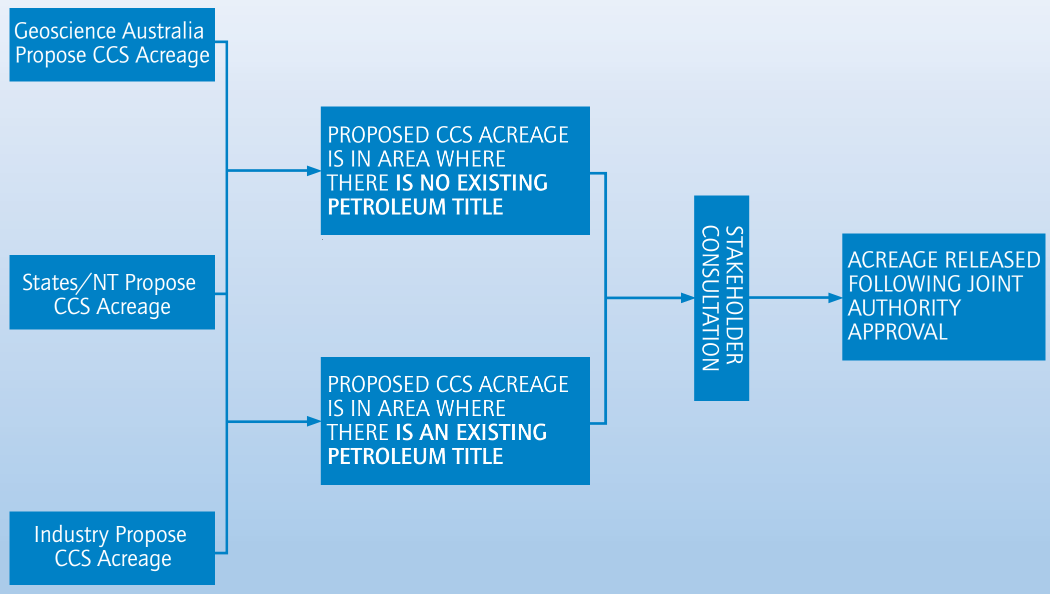
Property rights

A property right is an entitlement, or bundle of entitlements, defining an owner's right to use a resource, as well as limitations on its use. For property rights to be effective, the owner must be able to manage access of others to the property; appropriate the benefits from the property; prevent others from damaging the property; and enforce the property rights. There are a number of property rights relating to CO_2 storage; these include property in the CO_2, property in the storage site, property in the plant and equipment necessary to enable injection and monitoring and property in the land surrounding the storage site (including access rights). Other issues may include contractual acquisition of subsurface property rights; payment to lessees of such rights or damages; and service agreements for transportation. Governments can provide important guidance in this area via rules relating to release of property rights (see Australia case study below).

Australia: release of CO_2 storage exploration acreage

The first step will be the release of acreage by the Joint Authority as shown below.

Figure 2.1: proposed CO_2 storage acreage release process



Access rights

The licensing regime for CO_2 storage activities in Australia is proposed to follow the format of the petroleum licensing regime already existing in the Offshore Petroleum Act of 2006 (OPA), albeit with minor differences relating to size and life of permits. The process for assessing CO_2 storage licence applications, and the technological terms and conditions of the licences and environmental scrutiny that licence applications will undergo, will, however, be specific to CO_2 storage.

1. **Exploration:** the CO_2 storage exploration permit would allow the CO_2 storage proponent to conduct all exploration activities outlined in their work program. It will require the release of certain information; be subject to fees (to cover the cost of administration) and be valid for a term of six years provided conditions are met. After six years without conversion to a CO_2 storage retention lease or CO_2 storage injection and storage, the total area of the CO_2 storage exploration permit will be relinquished.
2. **Retention:** if an owner of a CO_2 storage exploration permit identifies a suitable storage reservoir for a CO_2 storage stream, but will not take delivery of the CO_2 storage stream for some time, a CO_2 storage exploration permit can be converted into CO_2 storage retention lease. A CO_2 storage retention lease may be granted for a period of five years and extended further. However, to prevent the warehousing of potential sites, an applicant will need to submit to the regulator a storage plan.
3. **Injection and storage:** if a CO_2 stream is available, a CO_2 storage exploration permit or a CO_2 storage retention lease may be converted to a CO_2 storage injection and storage licence. This will allow a CO_2 storage proponent to inject and store a CO_2 storage stream in the identified reservoir at a specified rate for a certain period of time. The licence will be granted after the regulator has accepted an injection and storage plan which will cover all phases of the project from the source to storage including safety and environmental considerations and detailed modelling of the expected migration of the CO_2 storage stream. Depending on storage capacity and other related factors, the CO_2 storage injection and storage licence will be viable for the life of the CO_2 storage stream. The area covered by the right to inject will cover the area of the injection activities and the area of anticipated migration of CO_2. Consideration also needs to be given to what happens if the CO_2 should migrate outside this area, and implication for other title rights holders nearby.
4. **Decommissioning:** CO_2 storage legislation will replicate petroleum decommissioning provisions.

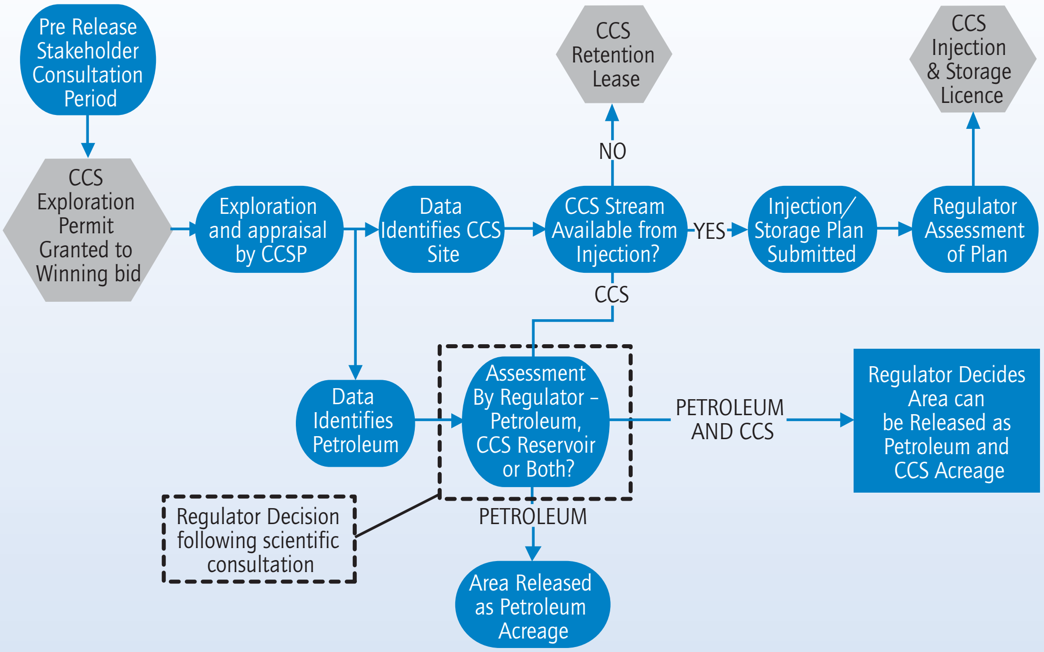
Approvals process

As shown above in Figure 2.1, when considering the release of acreage for the CO_2 storage stream injection and storage, note that there are two scenarios for the approval process.

Scenario 1: proposed area does not contain an OPA petroleum title

Where acreage is released in areas that are not under an OPA title the proposed approval process is outlined in Figure 2.2 below.

Figure 2.2: acreage release where an OPA title does not exist

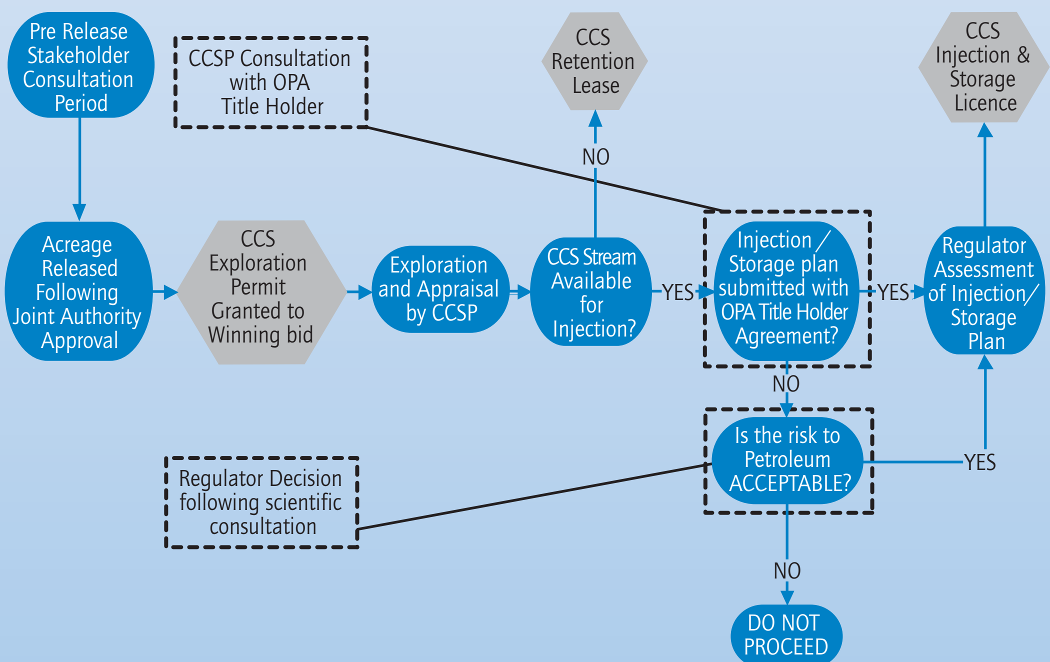


CCSP = CO_2 storage proponent

Scenario 2: proposed area does contain an OPA petroleum title

Where acreage is released in areas that are under an OPA title the proposed approval process is outlined in Figure 2.3 below.

Figure 2.3: acreage release where an OPA title exists



Property rights issues

Protection of both the existing petroleum and the new CO_2 storage industries will be reflected in proposed amendments to the OPA by the application of a "no significant impact" test and in the direction powers of the regulator. For petroleum titles pre-existing at the commencement date of the new legislation, the onus is completely on the CO_2 storage proponent to satisfy the regulator (ultimately the Minister) that there will be no significant impact on petroleum rights before the title can proceed. In practice, the regulator can be expected to allow most CO_2 storage exploration in or near petroleum titles to proceed but will have to carefully weigh the risks of granting CO_2 storage injection licenses close to or overlying pre commencement petroleum title (that is, petroleum titles that are in force before the CO_2 storage legistlation comes into force).

For post-commencement titles, the no significant impact test will apply to all stages of each sector's activities up to the granting of a CO_2 storage injection license or petroleum production licence. Where there are significant impacts and where negotiations to accommodate both CO_2 storage and petroleum activity fail, the regulator will have to make a choice based on the national interest.

Petroleum rights

The holder of a CO_2 storage title will not have rights to any discovered petroleum. If the area is held under an OPA title any discovered petroleum will automatically become the property of the OPA title holder, upon recovery. Where no title exists, a regulatory determination will be made as to whether the area should also be released as petroleum acreage.

Source: Australian Government Department of Industry, Tourism and Resources.

Access

Given the likely cost and long periods of operation of CO_2 storage projects, operators will require a high degree of certainty about access to a selected injection site before they will be willing to invest in a project. The need to clearly identify relevant parties' rights and obligations is a key consideration in examining a potential regulatory basis for access and property rights. In this context, issues that need to be considered include: possible impacts on land use titles and the use of contract; commercial and property law to regulate ownership; and access rights as opposed to defined statutory requirements. Caution should be exercised to avoid legal and regulatory frameworks that encourage or unfairly advance monopoly control of CO_2 storage sites. CO_2 storage regulations may allow for (or require) third-party access. Most countries have legislation that establishes legal rights for third parties to share the use of particular infrastructure services on reasonable terms and conditions. This may be particularly relevant in the case where a CO_2 storage lease covers, either wholly or partly, an existing petroleum or mineral exploration lease.

Subsurface rights: competing claims

The way in which models for the regulation of CO_2 storage projects are developed will depend on the differing nature of subsurface rights in different jurisdictions. For example, in the United States, the subsurface rights are owned, while in jurisdictions such as Australia the subsurface is vested in the government which then authorises access to rights to use the subsurface. This will likely result in different systems of regulating CO_2 storage in jurisdictions where the nature of the subsurface rights is managed differently. Related to this issue are the additional considerations of public versus private ownership; surface versus subsurface rights; and impacts on access to other minerals on the same property. Some guidance for addressing these issues can be found in the property rights arrangements associated with natural gas storage (McKinnon, 1998).

Further, reservoirs and injection sites may be subject to competing claims, in particular from the petroleum industry. The mineral industry could be also a party in the case of mineral rich brines and mineral deposits that are found in sedimentary basins. In this context, the interaction between CO_2 storage proponents and petroleum and mineral explorers' and producers' needs to be carefully balanced to ensure that neither industry impedes the other or impacts the other's resource, and to ensure that no competitive advantage is given to either industry, except for the recognition that existing petroleum and mineral rights must be honoured.

Transboundary issues

CO_2 storage sites crossing international boundaries and intra-country jurisdictional boundaries are likely to face unique property rights issues that will need to be addressed. These may be dealt with contractually, but may also require agreements between the jurisdictions involved to address issues such as access, liability and enabling long-term monitoring and verification. These types of agreements are central to the effective operation of oil and gas fields in the United States and Canada, and provide a corporate framework for operation.

Similarly, CO_2 storage projects in the same jurisdiction may occur on land with differing legal standing. For example, in Australia, land titles cover freehold land, unallocated state land and unallocated state land which has been dedicated for use as a specific purpose (onshore or offshore or under state or Commonwealth jurisdiction). Differing legal rights and restrictions generally apply for these different types of land. This is also the case in Canada. A model CO_2 storage regulatory framework may be one which allows for CO_2 storage in all types of land ownership without needing complex variations. For some countries, such as Australia, Canada and the United States, it may also be necessary to consider native (tribal) title issues that may arise in relation to government regulation of CO_2 storage.

Ownership of injected CO_2

Ownership of CO_2 post-injection is important as it may impact issues such as liability, responsibility for monitoring and verification and future use of CO_2. CO_2 ownership issues are matters that are subject to the specific legal regimes of national and sub-national jurisdictions and may be governed by common law, civil law, statute, contract or a combination of these.

After injection, CO_2 is likely to merge with and become part of the surrounding underground geologic structures. The legal implication is that, subject to any existing reservations to the State, or other contractual arrangements or statutory schemes, the injected CO_2 is likely to be owned by the owner of the land (or subsurface rights, if separable) into which it is injected. This legal presumption can be overcome via contract between the person undertaking the injection and the owner of the land.

In the case of CO_2 storage, the consideration of whether the CO_2 becomes tied to the property or remains separate depends on the intended permanency and nature of the injected CO_2 and could therefore vary from storage site to storage site. For example, at a particular storage site, the geology might be such that the injected CO_2 could be said *not* to have merged with the surrounding geologic structures and to remain fully capable of extraction at some future time. In contrast, at another storage site, the injected carbon dioxide may completely merge into and become part of the surrounding geologic structures, rendering future extraction of the CO_2 economically unviable.

However, underlying assumptions regarding injected CO_2 could change over time as CO_2 storage and other technology develops. This could result in legal uncertainty as to who owns the injected CO_2 with the potential for differing legal outcomes on ownership at differing storage sites. One approach to addressing these future uncertainties may be to ensure a contract is place to define the ownership of the injected CO_2.

Ownership of plant and equipment

Similar considerations arise for plant and equipment used to inject CO_2. Plant and equipment which are located below the surface of the ground and which are affixed to the ground (such as well casing) may constitute a "fixture" and would therefore typically be deemed as property of the landowner. This legal presumption can be overcome by contract or by statute. According to the law of fixtures, items that are permanently fixed to land may, by virtue of the circumstances surrounding their attachment, become fixtures and in that situation, they are then considered to be part of the real property to which they attach. To the extent that injection equipment does not display the characteristics of a fixture, it will continue to be owned by the injector.

However, it would be possible to overcome this legal presumption in relation to injection plant and equipment by contractual arrangement between the land owner and the person(s) seeking to install injection equipment on and in the land, whereby the landowner acknowledges that the injector retains ownership of the equipment either permanently or until the injection activities have been completed (or by statute). Retaining ownership of injection equipment throughout the lifecycle of a CO_2 storage project may be important for injectors for insurance purposes and to enable them to obtain favourable tax and depreciation treatment.

Site closure

Site closure occurs once the proponent discontinues its day-to-day management of the storage site. Jurisdictions that have regulated CO_2 storage typically only allow for site closure after the regulator agrees that predefined site closure criteria have been satisfied. Site closure should not be confused with decommissioning of plant and equipment, which is only one component of the site closure. Site closure is also likely to include obligations to reduce residual risk associated with the site. It is unlikely that the site closure criteria could be satisfied at the end of injection operations; therefore, there should be a post injection period prior to site closure where the proponent continues to have day to day management of the site to undertake ongoing monitoring and site management.

Site closure regulation needs to address long-term ownership of the CO_2, monitoring and verification (M&V), and fiscal measures such as bonds, taxes or royalties to ensure long-term financial accountability for carrying out a M&V programme and for unexpected occurrences. Governments have mitigated their own risk exposure following site closure via appropriate regulatory involvement during all phases of the project, including establishing appropriate site closure criteria with project proponents.

Monitoring and verification responsibilities

With appropriate site selection, a monitoring programme to detect problems, a regulatory system and the appropriate use of remediation methods to stop or control CO_2 releases if they arise, the local health, safety and environmental risks of CO_2 storage should be comparable to the risks of natural gas storage and enhanced oil recovery. Observations from engineered and natural analogues suggest that the fraction of CO_2 retained in appropriately selected and managed geologic sites is very likely to exceed 99% over 1 000 years (IPCC, 2005).

Norway: regulating the Sleipner project

On the Norwegian Continental Shelf, Statoil as operator of the Sleipner gas and condensate field in the North Sea has been separating CO_2 from natural gas since 1996. The captured CO_2 is injected into the Utsira sandstone formation, located well above the Sleipner gas reservoir. The Sleipner project is the first large-scale commercial application of CO_2 storage in a deep saline aquifer in the world. The CO_2 capture is not carried out for enhanced recovery, but is necessary as part of the gas processing on the production site to ensure that the CO_2 content of the produced gas meets sale specifications (maximum 2.5%). Since injection started in 1996, the CO_2 storage stream has been injected without any operational problems observed in the capture plant or in the injection well.

The CO_2 storage at the Sleipner field is carried out as part of the production activity on the field. Such activity is regulated by the Petroleum Act (Act 29 November 1996 No. 72 pertaining to petroleum activities) which applies to injection of CO_2 as part of or in connection with extraction of oil and gas from sub sea petroleum deposits under Norwegian jurisdiction. The Petroleum Act requires CO_2 storage in the Sleipner field to be permitted as part of the conditions for Ministry of Petroleum and Energy (Ministry) approval of the Sleipner field's Plan for Development and Operation (PDO). The approval of a PDO under the Petroleum Act is also subject to an impact assessment being undertaken by the licensee company to the Production Licence which is rendering them the right to explore for and produce oil and gas in the area in question.

Under the Petroleum Act, a "life-cycle approach" is applied to the regulation of CO_2 storage at the Sleipner field. Regarding an approved PDO, the Act states that any significant deviation or alteration of the terms and conditions on which a PDO has been submitted or approved, and any significant alteration of facilities is subject to notification to and approval of the Ministry. The Ministry may in this respect also require a new or amended PDO to be submitted for approval.

In addition, the Petroleum Act requires the owners of the Sleipner facility, the licensees on the Sleipner field, to accept third-party access to the facility on negotiated terms.

When the field is depleted sometime in the future, the Petroleum Act requires a decommissioning plan to be submitted to the Ministry. Based on this plan, a Government decision is made on the decommissioning of the field, including a time limit for shut-down and decommissioning of facilities. As part of this decision, conditions will be set with regard to future monitoring of the CO_2 that has been injected into the Utsira formation, and a time limit for the liability of the licensees.

Any pollution damage from the petroleum activities, including any pollution resulting from CO_2 storage on the Sleipner field, is subject to strict liability by the licensees under the Petroleum Act. As regards to safety, the Petroleum Act requires that the petroleum activities be conducted in such a manner as to enable a high level of safety to be maintained and further developed in accordance with technological development. Further, all reasonable precautions must be taken to prevent damage to animal life and vegetation in the sea, relics of the past on the sea bed and to prevent pollution and littering of the seabed, its subsoil, the sea, the atmosphere or onshore. The Ministry may issue such orders as necessary for the implementation of the provisions laid down in or pursuant to the Petroleum Act.

In addition, CO_2 storage on the Sleipner field is regulated by the Pollution Control Act (Act 13 March 1981 No. 6 pertaining to protection against pollution and to waste). The main rule of the Pollution Control Act states that pollution is prohibited, unless permitted by law, regulations or individual permits.

The Pollution Control Act applies to sources of pollution located, or which threaten to occur, in Norway, Norway's economic zone and on the Norwegian continental shelf. The Act applies to CO_2, as pollution is defined as, inter alia, *"the introduction to air, water, or into the ground of solid matter, fluid or gas (..) which is or may be harmful or detrimental to the environment."*

Consequently, CO_2 storage on the Sleipner field is also subject to a permit under the Pollution Control Act. The permit for the Sleipner field is subject to the following conditions as regards to CO_2 storage, the injection of CO_2 is to be monitored with respect to any leakage; up to 1 million tonnes of captured CO_2 may be injected into the Utsira formation each year; and in March each year, the operator is to report the actual amount of injected CO_2 in the previous year to the Pollution Control Authority. The same applies to the results of the monitoring.

Source: Norway Ministry of Petroleum and Energy.

Assuming the site has been selected properly, M&V is critical to ensure that the project has been designed and implemented to minimise possible leakage or other damage to the local area. Areas of focus for a M&V programme include the condition of the injection and offset wells – the most likely sites for accidental abrupt leakages – and the conditions in the storage reservoir. In the long term, monitoring is necessary to confirm the continued retention of the CO_2 stream in its intended location. The likelihood of unexpected migration of injected CO_2 is greatest in the early stages of a project. Experience to date has shown that the longer the CO_2 has been performing as expected, the lower the probability that it will start to behave unexpectedly. Correspondingly, the government's interest in establishing a plan of corrective remedial actions in response to unpredicted migration is much higher early in the life of a project. Therefore, governments should ensure that the regulations give appropriate weight to site characterisation and selection criteria and that an adequate monitoring system is in place during the early stages of a project. Effective near-term processes are highly likely to reduce the risk of significant long-term liability issues.

It is likely that regulations pertaining to M&V in the petroleum industry could be applied to CO_2 storage, with amendments to provide longer-term assurance that the injected CO_2 stream is consistently and accurately monitored. Such a framework would maintain consistency of treatment of CO_2 storage with that of other industries.

The development of internationally agreed project M&V guidance will increase industry certainty and provide the wider community with confidence that the project will not cause adverse impacts. Although projects will necessarily be assessed on a case-by-case basis, CO_2 storage project M&V practices should be designed to provide timely, accurate and relevant public information that is independently verifiable. It is likely that public acceptance of CO_2 storage will hinge on the acceptance that the probability of an adverse incident is low, and M&V is critical to confirm this in the public's eye.

Given existing practices, it is likely that an M&V regulatory framework for CO_2 storage will include at least four phases (MIT, 2007):

- **Site assessment:** this involves characterising the site geographically, geologically and geo-chemically. Undertaking modelling simulations will help to predict expected fluxes and possible leakage pathways, and the data generated will help to inform regulators and stakeholders about the suitability of the site.
- **Project baseline:** this includes conducting baseline surveys of the proposed project site to understand the current situation and to provide something to compare the project to.
- **Operational monitoring:** this takes place during CO_2 storage, and includes monitoring of injection wells to ensure that no leakage is occurring.
- **Long-term monitoring:** this phase involves active surface and subsurface monitoring, including any high-risk areas where potential abrupt leakages can occur. It is an open question how long and how frequent monitoring activities should be at a given site; however, factors such as the site parameters, commercial status of the project and regulatory needs should be taken into account at the onset of the project, and agreed upon by all stakeholders.

Establishing a suitable verification regime may involve legislating additional powers for regulators or third-party verifiers. It may also involve developing regulations or guidelines that outline M&V requirements to meet potential national and international reporting and commercial requirements. In particular, this includes data on the volume and location of CO_2 emissions that have been stored underground that is accurate enough to meet internationally approved inventory reporting and commercial requirements. Some have suggested that analogs exist in related industries, including hazardous waste injections, where operators are required to use models to demonstrate that migration is not occurring (Wilson, *et al.,* 2003).

Ground water monitoring requirements

A specific monitoring concern is the potential impact of CO_2 storage on nearby ground water resources. Ground water could be affected both by CO_2 leaking directly into an aquifer and by saline ground water that enters an aquifer as a result of being displaced by injected CO_2. The risk of these impacts can be minimised through appropriate management strategies. In the United States and other countries, underground injection of CO_2 for the purpose of sequestration is regulated to ensure that CO_2 storage activities are performed safely and do not endanger current or future sources of drinking water. These experiences offer models for other countries.

United States: groundwater protection regulatory framework

In the U.S., the Environmental Protection Agency (EPA) plays a key role in CO_2 storage. The EPA has programmatic jurisdiction over CO_2 injection for EOR and has asserted jurisdiction over the injection of CO_2 for geologic storage. The majority of the regulations that cover CO_2 storage operational issues are authorised and administered under the underground injection control (UIC) program established by the US Safe Drinking Water Act (SDWA). The EOR operations in the US today have all been authorised and/or permitted under the UIC program by state agencies that have promulgated the necessary regulations and been approved under the federal statute to implement their applicable state UIC Programs.

In July 2006, for the purpose of FutureGen and other planned CO_2 storage activities, EPA announced that geologic sequestration of carbon dioxide through well injection meets the definition of "underground injection" in section 1421 (d)(1) of the Safe Drinking Water Act.

The EPA indicated that it would work with States as co-regulators to protect underground sources of drinking water from any potential endangerment by CCS pilot projects using appropriate SDWA mechanisms, including issuance of UIC permits. In addition, in March 2007, EPA finalized UIC Program Guidance on using experimental wells for CO_2 storage demonstration projects (USEPA, 2007). The guidance will assist state and EPA regional UIC programs in processing permit applications for projects designed to assess the efficacy of CO_2 injection for the purpose of geologic sequestration. It is expected that proposed FutureGen pilot projects will test the application of this ruling and guidance.

However, there are no federal requirements under the UIC program to track the migration of injected fluids within the injection zone or to the surface. Lack of fluid migration monitoring is problematic when the UIC is applied to CO_2 geologic storage. For example, one source of risk for CO_2 storage is that injected CO_2 potentially leaks to the surface through old oil and gas wells that are inadequately plugged. This may be a concern, as depleted oil and gas fields are an attractive initial storage site in the United States. For this reason, regulations will likely be needed to address this circumstance.

Source: MIT, 2007.

Long-term retention: liability and post-closure responsibilities

A priority for CO_2 storage regulators is defining long-term liabilities and post-closure responsibilities. While relevant regulations for subsurface operations exist, few countries have developed legal or regulatory frameworks for long-term CO_2 storage liabilities. A consistent regulatory framework that considers post-closure responsibilities and liabilities associated with CO_2 storage activities is desirable to ensure that project operators, governments and future generations are not exposed to negative health, environmental and financial consequences and burden. However, deciding the type and nature of long-term legal responsibilities that will be assumed by governments and project proponents is likely to take years, and will only occur after initial demonstration projects have produced results. For this reason, it is recommended that demonstration projects move forward while governments determine what, if any, governmental assumption of responsibility (with associated financial impacts) will occur in the future.

IEA's Greenhouse Gas R&D Programme recently concluded a study which surveyed regulators on their opinions for appropriate risk assessment to ensure safe long-term CO_2 storage. The consensus was that it was a priority to develop a technical standard or protocol to address long-term safety at CO_2 storage projects. However, there were differing opinions concerning whether such a standard or protocol should be developed at the sub-national, national or international level (IEA Greenhouse Gas R&D Programme, 2007).

General issues

Liability rules derive from three sources: legislation, regulation and case law. Legislation may set forth liability requirements explicitly, or indirectly, *e.g.,* by restricting conduct with potential risks. Regulations are typically then developed to implement regulatory requirements. Case law decisions will result from judicial interpretations of relevant precedents or legislative/regulatory language. The lack of liability frameworks is the direct result of the immaturity of CO_2 storage applications. As a result, it is recommended that policy makers develop initial frameworks, and then continually adapt and modify these rules as lessons are gained from experience with CO_2 storage.

Regulations governing long-term liability in relation to CO_2 storage are not likely to differ significantly from related extraction and storage industries. In some cases, these industries have been exempted from stringent regulatory oversight. For example, in the United States, natural gas storage activities are exempted from federal Safe Drinking Water Act underground injection regulations (de Figueiredo, 2007). Nevertheless, there is a need to explore whether existing regulatory frameworks, arrangements and government policy adequately address potential liabilities associated with CO_2 storage. Given the potential timeframes associated with both the storage of the CO_2 stream and the limited longevity of commercial organisations, there are some important policy considerations in relation to dealing with any potential risk over the long term. Principles applying from the decommissioning of petroleum and mine site operations, long-term management of waste disposal sites and site remediation provide models to assist in dealing with post-closure liability.

Governments will need to consider whether the existing common law framework provides an adequate basis for dealing with potential liabilities. Project proponents may be exposed to tortious liability for property or groundwater damages in the case of negligence; however, there will likely have to be a showing of general causation, which means that it will need to be shown that CO_2 could cause the injuries or damage in question. If CO_2 is generally not able to cause the harm in question, there will not likely be liability. There have been legal cases in the acid gas injection, natural gas storage, and EOR arenas that may act as guiding precedent on tortious liability for CO_2 storage. However, to date, there have been no examples of tortious liability cases related to CO_2 injection for EOR (de Figueiredo 2007).

Alberta, Canada: liability regime for acid gas injection

The government of Alberta's liability regime for acid gas injection serves as a model for CO_2 storage. Since 1989, acid gas has been injected into geologic formations to comply with sulphur emissions regulations. This injection presents liability concerns because acid gas contains hydrogen sulphide, a poisonous flammable substance. To address liability, Alberta uses a license scheme combined with regulations, continuing liability, financial assurance and industry funds.

First, before acid gas injection can begin, proponents must meet regulatory requirements, including a showing of containment, reservoir properties, hydraulic isolation, and notification of relevant parties. There are similar requirements for the suspension and abandonment of an injection well, with costs accrued by those owing an interest in the well.

Second, licensees with interests in the wells are subject to continuing liability or responsibility for the management and control of the well if the well has already been abandoned.

Third, all licensees must report financial information to the Alberta Energy and Utilities Board, which compares the assets and liabilities of the licensee. If the licensee's liabilities exceed its assets under the Board's assessment, the licensee must place a security deposit for the difference in the form of cash or a letter of credit.

Finally, all licensees must pay into a general "orphan" fund, which is used to fund the suspension, abandonment and reclamations of orphaned wells.

Source: de Figueiredo, 2005.

Governments may decide to pro-actively assume responsibility for liabilities that occur after a set period of time. For example, these issues were addressed in the state of Texas in the United States, where the legislature enacted a law that makes the state liable for long-term storage issues associated with the FutureGen project (FutureGen Texas, 2007). Similar legislation is pending in the state of Illinois. In both cases, this legislation addresses liability only in respect to FutureGen project activities, not to CO_2 storage activities generally. This sort of assumption of liability is one of many governmental incentives that can be offered. However, this may be difficult in some nations, and there are other contractual or financial mechanisms that can be explored as alternatives to government assumption of liability.

Contractual assignment of liability

When private entities become involved in CO_2 storage, most activities will be undertaken via contracts between various entities, addressing issues such as storage site identification; CO_2 separation and collection technologies; transportation of CO_2; drilling of bores/wells; injection; and monitoring and maintenance. To illustrate how contractual liability might arise, if a subcontractor was to release liquid CO_2 into the ocean, instead of injecting it into the storage well as contracted to do, the contractor may be liable in contract. Defences to claims of breach of contract include public policy (such as illegality) and matters affecting the nature of the contract (such as misrepresentation and mistake, duress and undue influence). Remedies for breach of contract include termination, damages, injunctions and specific performance.

Financial issues

Financial issues include insurance and the provision of funding for post-closure costs and/or liabilities. These costs may include the cost of plant decommissioning, site rehabilitation and possible remediation, site monitoring and possible remediation costs and liabilities arising from leakage of the CO_2 stream. A number of options for assuring financial responsibility for CO_2 storage projects have been discussed, including the establishment of surety bonds, insurance funds, government trust funds, or public, private, or semi-private partnerships (IOGCC, 2005).

Normally, project proponents decide independently whether to seek long-term insurance or to self-insure over the various aspects of a project. However, given the long time horizons for CO_2 storage, it is currently impossible to procure insurance for the entire post-closure project period. There are no existing precedents for insurance instruments that provide liability protection for an occurrence after multiple decades or centuries. The issue of financial liabilities that might arise from negligent leakage from the storage site in the post-closure period is more complex. While a company continues to exist, liabilities would likely remain with the company involved. However, given the time scales involved, responsible entities may no longer exist when a leakage event occurs. Accordingly, a range of financial instruments may be required to address the long-term risks associated with CO_2 storage.

Financial precedents exist in the mining and petroleum industries in relation to site rehabilitation and decommissioning. These include the establishment of trust funds, environment performance bonds, or bank guarantees to cover the estimated costs. There is also the possibility that governments may opt to take on the role of insurer; but, as stated before, this is a significant policy decision that may take several years to sort out.

There are a number of criteria which should be taken into account when considering an appropriate financial instrument which may assist in managing potential long-term liability, including:

- Establishment of a project baseline;
- Compatibility with the timeframes of the above identified phases of CO_2 storage activities, including decommissioning and post closure;
- Flexibility to the site-specific nature of CO_2 storage activities;
- Promotion of 'leading practice' in CO_2 storage;
- Consistency with legal, regulatory, property lease and taxation requirements.
- Ability of the parties to bear the risk and adequacy of compensation for risk taking; and
- Inclusion of the cost of the risk being undertaken and therefore the total cost associated with CO_2 storage.

While contributions to a financial mechanism may place a cost burden on industry, these costs need to be within a reasonable range. The form and nature of a financial scheme will need to take into account the risks involved in the specific project. In general, however, governments should seek to design schemes so that the benefits – in the form of community confidence – outweigh the costs. Some have proposed creation of a governmental entity or fund to manage long-term liability and related compensation issues arising from CO_2 storage (MIT, 2007; de Figueiredo, 2007). The use of government incentives, such as favourable tax treatment or other financial support, also warrants consideration to mitigate financial risks.

Intellectual property issues

Intellectual property (IP) is the unique category of property resulting from creative thoughts and intellectual human efforts, such as an idea, expression, invention, design, unique name, business method, technology transfer, industrial process, software in industrial, scientific, literary or artistic fields, which can be reproduced (Kanagavel, 2003). IP rights are a set of legal powers to any IP in industrial, scientific, literary or artistic domain. IP protection allows a creation to be exploited to the benefit of the country and cultures of its origin.

CO_2 storage faces similar IP issues to the oil and gas sectors. There are three main issues in terms of IP rights in relation to ensuring the adoption of CO_2 storage. The first of these relates to the owner of the IP being assured that they will earn a rate of return on their IP and that these rights will not be eroded. Without this assurance, owners will be reluctant to transfer their knowledge. The second issue relates to mechanisms that will actually result in the transfer of technology that will be put to practical use. The third issue relates to the capacity of the receiving economy to be able to use any knowledge transferred. This can be addressed through capacity building. In the case of CO_2 storage, this relates not only to the technology involved, but also to overall policy and regulation.

On the one hand, the private sector will need to minimise the risk that investments made in CO_2 storage may be endangered by charges of IP infringement. On the other hand, the involvement of the public sector in funding or operating CO_2 storage projects complicates the IP analysis, both from the standpoint of IP ownership and that of enforcement. However, governments can also help address IP issues through cooperative research and other support.

Australia's intellectual property approach: the Cooperative Research Centre for Greenhouse Gas Technologies

The Cooperative Research Centre for Greenhouse Gas Technologies (CO_2CRC) commenced in July 2003. The CO_2CRC is developing advanced technologies and systems for the capture and storage of CO_2 that will enable Australia to decrease its CO_2 emissions, maintain the competitiveness of its industries and develop new commercial opportunities; ensure the long term sustainability of Australia's fossil fuel and energy intensive exports; provide the basis for low emission industries and a future hydrogen economy; and contribute to the resolution of a global environmental issue of great community concern.

The CO_2CRC Commercialisation and Utilisation Plan outlines the use and commercialisation strategy for IP resulting from its operations. The commercialisation of CO_2CRC IP was assigned to a separately incorporated entity, Innovative Carbon Technologies Pty Ltd (ICTPL) which was established specifically for this purpose. ICTPL is the commercialisation manager. It is a one-stop-shop for greenhouse gas technologies and expertise including holding and commercially exploiting IP and conducting commercial contracts. This includes the establishment of management procedures for dealing with actual or perceived conflicts of interest and confidentiality issues. Specific activities for which ICTPL is responsible include patenting of CO_2 storage technologies and systems; registering trade mark and maintaining the confidentiality of key proprietary knowledge for use in value added consultancies; and protection of software, data bases and other compilations.

The key strategy for commercialisation of patents, trademarks and industrial designs is to define the value proposition and to develop a business case for each opportunity. As program managers identify new IP, ICTPL ensures that provisional patents are lodged as necessary to obtain priority dates. Trademarks and/or industrial designs which emerge are registered in a timely manner. ICTPL also maintains an IP database and carries out an annual IP audit. ICTPL maintains transparency by preparing an annual IP management report for inclusion in the CO_2CRC Annual Report.

In any situation where an agreed collaborative research project exists within the CO_2CRC research program and which leads to a commercialisation opportunity, it is a matter for the respective owners of the IP to agree, on a case-by-case basis, the most appropriate commercialisation vehicle to use.

Where students are involved in research, students assign their IP rights to their institution through the execution of a Student Deed of Assignment at the commencement of studies. This enables the assignment of IP to ICTPL. Students do however retain copyright to their theses.

ICTPL has put in place an extensive and efficient publication tracking system to log and record all CO_2CRC publications and which assists in managing copyright.

Regarding protection of IP, project agreements make provision for maintaining confidentiality of research results, and for withholding publications and theses pending a review by CO_2CRC program managers in conjunction with ICTPL to determine commercial potential.

Benefits, such as royalties, which may accrue to a research institution as a result of successful commercialisation of new IP are calculated in accordance with the agreed project shares. University employees have rights to a share of the proceeds as defined in the university statutes and it is a matter for each university to make these determinations. Employees of ICTPL/CO_2CRC are not generally entitled to any share or royalties except with the approval of the ICTPL Board.

Source: CO_2CRC website, www.co2crc.com.au

Intellectual property issues specific to CO_2 storage

CO_2 storage is a multi-stage process, with the CO_2 storage component of the project forming an adjunct to some other type of plant, which might, for example involve gas processing, electricity generation, or conversion of coal to liquids. The CO_2 storage component of the operation, in turn, has distinct capture, transport and storage stages. As a result, an overall CO_2 storage operation will involve a range of different technologies, each with its own IP issues.

For the same reasons, there may be a range of commercial interests involved, both between different CO_2 storage operations and, possibly, even within a single CO_2 storage project. These different interests might include, for example, petroleum companies, coal companies, the electricity generation industry, equipment supply industries, as well a large number of potential service industries. As a result, the arrangements for handling IP may well vary widely between projects, meaning that specifics will have to be managed on a case-by-case basis. Any consideration of IP rights in the CO_2 storage industry has to take all these factors into account.

Experiences with CO_2 storage and intellectual property

A recent report by the U.S. Department of Energy and National Energy Technology Laboratory (DOE/NETL, 2006), outlining case studies of five CO_2 storage projects, revealed that:

- **CO_2SINK** does not have any IP rights issues;
- **In Salah** does not have any IP rights issues;
- **The Gorgon project** will manage IP issues that arise on a case-by-case basis;
- The rights of the results from the **RECOPOL project** lie with the organisations that fund the projects (project partners and the European Commission). This arrangement is outlined in a consortium agreement, which allows for the dissemination of project results; and
- For the **Sleipner project,** IP rights have been addressed through a consortium agreement between project partners which grants them broad, worldwide and irrevocable rights to use project results. Sleipner results and working documents are in the public domain which promotes public awareness and acceptance.

Similar to these examples, the U.S.-Canada Weyburn project proponents did not have IP rights issues. They signed confidentiality agreements to assist in protecting IP, and jointly agreed to own IP rights resulting from the project.

The largest single area of IP relating to CCS generally appears to be regarding capture technology, rather than transport and storage, although there will likely be significant IP issues throughout the stages of a CO_2 storage project. In the capture stage, IP can range from materials such as catalysts to processes and process integration. The CO_2 capture stage is highly capital-intensive and will usually involve large-scale plants. The IP for this part of the technology is largely in commercial ownership. There is a relatively small number of different capture technologies and hence this ownership is in a relatively small number of hands. Protection of IP in these areas can face different challenges. For example, patent law may give good protection in the case of a material, but may be more difficult to apply when the IP relates to process integration.

The capture technologies are not expected to be different from the processes and equipment currently found in the chemical process industries. The traditional method of IP protection for these sorts of processes is patenting. Inventors create value for themselves through negotiating agreements with licensors and/or equipment providers whereby they receive benefits as part of the broader supply of equipment and services to the end user. Technology payments by the end user can take the form of one-off, annual or rate-based fees and would be considered as part of the overall technology assessment and selection process from potential equipment vendors.

CO_2 transport is very similar to transport of other fluids. While there may be some specific IP rights, these will be limited in scope and technologies will be available from a large number of suppliers. It is expected that almost all countries will already have transportation technologies available. Hence, there are unlikely to be significant issues. CO_2 injection technology is almost identical to technology employed by the petroleum industry worldwide and almost all countries will already have the technology available. There are unlikely to be significant issues relating to intellectual property.

Selection of CO_2 storage sites will be very site-specific. However, the tools used to evaluate a site are also in widespread use by the petroleum industry. Almost all countries will already have the technology available. However IP may include such things as CO_2 corrosion resistant cement for injection wells, as well as measuring, monitoring and verification systems and protocols during the injection and post injection stages. In other cases, a service company may wish to contract to take and inject CO_2 from a capture source. In such cases, the service provider may possess a range of IP which they need to protect to enable them to compete for business. The majority of IP at this stage in the process is concerned with trade secrets rather than patents. Knowledge of where a good storage site is located could potentially be very valuable knowledge.

An important component of IP for CO_2 storage is likely to be related to services provided to the industry. Services might include, for example, planning tools, risk assessment, specialised analysis techniques for monitoring and verification, and specialised models for numerical simulations. In some areas, interests in IP may conflict with other objectives. For example, transparent monitoring and verification techniques may require that the technologies and techniques involved are open to public scrutiny.

The important consideration about IP is that value is only created for the inventor through the use and application of the invention. There is a significant incentive to deploy any technology into the marketplace as soon as the technology is robust and there is a need for it. The breadth of research into emerging capture technologies suggests that it is likely a healthy market and competition for CO_2 removal technologies will develop as there are today, *e.g.* a wide range of solvents and technology suppliers exist in the acid gas removal industry. The end user market for these technologies will eventually accommodate the valuation and supply of IP and will value it according to the general market drivers based on the usual parameters such as price, performance and robustness to name a few. The capture technologies are likely to be part of the larger equipment and services supply to the generation industries. Consequently the issue of IP is not expected to compromise or inhibit the deployment of the CO_2 storage industry.

Motivation for protecting or sharing intellectual property

Whether to protect or share IP depends on the individual organisation. It is important to identify IP rights at the outset. For example, it depends on whether the individual or organisation wants to derive benefit from public good research outcomes or from commercial outcomes. However it must be noted that public good and commercial benefit are not mutually exclusive.

A company aiming to achieve commercial outcomes may decide to patent the relevant technology or process and receive royalties through selling or licensing the product or maintain a trade secret and work as a consultant utilising this trade secret. On the other hand, another organisation may wish to make information publicly available in order to enhance the CO_2 storage industry; to prove that CO_2 can be stored underground; to increase public credibility, awareness and acceptability; to claim carbon credits; or to verify that CO_2 has not leaked.

The companies and organisations involved in the CO_2 storage industry have different motives and drivers relating to protection of IP. Coal and gas companies are more likely to share IP because they would be interested in protecting and prolonging their commodity market by encouraging the uptake of CO_2 storage and showing the community that they are responsible corporate citizens. Companies purely established to undertake CO_2 storage projects are likely to do all that is possible to protect IP, as CO_2 storage provides them with a source of income through patent royalties and consultancy contracts. Small and medium-sized enterprises (SMEs) involved in some stage of the CO_2 storage life-cycle are also likely to protect IP. For an SME, a successful well-managed patent could be the key to success. Alternatively, an electricity generator may wait for a market signal before it responds to CO_2 storage.

Intellectual property systems in developing countries

The three components of an effective IP regime are the underpinning law; the cost and quality of the right acquired; and the effectiveness and cost of enforcing the right.

A robust IP rights regime in developing countries is crucial to encourage companies to invest in CO_2 storage technologies in developing countries. There is a commercial concern that IP rights need to be recognised. New technologies such as those used in the capture stage of a CO_2 storage project have the greatest exposure to IP rights issues. It is unclear whether the owner of the IP rights for these technologies will be willing to license them, especially in the absence of a stringent regulatory framework. The technologies used for CO_2 storage projects are therefore not yet transferred to entities and/or countries where the protection of IP rights is weak.

It has been shown that unilateral initiatives such as education and training efforts offer significant potential in helping to establish meaningful IP protection regimes in developing countries. Unilateral initiatives can also foster willingness to cooperate and therefore reduce infringement of IP (Bird, 2006). Non-disclosure agreements are seen as being essential when transferring knowledge to developing countries and forming a joint venture may also be an effective method of deploying CO_2 storage in a developing country.

Due to the rapid expected growth in the use of coal-fired power plants in developing nations like China and India, there are plans in place to implement CCS activities in these countries. However, no projects are currently in operation. One concern that has been voiced by prospective CCS proponents is that IP rights protection and enforcement may not be as rigorous in these countries as compared to developed economies. There is a stigma that the first company to deploy CCS in a developed nation may face economic loss in the form of IP rights infringement. However, this need not be the case; a recommendation for future work is to expand outreach and capacity-building efforts here.

For example, China has in place an IP legislative framework which is compatible with international standards. This has developed over a very short period of time, since the mid-1980s, compared with western countries which have had longstanding IP regimes. Because of this short development time, there are some shortcomings in the Chinese system especially in its practical application. China is making concerted efforts to address criticisms through raising public awareness, establishing the necessary institutions, educating personnel and enforcing harsher penalties (Harvey and Morgan, 2007).

The area of enforcement is also a problem. Typically in developing countries, IP rights can be enforced through administrative agencies or courts. Administrative agencies provide an effective, reasonably cheap and quick way of stopping an infringement. They can impose fines; however, they typically cannot impose damages and therefore the threat of administrative enforcement does not always discourage the infringer. The court system is more effective in compensating for damages. Other remedies available through the court system include injunctions and public apology. Criminal action can also be taken by requesting the police to investigate.

Operating in developing countries should be no different to operating in a developed economy. In either case, it is prudent to have an understanding of the regulatory and enforcement systems, and their imperfections, of the particular country, and to employ other measures, such as confidentiality or non-disclosure agreements, which support and complement the strategies for protecting IP rights. Companies exporting products and services to developing regions or forming joint ventures need to be aware of the enforcement arrangements in place and take additional precautionary measures to protect their IP rights.

Support for CCS: government incentives, including interactions with emissions trading schemes

Given the promise of CO_2 storage to mitigate the risk of long-term climate change, countries have used a range of incentives to encourage CCS. Government support has occurred in four ways:

- setting the rules for private sector innovation and technology deployment incentives, *e.g.*, intellectual property protection and R&D tax credits;
- support for basic scientific research;
- support for pre-commercial technology and engineering development; and
- support for demonstration projects which inform industry and the public about the technical performance, cost and environmental risks (MIT, 2007).

In addition, including CCS in greenhouse gas emissions trading schemes is another incentive that governments are exploring. The first part of this section summarises government incentives for CCS; the second section explores current challenges and recent developments in including CCS in emissions trading schemes.

Table 2.1: Examples of incentive mechanisms

Mechanism	Operation	Impact	Development for CO_2 storage
Kyoto Mechanisms	The Kyoto Protocol defines three "flexibility mechanisms" to lower the overall costs of achieving its emissions targets. These mechanisms enable Parties to access cost-effective opportunities to reduce emissions or to remove carbon from the atmosphere in other countries.		
• Clean Development Mechanism	Under Article 12 of the Protocol, developed countries invest in emission reducing projects in developing countries to obtain credits to assist in meeting their emissions targets.	Potentially very significant, the main international policy tool to encourage/reward CO_2 storage in developing countries. But important to get CO_2 storage recognised.	Work underway within UNFCCC meetings, many countries very active in negotiations. Acceptance is unlikely before 2009.
• Joint Implementation	Article 6 of the Protocol permits developed countries to invest in projects in other developed countries to acquire credits to assist in meeting their emissions targets.	Could be significant for non-EU developed countries.	No work on CO_2 storage at present.
• International Emissions Trading	Article 17 of the Protocol allows developing countries to participate in emissions trading for the purposes of meeting their emissions targets. If introduced the trading system would allow the holder of a 'credit' (or Assigned Amount Units which would represent one tonne of CO_2 emissions each) the emission of a specified amount of greenhouse gases.	As above.	No work on CO_2 storage at present.
Emissions Trading	Emissions permits or credits, issued by Government, which can be traded amongst participants and acquitted to cover emissions. 'Cap and trade' (total supply of permits is limited; free to trade permits but must acquit sufficient permits to cover emissions) and 'baseline and credit' (specifies emission profile for each participant, credits traded to participants who wish to exceed baseline) trading systems are the two approaches.	As above.	Consistency across trading schemes is essential. Consider implementation of global guidelines. However national governments may develop for their own use (with no cross-border trading).

Mechanism	Operation	Impact	Development for CO_2 storage
• European Union Emissions Trading Scheme	Largest multi-national, greenhouse gas emissions trading scheme in the world. Each participating country proposes a National Allocation Plan, to be approved by the European Commission, including caps on greenhouse gas emissions for power plants and other large point sources.	Very significant, the main EU policy tool. Important to get CO_2 storage recognised.	Work underway at EC level and national level to include CO_2 storage in Phase II (2008-12).
• Regional Greenhouse Gas Initiative (RGGI)	Cooperative effort by 9 Northeast and Mid-Atlantic U.S. states to discuss the design of a regional cap-and-trade program initially covering CO_2 emissions from power plants in the region. In the future, RGGI may be extended to include other sources of greenhouse gas emissions, and other greenhouse gases.		Not yet in place.
Regulation	Could mandate, for example, that by a specific date, greenhouse gas emitters must decrease emissions by a certain percentage.	High significance within national jurisdictions, where ETS schemes not available.	Work underway at national level (*e.g.* Australia, UK, Norway) and at EU level.
Direct Subsidy			
• State Aid (European Union)	Any advantage given by a State to an undertaking in their domestic economy where such an aid may benefit particular industrial sectors or individual undertakings and affect trade in the European Union.	High impact, where nations may wish to support technologies such as CO_2 storage where the EU ETS is not sufficient to incentivise.	Some work in EU.
• Low Emissions Technology Demonstration Fund (Australia)	AUD500 Fund to demonstrate the commercial potential of new technologies or processes or the application of overseas technologies or processes to Australian circumstances to deliver long-term large-scale greenhouse gas emission reductions.	High impact where pricing mechanisms are not in place.	Underway, can include CO_2 storage.
Tax schemes	Carbon tax schemes than penalise high carbon emitters and/or reward low emitters.	Significant on a national level where ETS does not apply, *e.g.* in Norway. Efficiency may decrease over time.	Operating in Norway.

Mechanism	Operation	Impact	Development for CO_2 storage
Voluntary / Offset Markets	Companies in some countries that are yet to ratify the Kyoto Protocol are pursuing voluntary programs, such as emissions trading, to reduce greenhouse gas emissions.	Difficult to assess impact, as weak markets for the credits generated. Has been one large sale from CO_2 storage in North America.	
• Chicago Climate Exchange (CCX)	World's first greenhouse gas emission registry, reduction and trading system for all six greenhouse gases. CCX is a self-regulatory, rules unknown based exchange designed and governed by CCX Members. Members make a voluntary but legally binding commitment to reduce emissions. By the end of 2006 all Members to have reduced direct emissions 4% below a baseline period of 1998-2001.By 2010 all Members will be required to reduce emissions 6% below baseline.	No CO_2 storage activity at present.	
International Development Assistance	Funds projects in developing countries or loans money to developing countries to fund development.	See International Financial Institution entry below.	
• Global Environment Facility (GEF)	Helps developing countries fund projects and programs that protect the global environment. GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.	Highly significant for the first CO_2 storage activities in developing countries, if it allows CO_2 storage.	UNFCCC consideration for CO_2 storage underway at the moment.
• International Financial Institutions	Multilateral development banks or export credit agencies use public money to undertake or support investments in other countries. Export credit agencies facilitate and support exports to and investments in other countries.	Significant for the first CO_2 storage activities in developing countries (if they allow CO_2 storage, which is uncertain).	

Source: UK Department of Energy, Food and Rural Affairs.

Financial and other incentives

Existing tax-based and finance-based schemes that were designed to spur greater investment in renewable energy or low-carbon technologies should be examined for compatibility with CO_2 storage. Policy makers should ensure that eligibility criteria do not exclude CO_2 storage; schemes should be designed to be technology-and fuel-neutral.

Capital finance schemes, such as grant schemes, are often targeted at specific technologies or sectors, and therefore warrant consideration. One scheme that is international and not-technology specific is the Global Environment Facility (GEF). The GEF is designed to fund the incremental costs associated with improved environmental performance. To date, there have not been any CO_2 storage applications to test the GEF's approach to incremental cost baselines. The United Nations Framework Convention on Climate Change (UNFCCC)'s 11th Conference of the Parties in December 2005 asked GEF to consider how CO_2 storage could work within its funding programmes, including issues such as capital projects, enabling activities and project preparation. There has not been an update on the status of this inquiry.

Other national incentive programmes include FutureGen in the United States and ZeroGen in the European Union. To date, there has not been a comprehensive collection of the variety of incentive schemes governments can use to foster increased use of CO_2 storage; this is recommended for future work.

The European Union: economic incentives for CO_2 storage

The EU considers the major cost/economic factors that need to be considered are the increase in capital investment for the CO_2 storage activity and the increased operating costs needed to run the capture and storage plants. With certain technologies the latter generates an energy penalty – more fuel is needed per useful unit of energy generated, because some of it is used in capture and storage of carbon dioxide.

A key issue is the treatment of CO_2 storage under the EU Emissions Trading Scheme (ETS). The role of CO_2 storage under the EU ETS will be addressed in the review of the EU ETS post-2012. The Commission is aware, however, that a number of commercial CO_2 storage projects are expected to become operational before 2012. These include projects in Member States as well as in Norway, which may link with the EU ETS through the European Economic Area agreement in January 2008. The Working Group on the ETS set up under the Commission Communication "Building a Global Carbon Market" will address to what extent to recognise CO_2 storage, considering the need for comparable treatment of low- or non-CO_2 emitting activities and a level playing field between various CO_2 storage options and across the EU for investment in CO_2 storage technologies.

Enhanced oil recovery using captured CO_2 is another potential component of a value chain for CO_2 storage. However, due to the high cost of retrofitting existing platforms for EOR, it may not be commercially viable for all projects. In any case, because of the expense of building and running capture plants, it may be that projects are not commercially viable even with EOR. Also projects have to compete for funding and may not be as attractive as other oil and investments in an earlier maturity stage. The Commission is aware that some member states as well as Norway are considering the provision of supporting such cases, and the Commission will clarify the treatment of any such assistance under the EU state aid rules.

Facilitating a network of demonstration projects in Europe

A number of large-scale projects are in the pipeline in Europe which could form the basis of a range of demonstration projects across Europe and internationally, over the next 10 years, deploying a range of technologies. The Zero Emissions Fossil Fuel Technology Platform has produced a research agenda for CO_2 storage and a programme for strategic deployment, and recommends a network of 10-12 integrated, large-scale demonstration projects across Europe and a maximisation of co-operation at the international level.

As part of the EU-China Summit in September 2005, the EU and China agreed to develop a demonstration plan on "Near Zero Emissions Coal" (NZEC) by 2020. The EU-China Memorandum of Understanding, which relates largely to the feasibility study phase of the project, was signed in January 2006. Phase 1 of the project was started in July 2006, with around EUR 10 million in funding. The Commission and several member states are examining potential funding options for Phases 2 and 3 of the NZEC project (planning and design and construction/operation), and for a network of demonstration projects open to third-country participation.

Source: European Commission.

Including CO_2 storage in emissions trading schemes

Existing mechanisms such as the EU Emissions Trading Scheme and Clean Development Mechanism (CDM) were developed before CO_2 storage became a viable mitigation technology. Therefore there is uncertainty regarding whether these mechanisms apply to CO_2 storage. Efforts are underway at the UNFCCC and the Kyoto Protocol framework to address these issues. Such schemes allow market players freedom in decision making in mitigation options, but have to be specific in other ways such as sectors covered, spatial and temporal boundaries, and prescriptive on processes to ensure their environmental integrity and to minimise creating competitive disadvantages.

UN Framework Convention on Climate Change and Kyoto Protocol

The UNFCCC states as its ultimate objective the achievement of stabilisation of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Parties to the Convention are obligated to implement national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removal by sinks of all greenhouse gases. The main provisions of the UNFCCC relevant to CO_2 storage are included in Annex 10.

Article 2 of the Kyoto Protocol states that "each Party...., in achieving its quantified emission limitation and reduction commitments...., in order to promote sustainable development, shall: (a) implement and /or further elaborate policies and measures in accordance with its national circumstances, such as:... (iv) Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies..." (the main provisions of the Kyoto Protocol relevant to CO_2 storage are included in Annex 11). CO_2 storage is one option to mitigate climate change that addresses anthropogenic emissions by source.

Current status of CO_2 storage in the CDM framework

The Clean Development Mechanism is an arrangement under the Kyoto Protocol allowing industrialised countries with a GHG reduction commitment (so-called Annex 1 countries) to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries. The CDM is supervised by the CDM Executive Board and is under the guidance of the Conference of the Parties of the UNFCCC. CO_2 storage projects are not currently accepted as CDM projects.

Recently, however, the CDM Executive Board referred two CO_2 storage project proposals to its Methodological Panel with a view to using the CDM project methodologies proposed for the CO_2 storage projects to prepare recommendations on methodological issues related to CO_2 storage as CDM projects. The Panel was asked to address specific emissions accounting issues such as setting a project boundary, permanence, and leakage issues (see discussion below), for consideration by the Parties.

Views on including CO_2 storage as an acceptable CDM project were then discussed at the 24th session of the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC in May 2006, and by the UNFCCC CDM Methodology Panel in their September 2006 report. The SBSTA workshop offered several conclusions (see text box).

UN SBSTA workshop conclusions on CO_2 storage

- CO_2 storage should be considered as an emission reduction not a sink enhancement.
- Ensuring that monitoring and remediation occurs as long as necessary in accordance with provisions of 2006 IPCC guidelines even if this means after the final crediting period (when some project developers or participants may not exist anymore) and that the responsibility for long term stewardship of the reservoir is attributed to a party, *e.g.* the host country or the project participant, that is able to comply with the demands on the required timescale.
- CO_2 storage CDM projects should be validated and verified by a Designated Operational Entity especially accredited for geologic CO_2 storage CDM projects.
- The long-term responsibilities associated with CO_2 storage projects imply the need for appropriate upfront site requirements and site selection criteria. Financial considerations for monitoring costs should be taken into account.
- CO_2 storage projects should contribute to the objectives of the CDM, including assisting non-Annex I Parties in achieving sustainable development according to the host Party.
- Compatibility with all relevant international law.
- Definition of appropriate criteria for site selection, site management and monitoring to minimise risk of leakage from storage sites and remediation strategies.
- Accounting that reflects issues related to project boundary, leakage and permanence. The Conference of the Parties has to provide guidance to the CDM Executive Board on how to operationalise these aspects in assessing submitted methodologies and proposed projects.
- CO_2 storage CDM projects should be validated and verified by a Designated Operational Entity especially accredited for geologic CO_2 storage CDM projects.

Source: UNFCCC, see http://unfccc.int/resource/docs/2006/cmp2/eng/misc02.pdf

In September 2006, the CDM Methodological Panel's report identified four policy/legal issues for further consideration (CDM Methodological Panel, 2006):

- Acceptable levels of long-term physical leakage risk and uncertainty;
- Project boundary issues (such as reservoirs in international waters and several projects using one reservoir) and national boundaries (approval procedures for projects that cross national boundaries);
- Long-term responsibility for monitoring the reservoir, including any remediation measures that may be necessary after the end of the crediting period; and
- Accounting options for any long-term seepage of CO_2 from reservoirs.

In November 2006, at the second meeting of the Parties to the Kyoto Protocol in Nairobi, Parties decided that more work is required before allowing CCS to qualify as a CDM project. The CDM Executive Board will continue reviewing CCS project methodologies to gain further understanding of deploying CCS technology in the CDM. Organisations were given until May 2007 to submit views on legal, policy, and technical issues that need to be addressed before CCS is eligible under the CDM. Parties to the UNFCCC and Kyoto Protocol have been given until September 2007 to submit views. It is therefore unlikely that CCS projects will be eligible under the CDM before the fourth meeting of Kyoto parties in the fall of 2008.[1]

While the CDM Executive Board's resolution of the status of CCS as an allowable project will offer guidance, there are a number of other national, sub-national and private emissions trading efforts that are also considering what role, if any, CCS can play within their systems. These schemes are raising the same emissions accounting issues, including setting a project boundary and baseline, monitoring and verification requirements, and accounting for emissions leakage. These issues are discussed briefly below.

Nonpermanence

Emissions trading systems must account for the possibility of future release of CO_2 from storage sites. As discussed above, the IPCC believes the likelihood of release from properly selected and managed storage sites to be extremely low – such sites are expected to retain over 99% of stored CO_2 for over 1 000 years, which would represent a loss on the order of 0.001% per year (IPCC, 2005). However, if the release rate were one order of magnitude greater – 0.01% per year – and the volume of stored CO_2 was sufficient, future releases from geologic storage could account for a significant proportion of acceptable future GHG emissions budgets (Bode and Jung, 2004). The first strategy is to select, monitor and manage sites appropriately. However, it may also be important to account for the risk of future CO_2 releases in determining compliance with GHG emissions trading schemes or awarding offsets credits.

In principle, it is possible to apply an ex ante discount rate to the award of offset credits based on the probability of future releases over the crediting period, and this rate could be calibrated to the predicted integrity of the storage site (Haefeli, *et al.,* 2004). It is also possible to create rules that account for actual releases over time, provided that accurate, long-term monitoring is in place. For example, the project proponents could be required to self-insure by holding reserve

1 At the time of publication, the CDM Executive Board has received two CO_2 storage project proposals, one in Malaysia that involves storing CO_2 from a liquefied natural gas processing plant in a saline aquifer; the other is in Vietnam and proposes using captured CO_2 from a natural gas power plant for enhanced oil recovery. The Board has deferred consideration of these projects until the Parties have taken action regarding the eligibility of CO_2 storage as a CDM project (Hayes and Beauvais 2007).

credits as a hedge against future releases, or to adopt some temporary but renewable credits such as those used for biological sequestration projects under the CDM (Hayes and Beauvais, 2007).

Baselines and allocation

Baselines are required for emissions trading schemes. They may also be required for capital finance schemes, if they are to operate in a way which ensures equivalent treatment between competing CO_2 mitigation technologies. Whether baselines are determined at a project, sectoral or national level depends on the market mechanism under consideration. The Clean Development Mechanism generally requires project-level baselines, and much work has been undertaken and is continuing in the UNFCCC and Kyoto Protocol on baselines for the energy sector.

Guidance is needed to formulate CO_2 storage baselines. Given the variety of technologies and fuels, the age range of the generating plant, whether plants are new, existing or retrofitted, and the different market structures (for example, nationalised compared with privatised), determining baselines will be a complex process (Haefeli, *et al.,* 2004). There is work currently underway on baselines in the UNFCCC context. As a result, the next steps would be to monitor this activity with special emphasis on how the methods could be extended into the wider context of other incentive schemes, as well as for developing sound methods to determine the reductions that have been achieved through a particular project.

In addition, nations and/or project developers would benefit from guidance on baselines for CO_2 storage projects. Recent developments in the UNFCCC process indicate that this guidance may not be a priority; therefore, it may be appropriate for other organisations to propose guidelines for discussion.

Monitoring, reporting and verification

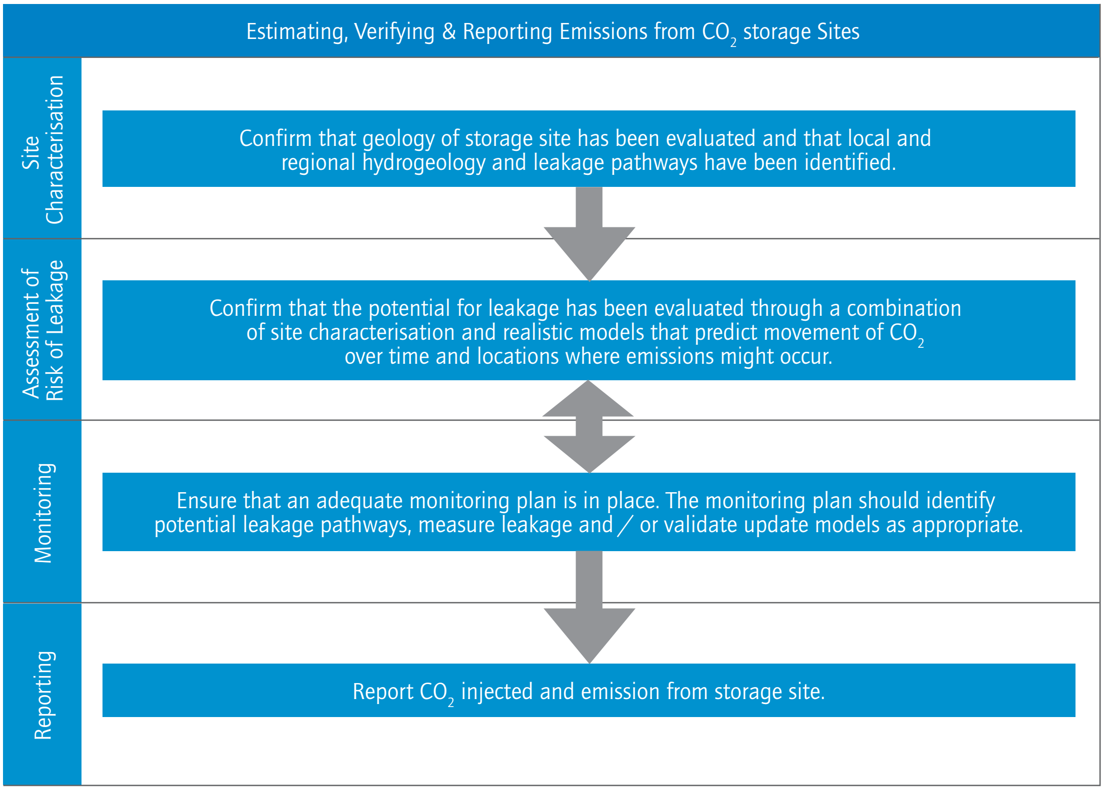
Monitoring, reporting and verification are required for CO_2 storage to be able to benefit from incentives from any emissions trading scheme, as it provides the assurance of environmental integrity. Without knowing to a sufficient degree of accuracy how much CO_2 has been mitigated, the emissions inventories, and hence the incentives, would lack credibility. It should be noted that CCS is perhaps the only mitigation technology that physically measures the quantity of CO_2 abated.

For the first time, the Intergovernmental Panel on Climate Change (IPCC) Inventory Guidelines issued in April 2006 provide guidance and good practice methods for including CO_2 storage in national inventories (IPCC, 2006). These guidelines, as well as all other inventory procedures, will be applied by each country, and there will need to be consistency between countries on how they are applied.

The "energy penalty" associated with carbon capture plants

The installed capacity of a generating unit with a carbon capture plant is significantly less than the installed capacity of an identical plant without carbon capture. This is because the carbon capture plant consumes a significant quantity of energy. This reduces the efficiency and increases the cost of electricity from CO_2 storage power plant. This cost will be accounted for in the system cost for CO_2 mitigation when assessing a project. Some policy makers are considering mitigating the penalty in some way. The CO_2 emissions arising from the energy consumption by the CO_2 capture plant should be accounted for by subtracting it from the CO_2 injected to give a figure for net CO_2 abated.

Figure 2.4: a timeline for estimating and reporting emissions



Source: IPCC, 2006.

Accounting for leakage from carbon storage sites

In any regulatory scheme based on the quantity of emissions mitigated, such as an emissions trading scheme, it will be important to determine the leakage of emissions from the whole CO_2 storage chain and in turn an overall figure for CO_2 emissions from any given installation.

To determine emissions leakages from the CO_2 storage chain, one option is to undertake mass balance calculations based on measurements of CO_2 flow rates at the production site, the capture site, entry and exit transportation means from the injection site. The alternative is to estimate leakage emission factors at each stage in the CO_2 storage chain (Zakkour, 2005). This is possible for transport by pipeline and perhaps storage but will be more complex for capture. There are differing views as to whether double-counting exists however if indeed it does there is a need to eliminate this double-counting.

In addition, to ensure the environmental integrity of any scheme, the potential for leakage has to be taken into account. In order for the private sector to have sufficient confidence to invest in CO_2 storage projects, it will need to be certain that the emissions credits for the sequestered carbon will be equivalent to those from other technologies. The cost of leakage needs to be understood and accounted for. Assessing the project boundaries for CO_2 storage projects will be important, and should allow for CO_2 migration within and outside the storage site.

The simplest means of providing the necessary certainty for private investors and regulators would be to assume that leakage from the storage site is zero, as indicated in the recent IPCC Inventory

Guidelines (IPCC, 2006). This assumption can be made once the storage site had passed through a stringent permitting process involving modelling and geologic surveys. Furthermore, the site will be monitored once CO_2 injection had finished, with the level of monitoring being reduced over time if the CO_2 was behaving as predicted. If permanence is assumed then liability for leakage should be dealt with by domestic licensing and permitting regimes since storage involves longer timescales and different regimes to those in existing emission trading schemes.

However, the principle of potential leakage should be accounted for to guarantee environmental integrity. A range of alternatives have been proposed including time-limited credits such as used for forestry projects which are of short project duration. However these are less attractive for CO_2 storage projects where CO_2 mitigation should be more certain and timescales are much longer. Time-limited credits have much less value than conventional credits, and would give much less incentive to CO_2 storage projects compared to other technologies.

Analysis of options is currently underway in the CDM process. The aim is to decrease the level of uncertainty while accounting for possible leakage, through a study that objectively analyses each option (Osman-Elasha and Pipatti, 2005). Some of the options include:

- Careful selection of CO_2 storage projects and assumption of permanence;
- Discounting emission reductions by a set rate to account for potential leakage;
- Requiring the holder of resulting emission credits to replace the units if and when leakage occurs;
- Requiring project participants to replace units if leakage occurs;
- Requiring host country to be responsible for dealing with any leakage (for example, by buying and cancelling units); and
- Issuing temporary emission credits which would periodically be renewed except in the case of leakage.

Ensuring public participation

Many international groups and national policy makers cite public acceptance as a key challenge that must be achieved prior to widespread use of CO_2 storage. Surveys have shown that stakeholder perception of risks from CO_2 storage – including water or land contamination, human health impacts or large-scale CO_2 releases – is not high, with only 3-6% of respondents expressing concern of high risks of these occurrences. However, a sizeable percentage of these experts also expressed that they had insufficient data to express an opinion on the seriousness of the risks (de Figueiredo, 2007). It is expected that the public perception of risks will be refined as more data becomes available.

There are many aspects of public acceptance, including government and private sector opinion polling, outreach campaigns and local consultation related to proposed storage projects. Of these, ensuring proper local public acceptance of planned CO_2 storage projects through a well-designed public consultation process is the only area that implicates legal issues. This section discusses public consultation relating to CO_2 storage projects; Annex 4 includes additional related information on CCS public opinion polling and national outreach efforts.

To convince the local community that a CO_2 storage site has been well-selected and storage will be carried out in a safe manner, risk assessments should form an integral part of the government's decision making process. Risk assessments should include evaluation of the probability for leakage and the likely effects on local and regional environments. Keeping in mind that the public's main concerns regarding CO_2 storage are the potential risks rather than the technology itself, a stringent risk assessment procedure and appropriate environmental impact assessments are likely to assist in increasing the public acceptability of CO_2 storage. Regulations must set out clearly the obligation to carry out risk assessments and the responsibility or liability for any leakage or pollution, including in the long term, to reduce the probability of leakage and thereby ensure minimum risk to health and safety.

To date there have been a handful of studies involving public perceptions to CO_2 storage which have predominantly focused on surveying the general public to assess levels of knowledge about the technology. In general, findings of studies completed over the past few years show that the public is not well-informed on CO_2 storage technologies nor the issues connected to its implementation and potential for mitigating global climate change. Lessons learnt from previous perceived high-risk technologies (dumping of toxic waste, biotechnology) demonstrate that social risk can delay or halt the implementation of a new technological process (Littleboy, Ashworth *et al.,* 2004).

Norway: reaching public acceptance for CO_2 storage

Norway has been at the lead in European deployment of CO_2 storage technologies. Environmental issues are high on the Norwegian agenda and popular concern for the environment is very strong. Thus, there is a positive view on CO_2 storage as a measure to reduce national emissions and mitigate global climate change.

The Sleipner CO_2 capture and storage scheme has attracted significant and positive international attention as a pioneering model for CO_2 storage projects in general. Public perception of the oil and gas industry in Norway is fairly positive. In surveys conducted in the past few years, about 60% of the population have at least a "fairly good" impression of the industry.

Norway hosts an energetic NGO community that has traditionally been very active in marine and other conservation issues, but also increasingly vocal in climate policy. Four major Norwegian environmental NGOs (Norwegian Society for Conservation of Nature, Nature and Youth, Greenpeace Norway, and The Future in Our Hands) have formed an alliance on climate change issues. The environmental organisation Bellona has a special focus on energy, climate and innovative solutions. Bellona started working on CO_2 storage as early as 1993, and has been involved in international activities to develop and promote the technology.

Social acceptability and lessons learned for CO_2 storage

In Norway, the social acceptability of CO_2 storage is quite different from other European countries. NGOs like Bellona and Zero have been very actively advocating CO_2 storage. Greenpeace Norway, however, has been in opposition to all forms of carbon storage both internationally and in Norway.

CO_2 storage on the Sleipner field since 1996 has not raised significant debate. Being located 250 kilometres offshore, the CO_2 storage project actually met limited interest in

Norway. Safety issues have not been a major point in the debate due to the offshore storage location.

CO_2 storage is viewed positively in Norway and several environmental organisations are very strongly in favour of the technology. Environmental organisations are actually demanding stronger enforcement of CO_2 storage. In general, most people seem to have some knowledge of the technology due to more than 10 years of active debate, but see CO_2 storage as only one clean technology among others. Concern about safe storage is lesser than in other countries due to the offshore location of storage reservoirs. Norwegians are accustomed to oil and gas extraction on their shores, and have a relatively high level of confidence in the industry.

The Norwegian CO_2 storage projects provide a few lessons:

- CO_2 storage is embroiled in other debates related to the oil and gas industry in Norway. Therefore, even if several environmental NGOs are positive to CO_2 storage, it is often a quite qualified and independently-minded type of support mixed with other environmental messages.
- The offshore and remote location of CO_2 storage sites in Norway can be assumed to have played a key role in the public and NGO support of CO_2 storage projects.
- The Sleipner CO_2 injection has lead to increased attention to CO_2 storage technology also in Norway, leading to demands for further CO_2 storage projects in Norway.

Source: Norway Ministry of Petroleum and Energy.

Developing guidelines for public involvement

In designing the legal aspects of public involvement in a planned project, consideration should first be given to the goal of the involvement. This will help identify the key stakeholders that need to be involved, including the local community, relevant government agencies, environmental non-governmental organisations and industry.

Common themes that are embodied in existing principles for engagement with stakeholders include:

- Open and effective engagement involving two-way communication,
- Clear, timely, accurate and relevant information communicated to stakeholders;
- Transparent and agreed information and feedback processes;
- Reporting decisions and outcomes of meetings with stakeholders;
- Working cooperatively to seek mutual beneficial outcomes;
- Recognise, understand and include communities and stakeholders early and throughout the process; and
- Conduct engagement with integrity, in a manner that fosters mutual respect and trust (Ministerial Council for Mineral and Petroleum Resources, 2005).

There is no reason why CO_2 storage public engagement guidelines cannot be based on these sorts of existing principles for engagement with stakeholders. Additional work is recommended to tailor existing mechanisms to address engaging the local community in proposed CO_2 storage projects.

3. INTERNATIONAL MARINE ENVIRONMENT PROTECTION INSTRUMENTS

Where CO_2 storage occurs completely within territorial land and waters, national and sub national laws apply. However, if project activities take place offshore in international waters, a variety of international marine environment protection instruments may apply, as there are potential risks to the marine environment associated with CO_2 leakage during CO_2 injection and long-term storage. To address issues related to offshore CO_2 storage, Contracting Parties to international marine environment protection instruments have proactively worked to develop appropriate amendments to the London Protocol and the OSPAR Convention to allow for regulation of sub-seabed CO_2 storage. This chapter discusses these updates.

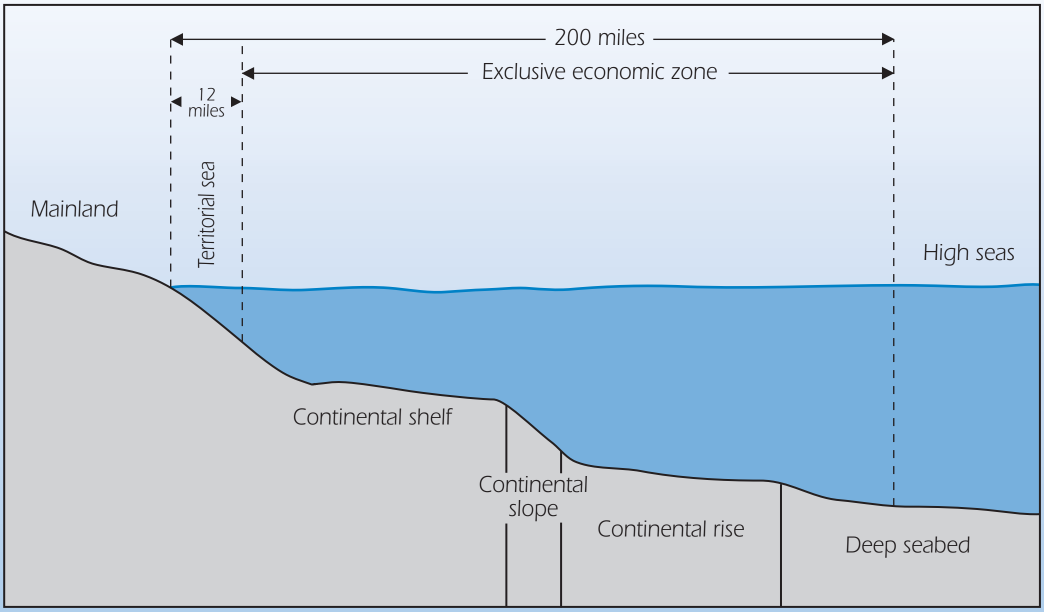
Background

International marine environment protection was established in 1972 with the London Convention to regulate the dumping of wastes and other matter at sea. In 1982, this field was extended through the adoption of the United Nations Convention on the Law of the Seas (UNCLOS). Being an overarching construction, UNCLOS does not contain detailed operative provisions on most maritime issues; rather, it provides a framework for all areas, including marine protection, and allows other, more targeted treaties to fill in the gaps. The main provisions of UNCLOS relevant to CCS are included in Annex 6. With regard to marine pollution, global standards are set by the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, signed in London in 1972 (London Convention). Beneath the London Convention exist several regional agreements that cover specific areas of the ocean. The most widely known of these is OSPAR, the Convention for the Protection of the Marine Environment of the North-East Atlantic. OSPAR is also notable as its regulations on marine pollution are markedly stricter than those of the London Convention, and its decisions are legally as opposed to politically binding on its Contracting Parties.

UNCLOS and the legal zones of the sea

The conditions of application of the various international maritime agreements to carbon dioxide storage depends on location of the storage sites within one or the other of the specific legal zones of the sea defined by UNCLOS: the territorial sea, the Exclusive Economic Zone and the high seas. A country's territorial sea constitutes the band of ocean stretching up to twelve miles from its shores. Within this area, nations' sovereignty over the territorial sea is exercised subject to rules of international law. A nation's Exclusive Economic Zone (EEZ) extends from the end of the Territorial Sea out to 200 miles from a country's coast. Coastal states have sovereign rights to explore and exploit the natural resources of the sea bed and subsoil of the continental shelf (land which is usually contained within the EEZ). Beyond this area are the high seas. The high seas are open to all states, however, the states may also complain if activities of others cause undue harm to their interests.

Figure 3.1: The legal zones of the sea



Source: IEA GHG Programme.

The London Convention framework

The London Convention framework comprises the London Convention itself and its 1996 Protocol (known as the London Protocol). The London Convention is one of the oldest global conventions to protect the marine environment from human activities. It has been in force since 1975 and has 80 contracting parties. The relevance of the London Convention to CO_2 storage is limited but important – it only applies to storage conducted from aircraft and vessels and platforms in the water column. Consequently, it does not apply to storage in the ocean seabed or its subsoil or from a land-based pipeline. In contrast, the London Protocol, which was developed in the 1990s to modernise and eventually replace the London Convention, is much more relevant to CO_2 storage. The Protocol entered into force in March 2006.

The London Convention

The London Convention's objective is to promote the control of all sources of pollution to the marine environment. As such, Contracting Parties (see Figure 3.2 below) agree to take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, harm living resources and marine life, damage amenities or interfere with other legitimate uses of the sea.

The London Convention also requires Contracting Parties to be guided by a precautionary approach to environmental protection in the implementation of their Convention obligations. According to this approach, appropriate preventive measures must be taken when there is reason to believe that substances or energy introduced in the marine environment are likely to cause harm even when there is inconclusive evidence to prove a causal relation between inputs and their effects.

Table 3.1: Summary of legal issues and gaps in international marine environment frameworks related to CO_2 storage

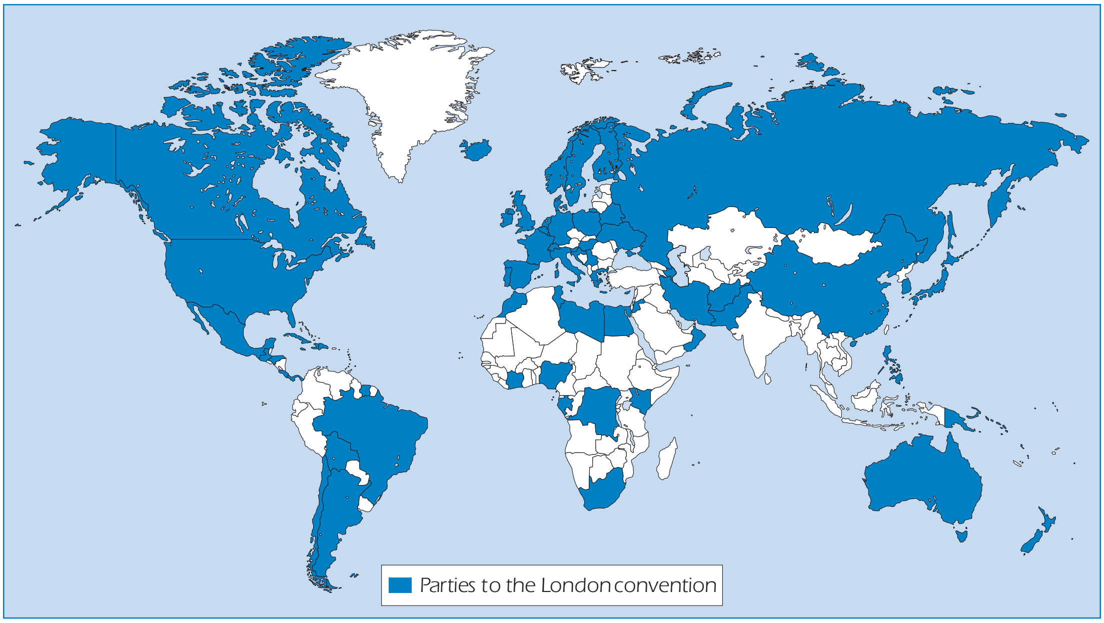
Legal Regime	Status and Issues
London Convention	Prohibits the dumping at sea of industrial wastes. Industrial waste includes waste materials generated by manufacturing or processing operations. Prohibits the deliberate disposal CO_2 directly into marine waters. Does not define "at sea" or expressly mention the sub-seabed.
London Protocol	Dumping of industrial wastes is prohibited. The deliberate disposal ("dumping") into the sea of wastes from vessels or manmade platforms is prohibited. "Sea" is defined to include seabed and subsoil thereof, but does not include sub-seabed repositories accessed only by land. Thus geologic storage by injection from vessels or manmade platforms at sea directly into sub seabed repositories is prohibited; and injection of CO_2 by pipeline from a land-based source to a sub-seabed repository is not prohibited (however, the precautionary principle may nonetheless apply to land-based injection).
OSPAR	Placements with different impacts on the environment may not be distinguished (*e.g.,* placement in the water column and placement in underground strata – if they occur by pipeline under Annex I) Different methods of placement with same impact may be treated differently (*e.g.,* placement from a specially-built structure at sea linked to land by a pipeline is permissible under Annex I; placement from a vessel equipped with special equipment is prohibited under Annex II). Makes a distinction between placement from offshore installations of arisings from offshore activities (oil and gas activities) (permissible under Annex III), and placement of non-offshore arisings from offshore installations (permissible only for enhancing hydrocarbon production under Annex III). Scope of the phrase "placement of matter for a purpose other than the mere disposal thereof" warrants clarification in the context of CO_2 storage activities, where storage is to be of indefinite duration. Methods and purposes of placement do not necessarily reflect risk. Requires a means to monitor and assess the quality of the marine environment in the context of CO_2 storage activities.

Source: Hendriks, et al., 2005.

The London Protocol

The objective of the London Protocol is to protect and preserve the marine environment from all sources of pollution and take effective measures to prevent pollution caused by dumping or incineration of wastes or other matter at sea. The Protocol adopts a more extensive approach to dumping at sea than the London Convention. Dumping applies to both:

Figure 3.2: Parties to the London Convention



Source: IEA, 2005.

- The deliberate disposal at sea (which includes both the water and the sea-bed and subsoil thereof) of wastes loaded on board a vessel; and
- Any storage of wastes in the sea-bed and the subsoil thereof.

In addition, the London Protocol prohibits all dumping except for acceptable candidate wastes contained in a "reverse list." This list does not currently include CO_2. Sea dumping under the Protocol does not include pipeline discharges from land, operational discharges from vessels or offshore installations or placement. The Protocol also contains a stricter precautionary approach formulation than the London Convention, as it requires Contracting Parties to apply the approach, instead of being guided by the approach as in the London Convention. CO_2 falls within the scope of the agreement, because the Protocol applies to the introduction in the marine environment of wastes or other matter. The main provisions of the London Protocol relevant to CCS are included in Annex 8.

The OSPAR Convention

The OSPAR Convention was established in 1992 by 15 Northern European States and the European Community, and is considered to be the most comprehensive and strict legal framework governing the marine environment. In 2002, the OSPAR Commission decided to establish an agreed position on whether placing of carbon dioxide in the sea was consistent with the OSPAR Convention and commissioned a study by the Jurists and Linguists Group (JL Group) of the OSPAR Convention. The final report of the JL Group was accepted, endorsed and authorised for publication by the OSPAR Commission in 2004.

According to this report, which is only an initial opinion and may be subject to subsequent modification, the OSPAR Convention already provides a complex framework allowing or prohibiting certain activities depending on the *source* of the material (land-based, from a vessel or from offshore activities) and the *nature* of the placement (scientific experiment, facilitating oil or gas production or other mere disposal, which includes placement for the purpose of mitigating climate change). The main features of the regime are:

- **Land-Based Sources regime:** discharges into the maritime area[2] from land-based sources[3] are not prohibited, but must be strictly regulated or authorised.
- **Dumping (from a vessel):** any carbon placement classified as dumping from a vessel is prohibited (scientific research is not dumping).
- **Offshore activities:**
  - Placement of CO_2 arising from the operation of an offshore installation ("offshore arisings") is not prohibited but must be authorised or regulated.
  - Placement of offshore arisings for scientific research is not prohibited but must be in accordance with the Convention.
  - Placement of non-offshore arisings brought to an offshore installation is authorised to enhance hydrocarbon production, but is otherwise treated as dumping.

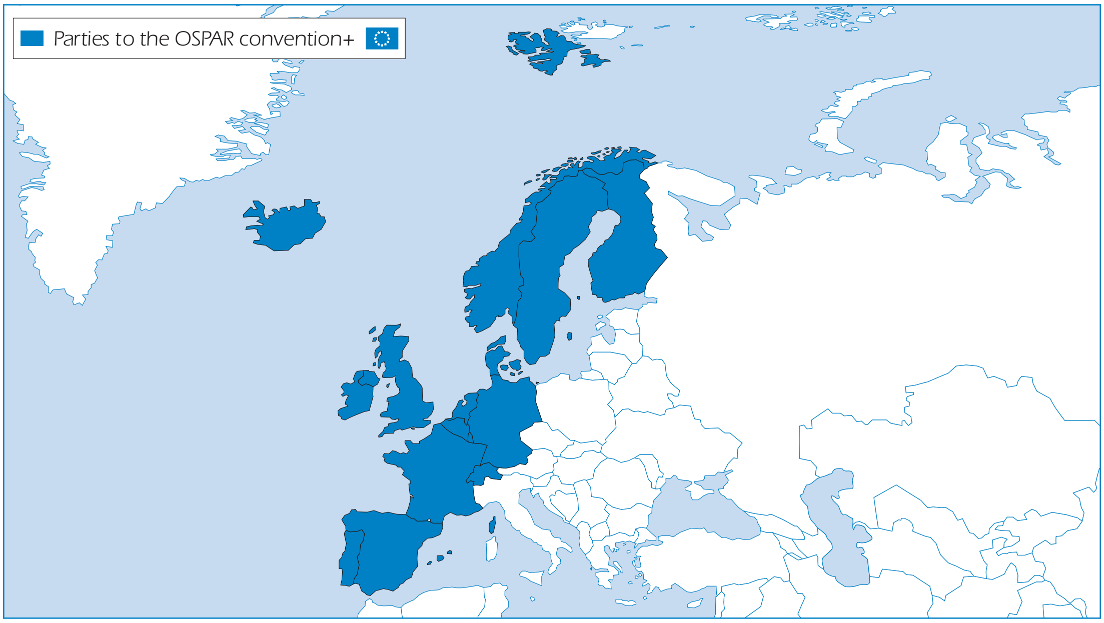
Like the London Protocol, the OSPAR Convention does not distinguish between storage in the water column and off-shore geologic storage, despite their significant differences in terms of environmental effects. According to the OSPAR JL Group, further thought is needed on the interrelations between the current legal report, possible physical impacts and the appropriate regulatory approach. Some participants in the JL Group note that the possible effect on the marine environment from placement directly into the water column and from placement into geologic structures in the subsoil will be different. Hence, these participants draw attention to the argument that, to the extent that placement of CO_2 into the maritime area does not result in "pollution" as defined in the Convention, there is no prohibition on such placement under the OSPAR Annexes. They also note that if CO_2 is injected into a geologic structure in the subsoil in such a manner that it is unlikely to escape, such an injection will fall outside the scope of these Annexes.

Others believe that there is a prohibition in general on the dumping of wastes and other matter, and that therefore, irrespective of whether there is pollution as defined in the Convention, these activities fall within scope of Annex II. One additional issue regards the impact on the marine environment of CO_2 released to the atmosphere. The OSPAR precautionary principle provides that preventive measures are to be taken when there are reasonable grounds for concern that substance or energy introduced directly *or indirectly* into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems. CO_2 released to the atmosphere is eventually absorbed to a large extent by the oceans is therefore *indirectly* introduced in the marine environment. The main provisions of the OSPAR Convention relevant to CO_2 storage are included in Annex 9.

2. Which covers the sea (from the tidal limit), the seabed and its underground strata.

3. Land-based sources include tunnel, pipeline as well as sources associated with man-made structures placed in the maritime area other than for the purpose of offshore activities ("non-offshore installations").

Figure 3.3: Parties to the OSPAR Convention



Source: IEA, 2005.

Other regional treaties

There are a number of regional marine environment protection instruments that will need to address the question of CO_2 storage in the future (see Annex 5). With the exception of OSPAR, no decision has been taken as to whether these other regional treaties and conventions clearly apply to CO_2 storage because they do not mention CO_2 storage activities nor apply below the seabed. As discussed earlier, the pro-active approach that the London Convention and OSPAR Convention are taking will serve as guidance for these regional treaties as they address issues related to their applicability to CO_2 storage activities.

Current status of CO_2 storage under the London Convention and OSPAR frameworks

The bulk of attention on the acceptance of CO_2 storage in the marine environment framework has focused on the London Protocol and the OSPAR Convention, because they are currently considering possible amendments in order to clarify the status of CO_2 storage within their auspices. These amendments are important due to the precedent that they may set, as future instruments may adopt similar approaches. The latest developments in the London Convention framework and the OSPAR Convention framework are discussed below.

The London Convention framework

In October 2005 at the 27th Consultative Meeting, a working group discussed the compatibility of CO_2 storage in sub-seabed geologic formations with the provisions of the London Convention and the Protocol. The group acknowledged that CO_2 storage in sub-seabed geologic structures had a role to play as part of a suite of measures to tackle the challenge of climate change and ocean acidification. The Working Group reached general agreement that under some circumstances – such as enhanced oil recovery – CO_2 storage in sub-seabed geologic structures is allowed. On other issues, however, there was less agreement. This difference of views reflected the fact that neither instrument was drafted with these technologies in mind; therefore, there were differing interpretations of how the instruments may apply. The working group expressed concern that if amendments were to be considered, they should be limited in scope. They felt that amendments should make clear that the intention was to facilitate and/or regulate only CO_2 storage (rather than other substances), in sub-seabed geologic structures (rather than the water column) and subject it to appropriate controls. An Intersessional Legal and Related Issues Working Group on CO_2 Sequestration was to develop a menu of options to clarify (and, if appropriate, amend) the Protocol and the Convention, with a view to facilitating and/or regulating the use of CO_2 sequestration in sub-seabed geologic structures.

In April 2006, the Intersessional Legal and Related Issues Working Group on CO_2 Sequestration met in London. At this meeting, the working group agreed to focus on the possible amendment of Annex 1 to the London Protocol (rather than the London Convention) whereby CO_2 storage in sub seabed geologic formations would be treated as permissible dumping, subject to regulation. Working group discussions resulted in the text of a possible amendment to Annex 1 to the Protocol. It was then a matter for one or more Contracting Parties to the Protocol to submit specific amendment proposals for consideration at a Meeting of Contracting Parties to the Protocol. Australia, with co-sponsorship from France, Norway and the United Kingdom, submitted a proposal for an amendment to the Protocol based on the outcomes of, and using the possible amended text agreed at, the Intersessional Working Group.

In October 2006, the Parties to the Protocol adopted the amendment to Annex 1. As amended, the rules state that CO_2 may be stored ("dumped") if (1) the disposal is into a sub-seabed geologic formation; (2) stored streams consist overwhelmingly of carbon dioxide (they may contain incidental associated substances); and (3) no waste is added for the purpose of disposal. In accordance with Article 22 of the Protocol, the amendment entered into force for each Party immediately on notification of acceptance (or on 100 days after the date the amendments were adopted if that was later).

Amendment to Annex 1 to the London Protocol

1.8 Carbon dioxide streams from carbon dioxide capture processes for sequestration

4 Carbon dioxide streams referred to in paragraph 1.8 may only be considered for dumping, if:

1. Disposal is into a sub-seabed geologic formation; and
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.

In paragraph 3, replace "1.7" with "1.8", to take account of the new paragraph 1.8.

Source: The International Maritime Organisation, www.imo.org/includes/blastDataOnly.asp/data_id%3D16775/5.pdf

This amendment is important because it provides a basis in international environmental law to regulate CO_2 sequestration in sub-seabed geologic formations: this sort of CO_2 storage will now be subject to licences issued by governments, with applicants being required to demonstrate the integrity of a proposed storage site with monitoring and mitigation safeguards in place. These monitoring provisions will be critical components of the license approval process. These rules also create a climate in which more research can be done to further develop and improve existing technologies enabling the ultimate safe storage of CO_2.

To address existing gaps in knowledge, the Contracting Parties agreed that guidelines should be developed for adoption when they meet again in November 2007 on how to capture and sequester CO_2 in a manner that meets all of the requirements of the Protocol and is safe – over the long- and short-terms – for the marine environment. The working group also developed *Risk Assessment and Management Framework for CO_2 Sequestration* guidelines which provide provisional information to regulators and others regarding:

- the selection of those underground reservoirs with the greatest potential for permanent storage;
- site-specific risks to the marine environment from CO_2 storage;
- the development of management strategies to address uncertainties; and
- the reduction of risks to acceptable levels.
  Using this framework, guidelines are now being prepared for adoption under the London Protocol in 2007 to cover all of the points which need to be taken into account by applicants for CO_2 storage licenses and also by licensing authorities when assessing license applications and enforcing permit conditions (London Protocol, 2006).

OSPAR Convention: current status

In June 2006, the OSPAR Committee recognised that ocean acidification and other effects on the marine environment caused by elevated emissions of CO_2 are a cause of serious concern. Mitigation of these impacts necessitates a portfolio of options to reduce levels of atmospheric CO_2, including the placement of CO_2 in sub-seabed geologic formations. The OSPAR Offshore Industry Committee (OIC) and the Biodiversity Committee concluded at their meetings in 2006 that it is technically feasible to store CO_2 safely in geologic formations and that appropriate monitoring/surveillance technology and methodologies should be in place. OIC also recommended the development of guidelines or a framework for risk management for the storage of CO_2 and the establishment of an intersessional correspondence group (including observers) for the development of guidelines or a framework for risk management under the leadership of the Netherlands, Norway and the United Kingdom.

During the 2006 OSPAR Committee meeting, the terms of reference for an Intersessional Correspondence Group (ICG-CO_2) were drawn up. This Group met in October 2006 to discuss legal, technical and environmental issues such as uniform international frameworks, prohibition of injecting CO_2 into the water column, liability and ownership of stored CO_2. The ICG-CO_2 met in November 2006, and agreed that in order to facilitate and/or regulate the placement of CO_2 in sub-seabed geologic formations, there was a need for amendments to Annex II and Annex III to the OSPAR Convention. The group agreed on the wording of possible amendments to these Annexes and that the wording should be consistent with the London Protocol amendment. There was discussion on whether there was a need to amend Annex I; however, consensus was not reached. The ICG-CO_2 was tasked with developing an OSPAR Framework for Misk Management of CO_2 storage under the seabed.

Issue of CO_2 purity in the London Protocol context

In the discussions on CO_2 storage within the London Convention framework, some participants have raised concerns about defining the correct "purity" for injected CO_2. The amended Annex refers to the stream being "overwhelmingly" CO_2, and allows incidental associated substances whether from the source material or the capture process. This was the result of concerns that the permission of CO_2 storage is primarily aimed at reducing emissions of CO_2 and should not be used to authorise the co-injection of a wide range of other substances.

The parties to the London Protocol decided on the term "overwhelmingly" on the basis that it was not possible to give a specific percentage, and it appeared to be impractical to require that an injection stream comprise 100% CO_2 due to limitations on separation technology, the energy penalties involved in high purity separation, and issues about final treatment of any separated impurities.

Going forward, it is likely that regulators will need to provide guidance as to what level of impurities (other compounds) will be accepted in the CO_2 injection stream. In determining these guidelines, regulators should consider that in the absence of CO_2 storage, many of these compounds would otherwise be emitted to the atmosphere as flue gas emissions, with the level of impurities being regulated through existing atmospheric emissions controls. It is therefore reasonable that the level of impurities that are tolerated in a CO_2 stream should be no less onerous than that allowed if the stream was emitted to the atmosphere. The scientific group will give guidance on the term "overwhelmingly" through the specific waste assessment guidance they will develop in 2007.

Source: IEA Research.

The Group met again in early 2007, establishing guidance on substances incidental to CO_2 capture, transport and storage and guidance on the technical aspects concerning liability, including long-term monitoring. Further discussions will take place at a series of OSPAR meetings in 2007.

4. RECOMMENDATIONS FOR FUTURE WORK

The IEA workshop in October 2006 helped to further advance international understanding of the key legal issues affecting CO_2 storage activities. Experts from around the world offered updates on a number of legal developments in the national legal and regulatory and international marine environment protection contexts. This allowed experts to re-visit the recommendations from the first workshop in 2004, and to prioritise future work based on these ongoing developments.

Given recent knowledge about the expansion of coal-fired power plants to supply electricity around the world, there is an even more urgent need to increase the quantity and pace of work on carbon capture and storage. Further investment in this important family of technologies continues to be impeded by confusion about the need for regulations and low public understanding and acceptance of these technologies. The first step continues to be an expansion of scientific trials and demonstration, which will enlighten legal and regulatory developments and foster increased public acceptance.

Additional recommendations for further legal work on CO_2 storage include:

- **Collect examples of regulatory streamlining and other incentives and adopt practices to facilitate critically needed near-term demonstration projects.** The international community appears to be in agreement that more needs to be done today to demonstrate the viability of CO_2 storage. Governments should work together to identify and share analysis of near-term actions that can be taken to facilitate these demonstrations, including expediting permits, providing incentives and addressing potential long-term responsibilities. Near-term projects can be made subject to temporary legal and regulatory requirements; they will in turn generate necessary data and experience to guide the development of future long-term comprehensive regulations.
- **Use existing project data to develop internationally consistent guidance for CO_2 storage project site identification, monitoring and long-term verification.** In a number of areas—including the development of national regulations, the expansion of emissions trading and other incentives schemes to include CO_2 storage, and the international marine environment protection process—there is a need for detailed guidance on CO_2 storage project site identification, and monitoring and verification of retention. Efforts are already underway at a number of organisations, but these efforts should be consolidated and standardised where possible. This will help address the public acceptance of CO_2 storage as a viable GHG mitigation option, and reduce costs for investors in early projects.
- **Continue to share national regulatory models internationally.** A number of jurisdictions already have well-established oil & gas and other regulatory regimes that can be modified to incorporate CO_2 storage issues. For these jurisdictions, the focus should be on adapting these regulations to address, among other issues, long-term responsibilities that are unique to CO_2 storage. For developing countries without existing regulations, capacity building is recommended to share best practice models and adapt them to national circumstances. Intellectual property rights do not appear to present significant issues; however, it is recommended that future work monitor developments, collect models that can be shared, and focus on outreach and capacity-building efforts to enhance intellectual property regimes in developing regions.
- **Collect and categorise existing incentives programs for CO_2 storage.** There is no international source that compiles the variety of national and regional incentives that are being used to advance CO_2 capture and storage throughout the project lifecycle, from R&D to demonstration

and deployment. To aid governments in exploring these models, it is recommended that future work focus on collecting and categorising existing incentives, with an eye toward identifying the best models for different regulatory and market situations.

- **Continue to address CO_2 storage in the international marine environment context.** Given recent amendment to the London Protocol there is now a basis in international environmental law to regulate CO_2 storage in sub-seabed geologic formations. Other regional treaties may wish to explore the approaches that the London Convention has taken to identify relevance for their contexts. The next step is to guide governments and CO_2 storage project proponents with guidance for monitoring and verification that will demonstrate the integrity of a proposed storage site with monitoring and mitigation safeguards in place. It is further recommended that the question of purity should be addressed by national regulators and should not be a barrier to the application of these international treaties to CO_2 storage activities.

ANNEX 1

Characteristics of power plants with CO_2 capture

Fuel & Technology	Starting year	Investment cost (USD/kW)	Efficiency (%)	Efficiency loss (%)	Additional fuel (%)	Capture efficiency (%)	Capture cost (USD/ t CO_2)	Electricity cost (US cents/ kWh)	Electricity cost reference plant (US cents/ kWh)	Additional electricity cost (US cents/ kWh)
Likely technologies										
Coal, steam cycle, CA	2010	1 850	31	-12	39	85	33	**6.79**	3.75	3.04
Coal, steam cycle, membranes + CA	2020	1 720	36	-8	22	85	29	**6.10**	3.75	2.35
Coal, USC steam cycle, membranes +CA	2030	1 675	42	-8	19	95	25	**5.70**	3.75	1.95
Coal, IGCC, Selexol	2010	2 100	38	-8	21	85	39	**6.73**	3.75	2.98
Coal, IGCC, Selexol	2020	1 635	40	-6	15	85	26	**5.71**	3.75	1.96
Gas, CC, CA	2010	800	47	-9	19	85	54	**5.73**	3.75	1.98
Gas, CC, Oxyfueling	2020	800	51	-8	16	85	49	**5.41**	3.75	1.66
Black liquor, IGCC	2020	1 620	25	-3	12	85	15	**3.35**	2.35	1.00

Fuel & Technology	Starting year	Investment cost (USD/kW)	Efficiency (%)	Efficiency loss (%)	Additional fuel (%)	Capture efficiency (%)	Capture cost (USD/ t CO_2)	Electricity cost (US cents/ kWh)	Electricity cost reference plant (US cents/ kWh)	Additional electricity cost (US cents/ kWh)
Biomass, IGCC	2025	3 000	33	-7	21	85	32	**10.06**	7.46	2.60
Technologies under development										
Coal, CFB, chemical looping	2020	1 400	39	-5	13	85	20	**5.26**	3.75	1.51
Gas, CC, chemical looping	2025	900	56	-4	7	85	54	**5.39**	3.75	1.64
Coal, IGCC & SOFC	2035	2 100	56	-4	7	100	37	**6.00**	3.75	2.25
Gas, CC & SOFC	2030	1 200	66	-4	6	100	54	**5.39**	3.75	1.64

Note: The above comparison is based on a 10% discount rate and a 30-year process lifespan. The investment costs exclude interest during the construction period and other owner costs, which could add 5-40% to overnight construction cost. This approach has been applied to all technologies that are compared in the study. Coal price = USD 1.5/GJ; Natural gas price = USD 3/GJ. CO_2 product in a supercritical state at 100 bar. CO_2 transportation and storage is not included. Capture costs are compared to the same power plant without capture. CA = Chemical Absorption. CC = Combined-cycle; CFB = Circulating Fluidised Bed; IGCC = Integrated Gasification Combined-cycle; SOFC = Solid Oxide Fuel Cell; USC = Ultra Supercritical.

Source: IEA, 2004.

ANNEX 2

Major commercial and research & development CO_2 storage projects

Project name and location	Source of CO_2	Type of geologic formation	CO_2 stored
Sleipner (Norwegian North Sea)	Stripped from natural gas	Saline reservoir	1 Mt/year since 1996
In Salah (Algeria)	Stripped from natural gas	Gas/saline reservoir	1.2 Mt/year since 2004
K12b (Netherlands)	Stripped from natural gas	Gas field -EGR	Over 0.1 Mt/year since 2004
Snohvit (Norwegian North Sea)	Stripped from natural gas	Gas/saline reservoir	0.75 Mt/year, starting from 2007
Gorgon (Australia –offshore)	Stripped from natural gas	Saline reservoir	129 Mt over the life of the project, starting between 2008-2010
Weyburn (Canada/USA)	Coal[4]	Oil field –EOR	1 Mt/year since 2000
Permian Basin, US	Natural reservoirs and industry	EOR	500 Mt stored since 1972
Frio Brine, USA		Saline reservoir	3 Kt injected in 2005-2006
Nagaoka, Japan		Saline reservoir	10.4 Kt in 2004-2005
Ketzin, Germany		Saline reservoir	60 Kt total, starting 2006
Ketzin, Germany	Stripped from natural gas	Depleted gas field	50 Kt/year, starting 2007
Callide, Australia	Coal		Starting 2010 Over 30Kt/year
Hazelwood, Australia	Coal		50t/day, starting 2008

Note: For comparison, a 500 MW coal-fired power station emits around 3 Mt of CO_2 per year.

Source: IEA Data.

4. *The CO_2 used for the EOR project in Weyburn is supplied by the Great Plains Synfuels Plant, a coal gasification plant located in Beulah, North Dakota, US.*

ANNEX 3

Intellectual property rights: background information

Types of rights

There are a variety of mechanisms that can be used to protect intellectual property rights. Registered rights include patents, trademarks and designs. Unregistered rights include copyright and trade secrets. With regards to CO_2 storage, the prominent IP rights are patents and trade secrets, and to a lesser extent, trademarks.

Patents

A patent is a right granted for any device, substance, method or process which is new/novel, inventive/non-obvious and useful. A patent is legally enforceable and gives the owner the exclusive right to commercially exploit the invention for the life of the patent. As it is a registered right, an application for protection has to be made with a patent office. Although timeframes differ depending on the jurisdiction, the protection is generally of limited duration of up to 20 years.

As a patent granted in one given country does not extend to other countries, inventors must file an application in each country where they desire exclusionary rights. To maintain the enforceability of a patent, the owner must also pay maintenance fees in each jurisdiction. Failure to do so will cause the patent to become abandoned and the exclusionary rights to lapse. Although there is no such thing as a world patent, there are international mechanisms available which assist with seeking protection in multiple countries. For example, the Paris Convention, the Patent Cooperation Treaty, regional patent agreements such as the European Patent Convention, the Eurasian Patent Convention, and the African Regional Industrial Property Organisation, and bilateral agreements such as Free Trade Agreements and technical agreements between countries and companies.

Trade secrets

A trade secret is both a type of IP and a strategy for protecting IP. A trade secret is broad in scope and can be anything that has not been publicly revealed, is not generally known in the industry, and gives the holder of the secret a competitive advantage. Common types of trade secrets include processes, methods, techniques or formulae that a business may use to produce a product. A trade secret does not require formal registration in order to obtain protection. If the owner of the trade secret exercises reasonable means to keep the information a trade secret, protection remains available for as long as the information stays secret and has economic value. Restricting access to the trade secret by preventing unauthorised entry into the facility where the trade secret is kept; obtaining non-disclosure agreements from key employees who come into contact with the trade secret; and obtaining non-disclosure agreements for the trade secret from suppliers and manufacturers are examples of advisable measures.

Unlike patents, trade secrets are not uniformly protected around the world (van Arnam, 2001).[5] While trade secret protection is well established in many common law countries such as the

5. Countries that do not explicitly protect trade secrets and confidential information are: Chile, Colombia, Costa Rica, Ecuador and Venezuela. Id. Some form of trade secret protection is available in Argentina, Australia, Austria, Brazil, Canada, Cyprus, Denmark, Egypt, Finland, Germany, Greece, Hong Kong, India, Ireland, Israel, Jamaica, Japan, Malaysia, Mexico, the Netherlands, New Zealand, Norway, Peru, Portugal, Singapore, South Africa, Spain, Switzerland, Taiwan, Thailand, Trinidad, the United Kingdom, and Uruguay.

United Kingdom and Australia, trade secrets are not recognised in many countries due to cultural attitudes regarding ownership and use of valuable business information.[6] The nature and extent of protection is also inconsistently applied in countries that have statutory or common law trade secret remedies.

An example of a trade secret would be a source code required to run a simulation model such as the Forward Modelling Simulation (FMS) software package developed by the CO_2CRC for modelling the movement of CO_2 in the subsurface. This FMS software is IP which is not necessarily patentable but can be protected by keeping the source code secret. Another example of trade secrets is the application of CO_2 storage know how and expertise in specific projects. This know-how and expertise is acquired by researchers over many years of involvement in CO_2 storage research and is used by research organisations and companies in commercial and confidential consulting projects. To protect trade secret aspects of such expertise from project to project, the proprietor should obtain a secrecy promise from any parties who need to receive the information.

Trademarks

A trademark is a designation used to identify the source and origin of goods and services. The trademark is a visual symbol of a word, name, device, or slogan or may be a letter, number, phrase, sound, smell, picture or any combination of these, which is used by a manufacturer or seller in association with goods and services. To obtain rights for a trade mark in most countries, it has to be registered. The term is unlimited provided payment of maintenance fees are made, usually every seven to ten years depending on the country. Trademarks serve four general functions, they: (1) identify a seller's goods and distinguish them from a competitor's goods; (2) signify that all goods bearing the trademark come from or are controlled by a single source; (3) signify that all goods bearing the trademark are of an equal level of quality; and (4) serve as a prime instrument in advertising and selling the goods.

The complexity of international recognition of trademarks stems from the concept of territoriality. Each country has different rules and requirements and a trademark is recognised as having a separate existence in each sovereign territory in which it is registered or legally recognised as a mark (McCarthy, 2005). However, some signatories to the Protocol Relating to the Madrid Agreement Concerning the International Registration of Marks have modified or considered modifying their trademark laws in order to adhere to the Protocol.

Companies and research bodies involved in CO_2 storage projects typically have a trademark sign, symbol or slogan to ensure their work, whether it is a publication or an operation, can be easily identified and attributed to them.

Copyright

Copyright protects the original expression of ideas, not the ideas themselves. It is free and automatically safeguards original works of art and literature, music, films, sound recording, broadcasts and computer programs from copying and certain other uses. Material is protected from the time it is first written down, painted or drawn, filmed or taped. Depending on the material and the jurisdiction, the protection period may differ. Copyright does not protect against independent creation of a similar work. Legal actions against infringement are complicated by

6. In some Asian countries, assignments of inventions and nondisclosure agreements are rare because employees do not expect to transfer ownership to their employers. Brazil and Mexico have statutes that specifically recognise an employee's right to choose employment including the right to use techniques and information acquired at work.

the fact that a number of different copyrights may exist in some works. A copyright notice with the owner's name and date helps prove ownership of the copyright, and is necessary to establish copyright in some countries. It can also act as a deterrent to potential infringement.

There is no such thing as an "international copyright" that will automatically protect copyrightable matter throughout the world. Copyright protection depends upon the laws of that particular country. Copyright material will also enjoy protection under the laws of other countries who are signatories to the international treaties (*e.g.,* Berne Convention, Universal Copyright Convention and Agreement on Trade-related Aspects of Intellectual Property Rights).

CO_2 storage companies and research bodies attach copyright notices to their written work to assist in protecting their IP rights. For example, reports published about CO_2 storage research findings and developments and software packages for monitoring and verification would typically include a copyright notice.

Intellectual property law harmonisation

The international IP system has become a network of numerous institutions operating under new structures and generating a welter of new norms. In addition to the World Trade Organisation, players in the international IP law system include the World Intellectual Property Organisation (WIPO), national courts, industry, non-governmental organisations and international institutions.

In assessing the system, it is important to attempt to strike two different balances simultaneously. One balance is that between private rights sufficient to provide an incentive for creative behaviour and third party access to the fruits of that creativity so as to maximise its social value. The second balance is between universal norms and the national autonomy necessary to legislate a substantive balance appropriate to each nation (Dinwoodie, 2006). Developing countries do not desire anything that goes beyond the minimum requirements of Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) and do not want a system that establishes an international patent or a binding opinion which would affect countries' sovereignty with respect to the grant of patents valid for their territories (Ahlert, 2003-2004).

WIPO has recognised the changed nature of the international IP system and the difficulty in achieving consensus among the numerous and diverse members of the system. It is hard to envisage an ambitious treaty on substantive norms that can obtain broad approval, therefore, WIPO now tends to generate more soft law such as non binding recommendations rather than hard law as it is accepted more speedily and provoke less entrenchment on the part of nations.

Trade arrangements remain important. As multilateral ministerial discussions have stalled, leading developed countries have pursued bilateral harmonisation agendas that cannot be achieved multilaterally. These bilateral agreements typically impose TRIPs plus standards. Bilateral agreements have become a means by which countries seek to harden the nonbinding resolutions of the WIPO. National courts are also beginning to tackle multinational cases and as such contribute to the effective creation of international norms. However, some people argue that the non-treaty based system lacks the process, transparency and representation required when developing universal standards.

When it comes to patents however, substantial international harmonisation efforts are underway (Barton, 2004). One example is the streamlined process of the Convention on the Grant of European Patents which provides for a patent effective in all European nations for which the patent applicant has paid the necessary fee. Realistically this is a bundle of national patents rather than a regional patent however discussions are underway in relation to a European patent and an internationalised patent infringement litigation process.

Strong reasons to move to a single global patent system include the cost of enormous waste of duplication, excess filing fees for filing in multiple jurisdictions, translation fees and extra legal fees. However an equally strong counterargument is that the system would benefit developed nations more than developing nations and it may even harm developing nations by increasing the cost of research-based products that are patented. If the global patent system route is decided upon, a number of issues must first be thought through, including: standards for granting a patent; patent granting institutions; language; enforcement mechanisms including litigations and appeal processes; supervisory body; financial and international political issues.

Although international IP harmonisation may be beneficial to increasing deployment of CO_2 storage, the road to harmonisation may not be as simple to implement as some may hope. However, perhaps there is room for a comprehensive and consensual harmonisation of IP law provided that developed countries are able to see the wider picture, recognising that countries in different stages of development have a desire for flexibility, have different needs and expectations with respect to IP; and provided that developed and developing countries are able to find a centre of gravity to balance such different points of view.

Managing intellectual property

An effective IP management strategy involves managing risk, liability and benefit associated with the IP. Components of such a strategy may include guidelines or policies dealing with identification of IP; protection of IP; ownership of IP including the use of agreements to determine, prior to invention, who will take credit for any IP generated; assessment of existing IP; management of IP; exploiting IP through commercial contracts; and sharing benefits of IP for the public good.

Technology transfer

Technology transfer is a subject of considerable interest to those with interests in CO_2 storage, including the nature of the technology being transferred, the method of its transfer and the ability of the recipient countries to make use of it (Nadoury, 1998).

In the past, developed countries have been criticised for transferring technology which is deemed too advanced for the recipient countries. The technology transferred must be able to be adapted to the local conditions of the recipient country, particularly in terms of the level of skill required. It should be seen as technology collaboration rather than technology transfer and the expertise of developing countries should not be underestimated. It is not always as simple as “developed” and “developing” countries. For example, China has more experience of running gasifiers than almost any other country in the world.

The traditional method of technology transfer is the licensing and/or sale of patent rights and trade secrets. Today it is also common for transfers to be made through contractual arrangements such as technical assistance contracts and management contracts.

Experience has shown that transferring technology (and the associated necessary capacity building) through joint ventures can be an effective way of commercially implementing projects in host countries. This mechanism allows the technology supplier to benefit from their IP, while protecting key elements through commercial contracts.

Build, own and operate systems, while often effective at deploying a technology, are less likely to result in the more widespread use of the technology, especially in situations such as CO_2 storage projects, where there will almost certainly be a host of project specific considerations to be taken into account.

Other forms of technology transfer include formal training such as courses and workshops, information networks, transfer of personnel and informal education networks. Information networks include both domestic and international groups, seminars, booklets and web sites. Many technology transfer programs focus on general information sharing and transfer, often focusing on material which is effectively public domain. Such transfer can be especially useful in developing policy, but rarely results in the transfer of the specific knowledge required for the actual implementation of projects.

With regards to transfer of personnel, universities, research institutions, companies and government all participate in this type of arrangement to enhance the information flow and also for goodwill reasons. These arrangements often lead to networks such as informal networks established at university graduate or undergraduate levels and formal networks forged through fellowships scholarships or research centres. These networks are important in fostering mobility and encouraging industry, researchers and government to work together on issues such as CO_2 storage.

Legal issues arising from technology transfer

The nature and scope of the legal problems that arise in technology transfer from a developed to a developing nation largely depend on the form of transfer and the economic and legal systems in place in the recipient country. The major legal problems which arise are protection of the technology proposed to be transferred, remuneration for the transfer and effective transfer of the technology.

The problem of protection arises due to the lack of registration and enforcement laws. In some developing countries where registration laws do exist, provision often exist which prevent registration because the patent has been in use longer than the maximum period allowed for use without registration. Clauses may be inserted in licensing agreements to prevent unauthorised use of patents by the recipient however this would not protect the licenser from infringement of the patent rights by a third party. In terms of enforcement, lack of enforcement of contractual clauses, particularly lack of sanctions, has led many recipients to violate such clauses. Common violations include recipient countries copying specialised equipment without paying royalties and disseminating know how without authorisation to third parties.

The two common forms of remuneration for technology transfer are royalties and lump sum payments. Each has its own set of issues. With regard to royalties, the recipient company may adjust data to limit the amount of royalties to be paid. Where the agreement provides for a lump sum payment, if the amount is substantial, the receiving company may have difficulty getting approval for the payment. However, within the past few years transferring companies have found that remuneration can be obtained with the least difficulty where it is tied either to a project, technical assistance or to a management contract.

The issue of effective transfer primarily lies in the effective use of technology from the point of view of the transferor and the recipient. To overcome this problem, a project contract which provides for certain performance guarantees may be utilised. The guarantee would be given from the transferring company and for both technical personal and replacement equipment.

ANNEX 4

Public awareness: background and case studies

To supplement the main text, this Annex includes additional background on general (non-legal) public awareness frameworks for CCS, along with case studies highlighting the different national experiences. There are also a number of helpful examples of public opinion polling and outreach campaigns.

Structuring public awareness programs

Understanding key concerns and influential factors that make CO_2 storage more acceptable are important considerations when structuring effective public awareness programs. In general, factors that cause social concern can be addressed by concerted efforts such as building trust and targeting information at key stakeholder groups. When communicating with the public about CO_2 storage a number of external factors must also be taken into account. To ensure the engagement process is seen as genuine and not advocating for any one particular solution, discussion about CO_2 storage needs to be undertaken within the broader context of climate change and the range of options which may form part of a more sustainable future. In addition, characteristics of communicators, such as expertise and trustworthiness, influence the message quality and ultimate acceptance (ter Mors *et al,* 2006). This can be summarised through a model represented by "3MA" (Reiner, 2006). This translates into:

- What is the *message?*
- Who is the *messenger:* government, industry, environmental NGOs, scientists?
- What are the *materials* (medium) and what is their quality?
- Who is the *audience:* general public, local public, interested parties?

An additional consideration is what is the objective of the public awareness program in terms of what level of awareness and acceptance is being strived for? For example, are we simply looking for enthusiasm and to dispel misconceptions of CO_2 storage or are we hoping for broad awareness of CO_2 storage technologies and engagement with key stakeholders?

It must be kept in mind that there is no quick fix solution to public awareness and acceptance. Although it is important to target information, the dialogue cannot be too prescriptive as dialogue will evolve differently depending on the group. When designing a public awareness campaign you need consistent real and open dialogue between the public and a credible source including two way communication, conferences, hearings, role plays and educational material. All of which are existing mechanisms ready to be used to gain awareness and acceptance for CO_2 storage. In the international context, more participation from developing countries and environmental NGOs is imperative.

Perceptions of risk

Being able to identify the risks people perceive with CO_2 storage can be used to predict the risk to technology diffusion and investment risk. It is human nature to resist the unknown. Research in the area of risk has shown that issues which are of most concern to consumers are those that will have a direct effect on their lives and those of their friends and families. These issues include personal security and safety, financial security now and in the future, and health and well-being (Slovic, 2000; National Consumer Council, 2002). How an individual will react to risk is complex and diverse. However, it is understood the factors which influence reactions include the disposition of the consumer, the type of risk, the risk outcome and external influences (National Consumer Council, 2002; Littleboy, Ashworth *et al,* 2004).

Risk perceptions of the public are mostly intuitive risk judgments. These perceptions are based on social and cultural factors of human behaviours (Slovic, 2000). Perceptions of risks are heightened when the risk is unknown, catastrophic and uncontrollable. In terms of CO_2 storage, questions have been what is the likelihood of a large explosive leak or death from asphyxiation? Conversely risks are perceived as lessened if they are known, limited in risk and controllable. For example, is regulation in place for CO_2 storage which requires approved monitoring and verification plans? The outcome can contribute to heightened sense of risk if it is irreversible or potentially devastating, may be felt immediately and affects other people. In this case, what effects might CO_2 leakage have on ecosystems, water and local communities? Further to the above, should policy makers give consideration to the likelihood of a negative event occurring early in the deployment of CO_2 storage and what might be the consequences?

Evidence shows that increased certainty is likely to reduce perceptions of risk. Therefore, consideration must be given to ways to alleviate the risk of CO_2 storage to the public. This could be done through involving the public at all stages of regulatory development to ensure adequate understanding of the levels or guarantees required by the public to deem CO_2 storage "safe". Early consultation has shown one way to increase certainty about CO_2 storage for the public is for an independent regulator comprised of representatives from environmental non-governmental organisations, government and industry to monitor projects at all stages (Ashworth, Pisarski *et al.,* 2006).

The influence of the media and government is also important in communicating about risk but is rarely trusted. In a similar way lobby groups, organisational representatives and experts are often felt to have their own agenda. Despite this, researchers have found that individuals are more likely to recall negative information obtained through the media or from lobby groups (Grice, Wegener *et al.,* 2003). Public attitudes to new technologies can change over time, and while attitudes can be fluid, once they are strongly formed they can be slow to change. To gauge the effectiveness of a risk communication strategy, there needs to be a monitoring program in place to identify and monitor changes in stakeholder attitudes and positions over time.

Case studies

Case study findings

The findings of the various studies show that there are low levels of awareness, recognition or understanding of CO_2 storage and mixed views of how CO_2 storage might fit within a broader portfolio of energy technologies or as part of a national climate change policy. Higher levels of education are likely to lead to increased knowledge and acceptance of CO_2 storage. Acceptance for the implementation of CO_2 storage is influenced mostly by overcoming the concern of risks and leakage of stored CO_2 associated with various stages of the CO_2 storage life cycle. Research shows that education, and extensive information on CO_2 storage increase likely acceptance of the deployment of CO_2 storage. In line with this, it was acknowledged that the public requires access to information about CO_2 storage. However, most people are too busy to seek this information on their own and therefore it will require a concerted public participation program to raise public awareness.

The key concerns highlighted from these studies include:

- The technology and its effectiveness are still relatively unproven;
- The possibility of leakage from either transportation site or from the storage site;
- The dichotomy between not in my back yard (NIMBY) and please in my back yard (PIMBY) for different regions; and
- The development of CO_2 storage should not be done at the expense of renewable energy.

Based on these concerns, there appears to be some principal prerequisites that must be met before CO_2 storage is regarded as a potential option for mitigating CO_2 emissions. These include:

- The public must accept the basic underlying science of climate change and the need to make very large reductions in carbon emissions over the century;
- Information on CO_2 storage provided to the public should be in the context of using CO_2 storage as a bridging technology as part of a portfolio of solutions to address climate change concerns;
- The information provided to the public must be balanced and from an independent source;
- A transparent, inclusive and open process must be adopted when developing regulations and making decision;
- Defining the responsibility and liability at each stage of the CO_2 storage life cycle of any CO_2 leakage or risk; and
- An independent regulator such as an environmental non-governmental organisation combined with government and industry to monitor CO_2 storage projects may make it more acceptable.

Having said this, it is important not to project "Western" attitudes to civil society and public opinion on other world regions when promoting CO_2 storage projects.

Increasing public awareness and gaining public acceptance are issues being studied and considered by a number of countries involved in CO_2 storage projects and research and development. The following section highlights a number of these case studies by examining the aims and objectives of the research, the process used, key findings and discussions about future work. These case studies are presented in alphabetical order.

Australia

In 2003-2004 an initial study was conducted in Queensland. This showed that members of the general public were not generally informed about issues surrounding energy supply, greenhouse gas emissions and CO_2 storage.

Aims and objectives

The purpose of engagement in the social research program for the Centre for Low Emission Technology (CLET) was to inform important stakeholders about research into cleaner generation of power from fossil fuels, and to provide an opportunity for those stakeholders to influence the research agenda. The proposed purpose statement permits a discussion (about how to do "coal" better) rather than an exchange of opinion (about how valuable coal is in the overall energy mix).

Specific aims were to

Establish a baseline of attitudes to low emission technologies in Queensland. Understand the issues and concerns associated with clean coal in more depth. Inform of the decision processes of the CLET partners. Provide an opportunity for the social shaping of low emission technologies and engage within environmental organisations and influential stakeholders.

Process used

The project adopted a mixed methodology involving quantitative and qualitative research approaches. A central component of the project was the implementation of a public participation programme based on linking a state wide quantitative survey (to establish a baseline) with more in depth regional dialogues to explore the issues and concerns about low emission technologies and climate change with a cross section of the public. An integral component of the research was to involve environmental groups and influential stakeholders in the design and implementation of the participation programme via an advisory Group.

To establish a baseline understanding of where the public sit in relation to low emission technologies, a random sample of 900 participants across Queensland was surveyed using the Computer Assisted Telephone Interview method in May/June 2005 and again in June 2006. Four half day workshops were also held in October 2005 in regions representing energy providers, energy end users, and those who had coal mining as one of their main industry. Workshops were also segmented into community leaders and those of general public. In total 35 participants attended the first round of workshops and 22 of those attended a follow up workshop in March 2006.

Key findings

Baseline Survey

Results of the survey demonstrated that the majority of people in Queensland (90%) agree that climate change is an important issue to Australia, with 60% strongly agreeing. Seventy-one percent of the population correctly identified coal as Australia's major source of electricity. The survey also revealed that the majority of respondents (70%) did not know what CO_2 storage is. Another 14% gave open-ended responses which were not meaningful or correct to the question "What do you understand by the term carbon capture and storage?". These results are similar to other international studies which show that only a small percentage of the population (5%) know anything about CO_2 storage. Similarly, the Queensland results also confirmed that those with higher education were more likely to have heard or know something about CO_2 storage.

Regional Dialogues

From the regional dialogues there was a strong message from participants for early action by government at all levels to raise awareness of the seriousness of the problem of climate change; the suite of technologies available to combat the situation; and the need for government to provide leadership, information and financial incentives to promote change.

The majority of the questions raised during the workshops concerned the risk of CO_2 storage and strategies that are in place to overcome those risks. For example, does leakage occur from pipelines? And will CO_2 eventually leak into the water system?

However, information provided about pipelines carrying CO_2 that have experienced no significant negative effects combined with information on how the oil industry has been using CO_2 in enhanced oil recovery for some time helped to overcome most concerns that individuals raised in relation to the risk of CO_2 storage.

When compared to the baseline survey, results from the pre-and post-dialogue surveys indicated a positive shift in participants' attitudes towards low-emission technologies, including CO_2 storage, as a result of the workshop. Workshops significantly increased participants' knowledge and attitudes about the use of CO_2 storage, with many participants recommending it was important to have demonstration projects implemented as soon as possible to truly test the viability of CO_2 storage as a mitigation option to reduce the effects of climate change. Analysis showed that the workshops also had some impact on those who were unsure about CO_2 storage to being more positive (Ashworth, Littleboy *et al.,* 2006).

Future work

The Queensland model has recently been extended into New South Wales with completion of a state wide survey and two regional dialogues. In addition, the process has been extended to the Emerald Springsure region in Queensland where Stanwell have announced the ZeroGen demonstration site. It is also hoped to receive funding to scale up the workshop process to large scale engagement activities with large groups of eighty people.

Canada

Aims and objectives

Canadian research has been undertaken to help understand the extent of public awareness about CO_2 storage, determine the public's potential level of support for the technology, investigate the perceived benefits and risks, and identify factors that could influence public support (Sharp, 2005).

Process used

The study was conducted in 2004-2005, and included both focus groups and a subsequent national internet-based survey of approximately 2 000 Canadians. The survey sample was recruited by a market research firm and was designed to be representative of the population, while overweighting the provinces of Alberta and Saskatchewan – where much of Canada's CO_2 storage activity will occur – so that these results could be analysed separately and compared with the results from the rest of the country. Because awareness of CO_2 storage was low, the survey included a neutral primer on the technology.

Key findings

Canadians identified the most important benefits of CO_2 storage to be its usefulness as a bridging technology while long-term climate change solutions are developed, the potential for its use as part of enhanced oil and gas recovery, and its potential to reduce greenhouse gas emissions faster and cheaper than alternatives. The public's greatest concerns were about unknown future impacts; contamination of groundwater; the risk of CO_2 leakage; harm to plants and animals; and displacement of renewable energy and energy efficiency investments. In general, the concerns were each rated as more important than the benefits.

Overall, Canadians indicated that they were slightly supportive of CO_2 storage development, and perceived the technology as having a net positive impact on the environment. CO_2 storage was also rated as less risky than normal oil and gas industry operations, nuclear power, or coal-burning power plants. A majority of respondents would likely include CO_2 storage in Canada's climate change strategy, while only a quarter of respondents would likely exclude it. Those who opposed CO_2 storage generally indicated that they were concerned about the technology's risks, rather than fundamentally opposed to CO_2 storage. They also identified a number of measures that could be taken to reduce their opposition, including disseminating more information about the technology; regularly consulting the public; undertaking more demonstration projects; increasing involvement of both the federal and provincial governments; involving independent experts and non-governmental organisations in management and monitoring; maintaining spending on renewable energy and energy efficiency; and implementing strong regulations and monitoring programs. The extent to which CO_2 storage is accepted and used in other countries and the media's portrayal of CO_2 storage were also factors that caused significant shifts in Canadian public attitudes toward the technology.

Future work

Canada maintains a strong public communications and outreach program. In addition to public attitude research through focus groups and surveys, Canada organised and hosted a parallel event at the United Nations Climate Change Conference in Montreal in December 2005 which focused on Canadian efforts on CO_2 storage; the Weyburn-Midale CO_2

monitoring and storage project is in its final phase; and a CO_2 storage technology roadmap was released in mid-2006.

The Roadmap identifies activities to be undertaken to educate the public on CO_2 storage such as encouraging independent experts in the scientific, engineering and non-governmental organisation communities to participate in taskforces or advisory panels to whom the media will turn for information; informing education leaders and educational institutions of the importance of science in maintaining an informed public; developing a public outreach program to act as a forum for discussion on energy and energy system options available to Canada; providing more public education about climate change and its implications for Canada; reaching out to the media proactively to increase the public's awareness and prevent misinformation; and actively involve the federal and provincial governments in managing CO_2 storage.

Japan

Aims and objectives

The aim of the study was to assess current potential acceptability of public on CO_2 storage and also to identify factors influencing public acceptance of this technology by a statistically based research (Itaoka, Saito and Akai, 2005).

Process used

In Japan, a paper questionnaire survey was carried out in December 2003 to men and women who were 20 years of age or older residing in two large Japanese cities, Tokyo and Sapporo. A multi-stage stratified random sampling method from the Basic Resident Register was used to choose people. A total of 1 006 people completed the questionnaire, resulting in an overall response rate of 63.9%. Two versions of the questionnaire were prepared. One providing limited information about CO_2 storage and the other more in-depth information

Key findings

It was found that 22% of respondents had heard of or read about CO_2 storage while only 9% had extensive knowledge of CO_2 storage. Television and newspapers were the main source of information for the people that knew of CO_2 storage. The portion of public who were familiar with CO_2 storage was much less than that for bio-energy/biomass and solar energy.

Four factors influencing opinions included environmental impacts and risks caused by injecting CO_2, effectiveness of CO_2 storage, societal responsibility for the environment and relation of CO_2 storage with maintenance on fossil fuels use. The factor "understanding of effectiveness" was the most influential for promotion of CO_2 storage and the factor "concern about risks and leakage" was the most influential for the implementation of CO_2 storage. This implies public perception of risks on CO_2 storage would be a potential barrier in implementation.

In terms of the acceptability of CO_2 storage, the survey results revealed that the public possess positive opinions in general for promotion of CO_2 storage but rather negative opinions for implementation of each of the four specific types of CO_2 storage technologies (onshore geologic storage, offshore geologic storage, dilution type of ocean storage and lake type of ocean storage) covered in the survey. It was also found that ocean storage was more opposed than geologic storage.

It was found that providing more education increases the public's acceptability and therefore reduces fundamental opposition. Education to assist understanding of issues relating to maintaining use of fossil fuel enhances acceptability of CO_2 storage. However, education to increase public awareness of responsibility for mitigation of CO_2 emission does not necessarily enhance acceptability of CO_2 storage. It was shown that onshore CO_2 storage requires a careful communication strategy because it was the only of the four CO_2 storage options where the amount of education did not influence public perceptions or acceptance.

Future work

A similar public survey is planned to be conducted in the near future.

Netherlands

Aims and objectives

In the Netherlands, workshops and surveys were conducted focusing on whether CO_2 storage should be used to combat climate change and if it is to be used, what conditions influence the acceptance or dismissal of CO_2 storage.

Process used

Two major studies were conducted. In one of these studies, workshops were conducted with decision and policy makers (van Alphen *et al.,* 2006). The other study focused on the awareness of the general public, and used a representative sample of 1 000 Dutch respondents to investigate the choices the general public would make after having received and evaluated expert information on the consequences pertaining to these choices (de Best-Waldhober, Daamen and Faaji, 2006).

As respondents in the latter study were not only given information on the aspects and consequences of six CO_2 storage options but were also asked to evaluate these aspects and consequences, the relationship between respondents' attitude towards the technology and the evaluation of its aspects and consequences could be analysed.

Key findings

The general public in the Netherlands is largely unaware of the possibility of CO_2 storage. This study also shows that despite respondents' lack of knowledge on this subject, respondents are likely to give an opinion, which results in unstable opinions that are easily affected. Respondents did not base their opinion of the technology entirely on the information from experts. Either not all the arguments that are important to respondents are stated in the given information from experts, or respondents had not quite made up their mind yet. Also, none of the evaluations of the technologies seem to be based on one or a certain kind of aspect or consequence. This means that changing single aspects or consequences of a technology probably does not change Dutch public acceptance of a CO_2 storage technology.

The results of the general public survey suggest that, after processing relevant information, people are likely to agree with large-scale implementation of each of the six CO_2 storage options in the survey. Respondents find all CO_2 storage options on average "adequate", seldom find these options unacceptable and do not choose one of the options over the others with a majority of respondents.

In the workshops potential barriers to the deployment of CO_2 storage were seen as the significant costs; long-term risks (mainly CO_2 leakage); absence of an appropriate legal framework; and the lack of public acceptance. Despite this, it was found that there is a positive fundamental attitude towards CO_2 storage in the Netherlands. However, this acceptance of CO_2 storage by government, industry and environmental non-governmental organisations is conditional.

The conditions noted were:

- **Safety:** stakeholders want to be ensured that CO_2 storage is safe in the short and long term for both humans and the environment. Leakage of CO_2 out of reservoirs is generally perceived as the largest risk. Uncertainties such as this have to be reduced to improve the acceptance of CO_2 storage by environmental non-governmental organisations.

- **Temporality:** stakeholders generally agreed that CO_2 storage should be used only temporarily and only in addition to measures to stimulate the development and deployment of sustainable energy and energy efficiency measures. However, if the time period is too short to recover costs, companies will not be willing to make various investments.
- **Simplicity:** CO_2 storage should not be linked obligatorily with other possible advantages such as enhanced recovery or hydrogen production.

Financial stimuli: CO_2 storage is rather expensive, while it yields no direct benefits for the investing company. CO_2 storage is currently not included under the European Union's Emission Trading Scheme (ETS). In addition, no emission targets are agreed on for the post-2012 Kyoto period. This creates uncertainty, and so a lack of willingness to invest in mitigation measures. According to the workshop participants the financial stimuli should be generated by generic measures which are applicable for all CO_2 mitigation options.

Cooperation and commitment: In order to take advantage of the Netherlands strategic position of existing gas fields and knowledge in this area, cooperation and commitment of various parties as well as a long term vision are necessary.

Public acceptance: Appropriate communication is essential. If CO_2 storage is to be implemented on a larger scale, the communication to society has to intensify and has to be organised in such a way that it creates awareness and acceptance by the public.

The consensus about these conditions was remarkable, as well as on the action that was suggested to meet these conditions. To meet these conditions suggested actions included undertaking pilot projects and research to reduce uncertainty and increase knowledge about the long term fate of CO_2 in geologic repositories; developing rules and standards for storage site selection, operation and storage activities, and for monitoring and reporting; preventing obligatory links between CO_2 storage and special projects; including CO_2 storage in the European Union's ETS; setting ambitious emission targets for the post-Kyoto period; drafting a CO_2 storage roadmap; and communicating the necessity and risks of CO_2 storage to society at large in a fair and understandable way.

Future work

Most of the CO_2 storage work in the Netherlands is done by CATO, a program implemented by a strong consortium of Dutch companies, research institutions, universities and environmental organisations, led by the Utrecht Centre for Energy research. CATO runs from 2004 until the end of 2008.

In the CATO program, research on the perception of the public and other actors is done. The program also aims to establish a dialog between key players in the CO_2 storage field. In this dialog the necessity of de implementation of CO_2 storage, and the conditions on how CO_2 storage should be implemented, is discussed. The program does not have an active outreach program for the general public.

United Kingdom

Aims and objectives

There have been two studies which explore the public perceptions of CO_2 storage in the United Kingdom. The first study combined focus groups with a face to face public survey to assess the public perceptions of the key risks and concerns surrounding CO_2 storage, both when first presented with the idea and when more background information is provided. The study also considered what information, policies and processes would make CO_2 storage more and less acceptable to the public. In the second study, questions on CO_2 storage were included in an internet survey of pubic attitudes towards energy and the environment.

Process used

The face to face study conducted two citizen panels were held in 2002-2003 to explore public perceptions of CO_2 storage. Each panel met five times for two hours and heard from a variety of technical experts. This work was supplemented by a face-to-face survey of 212 individuals which was conducted during August 2003. The internet study contained questions on a range of carbon mitigation options including CO_2 storage in a survey conducted by the online polling company YouGov. The 1 056 responses were 40% of the 2 640 people polled.

Key findings

Focusing first on the outcomes of the face to face study, on first hearing about CO_2 storage, without information as to its rationale or risks, the majority of respondents either had no opinion or were sceptical. When provided with more information on CO_2 storage and climate change participants did recognise CO_2 storage as a potential CO_2 mitigation option. However, this support was conditional on understanding the reasons for CO_2 mitigation and on CO_2 storage being integrated within a portfolio of decarbonisation options, including social change as well as technological solutions. Overall, belief in, and concern about, human-caused climate change, plus recognition of the need for major CO_2 emission reductions, are likely to be necessary prerequisites for including CO_2 storage as a serious response option to climate change.

The main concerns participants had regarding CO_2 storage were: possible leakage of CO_2; impacts that CO_2 storage may have on ecosystems and the environment in general; impacts on human health; and the new and untested nature of the technology. Whilst supportive of CO_2 storage, it was seen as treating the symptoms and not the causes of climate change. Concern was also expressed that CO_2 storage would divert research and development resources and attention away from renewable energy technologies, reduction of energy demand and energy efficiency.

A number of measures were also identified that would increase the public acceptability of CO_2 storage. These measures include: increasing certainty about the long term risks of CO_2 storage; including CO_2 storage within a portfolio of decarbonisation technologies; and combining CO_2 storage with enhanced oil recovery. It is vital that relevant government, industry and environmental non-governmental organisations develop legal and regulatory frameworks in partnership and that decision making processes are transparent and inclusive (Gough, Mclachlan and Shackley, 2004).

Comparing the result of the two surveys, the findings of both studies are broadly in agreement. Few of those polled in the internet study had heard of CO_2 storage, and most favoured immediate action on climate change. There are differences between the two sets of results, with the internet study finding lower support for CO_2 storage (30% versus 50%) and greater support for nuclear power (35% compared to 25% in favour). Both surveys revealed levels of opposition in the region of 20%. Overall, both studies concluded that CO_2 storage is viewed positively, and more favourably than other carbon mitigation options such as nuclear power.

Future work

This work is being continued under the auspices of the UK Carbon Capture and Storage Consortium, made up of engineering, technical, natural, environmental and social scientists from fourteen UK research institutions. The consortium is funded by the UK research councils with the aim of rapidly expanding UK research capacity into CO_2 storage, and facilitating the delivery of viable, large-scale CO_2 storage options for the UK. Current research is related to media framing of CO_2 storage, and its impact on citizen perceptions of the technology.

United States

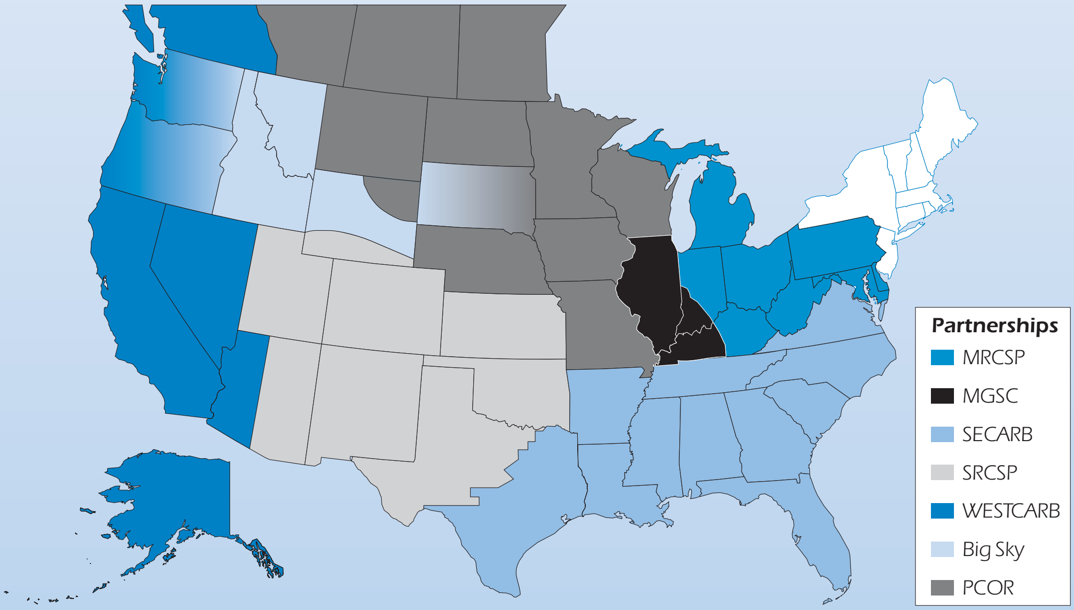
Introduction

The United States considers outreach and education efforts as a critical precondition for the acceptance of CO_2 storage. The U.S. Department of Energy has undertaken several activities to broaden the understanding and acceptance of this technology. These include outreach activities of the Regional Carbon Sequestration Regional Partnerships, FutureGen program, and the Carbon Sequestration Core Program & Public Information, and CSLF Domestic Activities. Of these, activities of the Carbon Sequestration Partnerships are the most comprehensive.

Regional Carbon Sequestration Partnerships

In 2003, the U.S. Department of Energy and the National Energy Technology Laboratory named seven Regional Carbon Sequestration Partnerships to develop a nationwide network to help determine the best approaches for CO_2 storage. Each Partnership project is unique in its geology, land use, population base, socio-economic condition and cultural backgrounds. These partnerships include 216 universities, state agencies, private companies and NGOs located in 40 states, three Indian Nations and four Canadian provinces. The regional coverage of each Partnership is shown in Figure A.2.2.

Figure A.2.2: The Seven Regional Carbon Sequestration Partnerships



Source: DOE/NETL website, www.netl.doe.gov/sequestration

Public outreach efforts are an important component of the activities of the Regional Partnerships. Regional differences influence the design of outreach activities, but each Partnership engages in two types of such activities: data gathering and awareness building.

Public outreach by the partnerships

The Partnership program is being conducted in two phases. Both phases emphasise engaging regional, state and local governments as well as laying the groundwork for helping the public toward a basic understanding of the role of sequestration, methods to accomplish sequestration and the implications for the region.

Each Partnership has made public outreach an important function by designating an outreach coordinator. The outreach coordinators formed the outreach working group to provide a vehicle for sharing ideas and materials related to outreach and CO_2 storage. Information shared during outreach working group meetings describes the broad challenges facing the outreach coordinators.

During Phase I, the Partnerships assessed public acceptance, identifying potential issues of concern and developing programs for public education and outreach in order to build public awareness and acceptance. The Partnerships used a variety of approaches and techniques for informing the public and assessing public acceptance levels and issues.

During Phase II, which began in 2005, the Partnerships will field test and validate CO_2 storage technologies that are best suited to their respective regions and evaluate the most promising regional repositories for CO_2. As part of this effort, the partnerships will also conduct public outreach, satisfy permitting requirements, and identify best-management practices for future deployment.

Lessons learned

In lessons learned so far, it was determined through these discussions that, among those who are informed, there are different points of view regarding CO_2 storage. Even some who are "informed" and especially the general public do not know much about climate change, let alone CO_2 storage. Given that few people are well-informed about climate change and CO_2 storage, it may be difficult to identify real attitudes. It was also determined that the complexity of CO_2 storage contributes to this a perception of risk and requires thoughtful approaches to sharing information and eliciting concerns.

The outreach working group also learned about several prior field tests, two that are successful and one that failed. The failure involved the proposal to conduct a field test of ocean sequestration off the coast of Hawaii, a problem associated with a lack of public acceptance – in fact outright opposition. The two successes were the Mountaineer and the Frio Brine projects. In both cases, the projects were discrete and the outreach activities were intensive and focused on very specific sites. Lessons learned in Phase I will be applied to outreach during Phase II oriented towards specific field tests.

ANNEX 5

Marine environment protection: overview of relevant international treaties and conventions

This section provides background on relevant legal instruments on the protection and conservation of the marine environment.

Multilateral treaties and conventions

United Nations Convention on the Law of the Sea, 1982 (UNCLOS)

UNCLOS is a framework convention containing fundamental rules for ocean governance. It provides a legal framework for ocean governance, including protection of the marine environment. State Parties and competent international organisations can build on this legal framework in implementing the framework provisions of UNCLOS.

While States have the sovereign right to exploit their natural resources pursuant to their environmental policies, they must do so in accordance with their duty to protect and preserve the marine environment (UNCLOS Article 193). This duty can be carried out in an individual or joint manner and relates not only to the prevention, reduction and control of all sources of pollution of the marine environment, but also includes a duty to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species and other forms of marine life (Article 194). The sources of pollution comprise pollution from land-based sources, from sea-bed activities subject to national jurisdiction, from activities in the Area, from vessels, from or through the atmosphere and pollution by dumping. In carrying out their obligations to prevent, reduce and control pollution of the marine environment and to protect and preserve it, States are further required not to transfer, directly or indirectly, damage or hazards from one area to another or to transform one type of pollution into another (Article 195).

While UNCLOS does not explicitly regulate nor prohibit CO_2 storage, it does require States to prevent, reduce and control pollution of the marine environment and to protect and preserve the marine environment from human activities that might adversely affect it. In line with this, it can be argued that CO_2 storage is protecting the marine environment from acidification. UNCLOS being a framework convention containing fundamental rules for ocean governance also calls upon States to act through, *inter alia,* competent international organisations to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution by dumping. Such rules, standards and recommended practices and procedures should be re-examined from time to time (compared with Article 210, paragraph 4).

Existing legal frameworks applicable to CO_2 storage were established before CO_2 storage became an option for climate change mitigation. Consistent with UNCLOS, the international community is in the process of re-examining these rules standards and recommended practices and procedures for the purpose of regulating offshore CO_2 storage in regional and other multilateral conventions dealing with pollution control and the protection and conservation of the marine environment. This is discussed further below.

The main provisions of UNCLOS relevant to CO_2 storage are included in Annex 2.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (London Convention)

The London Dumping Convention is one of the early global conventions dealing with the protection of the marine environment. It was developed based on a recommendation of the United Nations Conference on the Human Environment (Stockholm Conference 1972). The Parties to the London Convention have pledged themselves to individually or collectively promote the effective control of all sources of pollution of the marine environment. In particular, to take all effective measures to prevent pollution of the sea caused by the dumping of wastes or other matter, while harmonising policies in this regard (Article II). Article III of the Convention defines what is meant by the activity of dumping as well as the area of application of the Convention. The London Convention applies to the territorial sea, the continental shelf, the EEZ and the high seas. London Convention Resolution 44/14 also requires Parties to be guided by a precautionary approach.

The London Convention is applicable to offshore CO_2 storage activities conducted in the water column. CO_2 falls under the definition of "wastes or other matter (Article III, paragraph 4) and depending on the purpose of disposal or the means by which it is carried out CO_2 storage activities conducted in the water column are included in the definition of "dumping" (Article III, paragraph 1).

Based on the overall objective of the London Convention and the precautionary approach, which is that preventive measures should be taken when there are reasonable grounds for concern that substances introduced to the water column (directly or indirectly) may harm the marine environment, offshore CO_2 storage activities conducted in the sea-bed and subsoil thereof could well fall under the scope of the Convention in view of the potential risk of pollution and adverse impact on the marine environment due to seepage.

The main provisions of the London Convention relevant to CO_2 storage are included in Annex 7.

London Protocol 1996

The London Protocol requires Parties to protect and preserve the marine environment from all sources of pollution with the ultimate aim of eliminating pollution, where practicable, of the marine environment caused by dumping or incineration at sea of wastes or other matter (Article 2). The Protocol codifies the precautionary approach to environmental protection and the "polluter pays" principle (Article 3, paragraphs 1 and 2). In addition Parties are required to act so as not to transfer, directly or indirectly, damage or possibility of damage from one part of the environment to another or transform one type of pollution into another (Article 3, paragraph 3). Dumping of any wastes or other matter is prohibited under the Protocol with the exception of those listed in its Annex 1, the dumping of which requires a permit. The issuance of permits and permit conditions must comply with the waste assessment procedure contained in Annex 2 of the Protocol (Article 4). The geographical area of application of the Protocol is expanded to include the seabed and the subsoil of all marine waters, other than the internal waters of States. Sub-seabed repositories accessed only from land are not included in the convention area (Article 1, paragraph 7). The export of wastes or other matter to other countries for dumping or incineration at sea is also prohibited (Article 6).

The Protocol entered into force on March 24th 2006. Subject to limited possible exceptions, like enhanced oil recovery, offshore CO_2 storage activities in the seabed and subsoil are prohibited by the Protocol. One of the first key issues for discussion at the first Meeting of the Parties to the Protocol was the proposal to amend the Protocol with a view to facilitating and/or regulating the use of CO_2 storage in sub-seabed geologic structures. This is discussed further below.

The main provisions of the London Protocol relevant to CO_2 storage are included in Annex 8.

Basel Convention on the Control of Transboundary Movements of Hazardous Waste (1989)

The aim of this multilateral Convention is, *inter alia:*

- To reduce transboundary movements of hazardous wastes and other wastes subject to the Basel Convention to a minimum consistent with their environmentally sound management;
- To dispose of the hazardous wastes and other wastes generated, as close as possible to their source of generation;
- To minimise generation of hazardous wastes in terms of quantity and hazardousness;
- To ensure strict control over movements of hazardous wastes across borders; and
- To prohibit shipments of hazardous wastes to countries lacking the legal, administrative and technical capacity to manage and dispose of them in an environmental sound manner.

Basel is likely to apply only to something that can be exported from a Party to the Basel Convention and imported into another Party. If CO_2 is classified as "hazardous waste" under Article 1 of the Basel Convention and in the context of underground storage, the Basel Convention may be applicable to transboundary movement of CO_2 in view of the disposal operation of releasing CO_2 into seas/oceans, including sea-bed insertion (Basel Convention: Annex IV, D7). The purity of the CO_2 in the CO_2 stream is of importance in determining whether the CO_2 is a hazardous waste or not. Article 1 and reference to Annex I do not seem to easily apply to CO_2. Article 1 and reference to Annex III would appear certainly not to apply because CO_2 does not exhibit a hazard characteristic as defined by Annex III. Since there is no consensus on the definition of CO_2 for the purpose of CO_2 storage it is unclear whether it will be classified as hazardous waste and is therefore unclear whether the Basel Convention relates to CO_2 storage. As it currently stands CO_2 is not considered a hazardous waste to the marine environment however if it is mixed with toxic substances it may be considered hazardous. However when ocean acidification is considered in the future, perhaps CO_2 will be classified as a hazardous waste to the marine environment.

To overcome this issue, the international community would either have to amend the Basel Convention to clarify its position on whether CO_2 storage should be included or establish a separate international regulatory approach for the transboundary effects of CO_2 storage. It may also be determined that enhance resource recovery projects do not fit under the Basel Convention, as they do not produce hazardous waste, but that other CO_2 storage projects do fit under its purview. If enhance resource recovery is not included in the Basel Convention, some other international framework would have to be established to cover this type of CO_2 storage project.

Regional treaties and conventions

The Convention for the Protection of the Marine Environment of the North-East Atlantic, 1992 (OSPAR Convention)

The Contracting Parties to the OSPAR Convention pledge themselves to take all possible steps to prevent and eliminate pollution of the maritime area as well as to take the necessary measures to protect the maritime area against the adverse effect of human activities (Article 2). The Convention thus addresses both pollution as well as disturbances to the marine environment. The general obligation relating to the prevention and elimination of pollution is dealt with in the Annexes on land-based sources (Annex I), on dumping or incineration (Annex II) and on offshore sources (Annex III). In Annex V on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area (adopted in 1998) the general obligation relating to the protection of the marine environment from human activities having an adverse effect on the marine environment is addressed.

The definition of the OSPAR maritime area includes the sea, the sea-bed and the subsoil of the marine waters within the geographical limits laid down in the Convention.

For the purpose of CO_2 storage, the application of the Convention and its Annexes is briefly discussed below. A more detailed consideration of this issue within the OSPAR framework can be found in the initial views of the Group of Jurist and Linguist as presented to the OSPAR Commission at its meeting in June 2004.

Application of Annex I of the Convention (land-based sources) to CO_2 storage would result in strict authorisation or regulation of the activity, implementing relevant decisions of the OSPAR Commission. The land-based sources (point and diffuse) from which substances or energy reach the maritime area (by water, through the air or directly from the coast) include the deliberate disposal under the sea-bed made accessible from land by a tunnel, pipeline or other means. Sources associated with man-made structures placed in the maritime area under the jurisdiction of a Contracting Party (oil and gas offshore installations excluded) are also included in the definition of land-based sources.

Annex II of the Convention (dumping and incineration) is straightforward: dumping of wastes or other matter is prohibited with the exception of wastes listed in article 3 of the Annex. The definition of dumping excludes the placement of wastes or other matter for a purpose other than the mere disposal thereof, from this prohibition.

Under Annex III of the Convention (offshore sources) dumping of wastes or other matter from offshore installations is prohibited. This prohibition does not apply to the discharge or emission of substances arising on an offshore installation from its normal operations. Any such discharge or emission is however strictly subject to authorisation or regulation, implementing decisions, recommendations and other agreements adopted by the OSPAR Commission, if such discharge or emission reaches or affects the maritime area.

Annex V of the Convention may apply where storage of CO_2 results or is likely to result in adverse effects on the marine environment, other than pollution.

The OSPAR Convention prohibits the deliberate disposal of wastes and other matter in the maritime area. However, its legal framework which requires Parties to apply, inter alia, the precautionary principle and to define the use of "best available techniques", emphasising the use of non-waste technology, and "best environmental practice", meaning the application of the most appropriate combination of environmental control measures and strategies (compare Article 2 and Appendix 1 to the Convention) may amongst other provisions of the Convention, contain a basis for Regulating CO_2 storage activity for the purpose of climate mitigation.

The main provisions of OSPAR relevant to CO_2 storage are included in Annex 9.

Convention on the Protection of the Marine Environment of the Baltic Sea (1992, HELCOM)

One of the main obligations of the Contracting Parties to the HELCOM Convention is to take all appropriate legislative, administrative or other relevant measures to prevent and eliminate pollution for the purpose of promoting the ecological restoration of the Baltic Sea and the preservation of its ecological balance. While the convention area comprises the water body and the seabed, including their living resources and other forms of marine life, implementation of the provisions of the Convention each Contracting Party is restricted to its territorial sea and its internal waters (Article 4).[9] The HELCOM Convention also addresses the prevention of pollution from ships insofar as the HELCOM Contracting Parties shall, inter alia, cooperate within the International Maritime Organisation in matters concerning the protection of the Baltic Sea Area from pollution by ships.

With the exception of dredged material, the HELCOM Convention prohibits dumping, that is the deliberate disposal of waste or other matter, in the Baltic Sea Area (Article 11). Contracting Parties are required to promote the use of Best Environmental Practice and Best Available Technology.

The HELCOM Convention prohibits the deliberate disposal of wastes and other matter in the Baltic Sea Area, with the exception of dredged material. Under Article 122 of the UNCLOS the Baltic Sea can be classified as an "enclosed or semi-enclosed sea".

Convention on the Protection of the Black Sea against Pollution (1994)

The area of application of the Convention on the protection of the Black Sea against pollution includes the territorial sea and exclusive economic zone of the Contracting Parties.[10] There is a general obligation to take all appropriate measures and to cooperate in the prevention, reduction and control of pollution caused inter alia by dumping. This general obligation is further elaborated on in the Protocol on the protection of the Black Sea marine environment against pollution by dumping which contains a prohibition on the dumping of wastes or other matter containing substances listed in the Annex 1 to the Protocol.

The Convention on the protection of the Black Sea against pollution does not explicitly contain a prohibition on dumping of waste or other matter in the seabed and subsoil. The activity of CO_2 storage would be regulated in accordance with the provisions of the Protocol.

9. Article 4.1: "This Convention shall apply to the protection of the marine environment of the Baltic Sea Area which comprises the water-body and the seabed including their living resources and other forms of marine life".

10. Article 1.1: "This Convention shall apply to the Black Sea proper with the southern limit constituted for the purposes of this Convention by the line joining Capes Kelagra and Dalyan. 2. For the purposes of this Convention the reference to the Black Sea shall include the territorial sea and exclusive economic zone of each Contracting Party in the Black Sea. However, any Protocol to this Convention may provide otherwise for the purposes of that Protocol".

Convention on the Protection and Development of the Marine Environment of the Wider Caribbean Region (1983, Cartagena)

The area of application of the Cartagena Convention is defined in geographical terms[11] and does not explicitly refer to the seabed and subsoil of these waters (excluding the internal waters of the Contracting Parties).[12] There is a general obligation for the Contracting Parties to take all appropriate measures to prevent and control pollution of the Convention area by dumping of wastes and other matter from ships, aircraft or man-made structures at sea and to ensure effective implementation of applicable international rules and standards.

The Convention on the protection and development of the marine environment of the wider Caribbean region does not explicitly contain a prohibition on dumping of waste or other matter in the seabed and subsoil. However, Parties are to ensure effective implementation of applicable international rules and standards, the London Convention and the London Protocol including.

Convention for the Protection of the Mediterranean Sea against Pollution (with Protocols, 1976)

The area of application of the Convention for the protection of the Mediterranean Sea against pollution comprises the maritime waters geographically defined in Article 1 of the Convention.[13] There is a general obligation for the Contracting Parties to take all appropriate measures to prevent and abate pollution of the Mediterranean Sea caused by dumping from ships and aircraft. This general obligation is further elaborated on in the Protocol for the prevention of pollution of the Mediterranean Sea by dumping from ships and aircraft which contains a prohibition on the dumping of wastes or other matter containing substances listed in the Annex 1 to the Protocol.

The Convention for the protection of the Mediterranean Sea against pollution does not explicitly contain a prohibition on dumping of waste or other matter in the seabed and subsoil. The activity of CO_2 storage would be regulated in accordance with the provisions of the Protocol, more in particular Annex II section 4.

BAMAKO Convention on the Ban of the Import to Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa (1991, Bamako)

The area of application of the Bamako Convention includes the land, marine area or airspace within which State parties exercise jurisdiction. The Convention draws on the relevant articles of the Basel Convention establishing a regional agreement which may be equal to or stronger than the Basel Convention. The Convention contains a definition of "waste" as well as one of "hazardous waste". Disposal and dumping are also defined in the Convention and these definitions include the sea, the seabed and sub-seabed.[14]

11. Article 2.1: "The marine environment of the Gulf of Mexico, the Caribbean Sea ...south of 30° north latitude and within 200 nautical miles of the Atlantic coast of the Contracting Parties".

12. Article 1.1: "This Convention shall apply to the wider Caribbean region, hereinafter referred to as "the Convention area" as defined in paragraph 1 of Article 2". Article 2: "1. The "Convention area" means the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30 deg north latitude and within 200 nautical miles of the Atlantic coasts of the States referred to in article 25 of the Convention".

13. Article 1.1: "For the purposes of this Convention, the Mediterranean Sea area shall mean the maritime waters of the Mediterranean Sea proper, including its gulfs and seas, bounded to the west by the meridian passing through Cape Spartel lighthouse, at the entrance of the Straits of Gibraltar, and to the east by the southern limits of the Straits of the Dardanelles between the Mehmetcik and Kumkale lighthouses".

14. Article 1.23: "Dumping at sea" means the deliberate disposal of hazardous wastes at sea from vessels, aircraft, platforms or other man- made structures at sea, and includes ocean incineration and disposal into the seabed and sub-seabed".

The overall aim of this convention is, inter alia:

- To prohibit the import of all hazardous wastes into Africa from non-Contracting Parties;
- To control all carriers from non-Parties, and prohibit the dumping at sea of hazardous wastes, including their ocean incineration and disposal in the seabed and sub-seabed;
- To reduce transboundary movements of hazardous wastes to a minimum consistent with their environmentally sound management;
- To minimise the generation of hazardous wastes in terms of quantity and hazardousness;
- To ensure strict control over movements of hazardous wastes across borders; and
- To prohibit hazardous wastes to be exported to a State which does not have the facilities for disposing of them in an environmentally sound manner.

The Convention focuses on prohibiting and regulating the transboundary movement of hazardous waste. The prohibition on the dumping of hazardous waste includes their disposal in the seabed and sub-seabed. However "waste" is defined as a substance or material which is disposed of, or is intended to be disposed of, or is required to be disposed of by national law. For the purpose of its classification as hazardous waste, this waste can inter alia, belong to a category contained in the Annex I of the Convention, be defined as hazardous waste by domestic legislation or possess any of the characteristics contained in Annex II of the Convention.

If CO_2 is classified as waste that possesses any of the hazardous characteristics contained in Annex II of the Bamako Convention, the Bamako Convention may prohibit the import of CO_2 to Africa (Bamako Convention: Article 4.1) as well as the dumping at sea, which includes ocean incineration and disposal in the seabed and sub-seabed (Bamako Convention: Article 4.2, under (a)).

Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution (Kuwait, 1978)

The area of application of this Convention is defined in geographical terms[15] and does not explicitly refer to the seabed and subsoil of these waters (excluding the internal waters of the Contracting Parties). The Convention applies, roughly, to the marine environment in the Region shared by Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

There is a general obligation to take all appropriate measures to prevent, abate and combat pollution of the marine environment, *inter alia,* by dumping of wastes and other matter from ships, aircraft or man-made structures at sea. Moreover, Parties are to ensure effective compliance with applicable international rules relating to the control of this type of pollution.

The Kuwait Regional Convention for co-operation on the protection of the marine environment from pollution does not explicitly contain a prohibition on dumping of waste or other matter in the seabed and subsoil. However, Parties are to ensure effective compliance in the Sea Area with applicable international rules relating to the control of this type of pollution.

Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan, 1981)

The area of application of this Convention is the marine environment, coastal zones and related inland waters falling within the jurisdiction of the States of the West and Central African Region,

15. Article II a: "the sea area in the Region bounded in the south by the following rhumb lines: from Ras Dharbat Ali in (16 deg 39 min N, 35 deg 3 min 30 sec E) ...to Ras Al-Fasteh in (25 deg 04 min N, 61 deg 25 min E)".

from Mauritania to Namibia inclusive, which have become Contracting Parties.[16] The Convention area does not explicitly refer to the seabed and subsoil of these waters.

There is a general obligation to take all appropriate measures to prevent, reduce, combat and control pollution of the Convention area, *inter alia,* by dumping from ships and aircraft. Parties are also required to cooperate with competent international, regional and sub-regional organisations to establish and adopt recommended practices, procedures and measures to prevent, reduce, combat and control pollution from all sources. Parties equally commit themselves to act so as not to transfer, directly or indirectly, damage or hazard from one area to another or transform one type of pollution into another. The Convention contains a provision on environmental impact assessment to be undertaken in any planning activity entailing projects within their territory that may cause substantial pollution of, or significant and harmful changes to the Convention area. Parties are also to ensure the effective application in the Convention area of the internationally recognised rules and standards relating to the control of this type of pollution.

The Convention for co-operation in the protection and development of the marine and coastal environment of the west and central African region does not explicitly contain a prohibition on storage of CO_2 in the seabed and subsoil. However, the Parties are to ensure the effective application in the Convention area of the internationally recognised rules and standards relating to the control of this type of pollution.

Convention for the Protection of the Marine Environment and Coastal Area of the South Pacific (Lima, 1981)

The area of application of this Convention is defined in geographical terms[17] and does not explicitly refer to the seabed and subsoil of these waters.

There is a general obligation to take all appropriate measures to prevent, reduce and control pollution of the marine environment in the Convention area. This includes the adoption of measures to minimise to the fullest possible extent the release of toxic, harmful or noxious substances from land-based sources, from or through the atmosphere and by dumping. Measures are also to be adopted to minimise pollution from vessels and pollution from any other installations and devices in the marine environment. Parties are to cooperate on a regional basis, directly or in collaboration with the competent international organisations, in formulating, adopting and implementing effective rules, standards and procedures for the protection and preservation of the marine environment. There is also an obligation to ensure that activities under their jurisdiction or control do not cause damage by pollution to others or to their environment. Moreover, Parties are to ensure that the laws and regulations they may promulgate for the implementation of this Convention are as effective as the existing international standards.

The Convention for the protection of the marine environment and coastal area of the South Pacific does not explicitly contain a prohibition on dumping of waste or other matter in the seabed and subsoil. However, the Parties are to ensure that the laws and regulations they may promulgate for the implementation of this Convention are as effective as the existing international standards.

16. Article 1: "This Convention shall cover the marine environment, coastal zones and related inland waters falling within the jurisdiction of the States of the West and Central African Region, from Mauritania to Namibia inclusive, which have become Contracting Parties to this Convention under conditions set forth in article 27 and paragraph 1 of article 28".

17. Article 1: "the sea area and the coastal zone of the South-East Pacific within the 200-mile maritime area of sovereignty and jurisdiction of the High Contracting Parties and, beyond that area, the high seas up to a distance within which pollution of the high seas may affect that area".

Convention for the Protection of Natural Resources and Environment of the South Pacific Region (Noumea, 1986)

The Noumea Convention for the Protection of the Natural Resources and Environment of the South Pacific Region 24 November 1986 (SPREP Convention) came into force on 22 August 1990. The Convention covers the South Pacific Region which is stated in Article 2 to be the 200 nautical mile zone established in accordance with international law off the South Pacific island countries, and those areas of high seas which are enclosed from all sides by the 200 nautical mile zones of those countries.

The text of the SPREP Convention largely follows that of Part XII of UNCLOS; however in some cases the language is not as strong. It requires Parties to prevent, reduce and control pollution of the Convention Area generally, from land-based sources and from seabed activities (Articles 5, 7 and 8). "Pollution" has the same definition as UNCLOS. The Convention also requires parties to prevent, reduce and control pollution from dumping (Article 10). Dumping has the same definition as in UNCLOS. The SPREP Convention further requires parties to prevent, reduce and control pollution from the storage of toxic and hazardous wastes (Article 11). Parties are also required to take into account environmental factors when using natural resources and planning major projects to minimise harmful impacts on the marine environment. Parties must also assess the potential effects of projects on the marine environment so that 'appropriate measures can be taken to prevent substantial pollution of or significant and harmful changes within the Convention Area' (Article 16).

Articles 11 and 16 of the SPREP Convention establish obligations over and above those in UNCLOS. CO_2 storage is unlikely to be considered 'storage' as the storage duration is likely to be many thousands to millions of years and there is no intention to extract the CO_2 at any stage. However if CO_2 storage can be argued to be 'storage' then Article 11 imposes an obligation to prevent, reduce and control pollution in the Convention Area from this source. Article 16 would require environmental factors to be taken into account when planning CO_2 storage projects, and would require environmental impact assessments to be undertaken prior to commencing CO_2 storage activities, in order to prevent or minimise harmful impacts on the marine environment in the Convention Area.

ANNEX 6

Selection of relevant provisions under UNCLOS

(concluded in 1982, in force since 1994)

Part I Introduction

Article 1

Use of terms and scope

1. For the purposes of this Convention:
   - (1) "Area" means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction;
   - (2) "Authority" means the International Seabed Authority;
   - (3) "activities in the Area" means all activities of exploration for, and exploitation of, the resources of the Area;
   - (4) "pollution of the marine environment" means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities;
   - (5) (a) "dumping" means:
       - (i) any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;
       - (ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea;

     (b) "dumping" does not include:
       - (i) the disposal of wastes or other matter incidental to, or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment, other than wastes or other matter transported by or to vessels, aircraft, platforms or other man-made structures at sea, operating for the purpose of disposal of such matter or derived from the treatment of such wastes or other matter on such vessels, aircraft, platforms or structures;
       - (ii) placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention.

Section 2. Principles of Governing the Area

Article 136 Common Heritage of Mankind

The Area and its resources are the common heritage of mankind.

Article 145 Protection of the Marine Environment

Necessary measures shall be taken in accordance with this Convention with respect to activities in the Area to ensure effective protection for the marine environment from harmful effects which may arise from such activities. To this end the Authority shall adopt appropriate rules, regulations and procedures for *inter alia:*

(a) the prevention, reduction and control of pollution and other hazards to the marine environment, including the coastline, and of interference with the ecological balance of the marine environment, particular attention being paid to the need for protection from harmful effects of such activities as drilling, dredging, excavation, disposal of waste, construction and operation or maintenance of installations, pipelines and other devices related to such activities;

(b) the protection and conservation of the natural resources of the Area and the prevention of damage to the flora and fauna of the marine environment.

Part XII - Protection and Preservation of the Marine Environment

Section 1. General Provisions

Article 192 General Obligation

States have the obligation to protect and preserve the marine environment.

Article 193 Sovereign Right of States to Exploit their Natural Resources

States have the sovereign right to exploit their natural resources pursuant to their environmental policies and in accordance with their duty to protect and preserve the marine environment.

Article 194 Measures to Prevent, Reduce and Control Pollution of the Marine Environment

1. States shall take, individually or jointly as appropriate, all measures consistent with this Convention that are necessary to prevent, reduce and control pollution of the marine environment from any source, using for this purpose the best practicable means at their disposal and in accordance with their capabilities, and they shall endeavor to harmonise their policies in this connection.
2. States shall take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights in accordance with this Convention.
3. The measures taken pursuant to this Part shall deal with all sources of pollution of the marine environment. These measures shall include, inter alia, those designed to minimise to the fullest possible extent:

   (a) the release of toxic, harmful or noxious substances, especially those which are persistent, from land-based sources, from or through the atmosphere or by dumping;

   (b) pollution from vessels, in particular measures for preventing accidents and dealing with emergencies, ensuring the safety of operations at sea, preventing intentional and unintentional discharges, and regulating the design, construction, equipment, operation and manning of vessels;

(c) pollution from installations and devices used in exploration or exploitation of the natural resources of the seabed and subsoil, in particular measures for preventing accidents and dealing with emergencies, ensuring the safety of operations at sea, and regulating the design, construction, equipment, operation and manning of such installations or devices;

(d) pollution from other installations and devices operating in the marine environment, in particular measures for preventing accidents and dealing with emergencies, ensuring the safety of operations at sea, and regulating the design, construction, equipment, operation and manning of such installations or devices.

4. In taking measures to prevent, reduce or control pollution of the marine environment, States shall refrain from unjustifiable interference with activities carried out by other States in the exercise of their rights and in pursuance of their duties in conformity with this Convention.
5. The measures taken in accordance with this Part shall include those necessary to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life.

Article 195 Duty not to Transfer Damage or Hazards or Transform one Type of Pollution into Another

In taking measures to prevent, reduce and control pollution of the marine environment, States shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into another.

Section 2. Global and Regional Cooperation

Article 197 Cooperation on a Global or Regional Basis

States shall cooperate on a global basis and, as appropriate, on a regional basis, directly or through competent international organisations, in formulating and elaborating international rules, standards and recommended practices and procedures consistent with this Convention, for the protection and preservation of the marine environment, taking into account characteristic regional features.

Section 5. International Rules and National Legislation to Prevent, Reduce and Control Pollution of the Marine Environment

Article 207 Pollution from Land-based Sources

1. States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from land-based sources, including rivers, estuaries, pipelines and outfall structures, taking into account internationally agreed rules, standards and recommended practices and procedures.
2. States shall take other measures as may be necessary to prevent, reduce and control such pollution.
3. States shall endeavor to harmonise their policies in this connection at the appropriate regional level.
4. States, acting especially through competent international organisations or diplomatic conference, shall endeavor to establish global and regional rules, standards and recommended practices

and procedures to prevent, reduce and control pollution of the marine environment from land-based sources, taking into account characteristic regional features, the economic capacity of developing States and their need for economic development. Such rules, standards and recommended practices and procedures shall be re-examined from time to time as necessary.

5. Laws, regulations, measures, rules, standards and recommended practices and procedures referred to in paragraphs 1, 2 and 4 shall include those designed to minimise, to the fullest extent possible, the release of toxic, harmful or noxious substances, especially those which are persistent, into the marine environment.

Article 208 Pollution from Seabed Activities Subject to National Jurisdiction

1 Coastal States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with seabed activities subject to their jurisdiction and from artificial islands, installations and structures under their jurisdiction, pursuant to articles 60 and 80.

2. States shall take other measures as may be necessary to prevent, reduce and control such pollution.
3. Such laws, regulations and measures shall be no less effective than international rules, standards and recommended practices and procedures.
4. States shall endeavor to harmonise their policies in this connection at the appropriate regional level.
5. States, acting especially through competent international organisations or diplomatic conference, shall establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine environment referred to in paragraph l. Such rules, standards and recommended practices and procedures shall be re-examined from time to time as necessary.

Article 209 Pollution from Activities in the Area

1. International rules, regulations and procedures shall be established in accordance with Part XI to prevent, reduce and control pollution of the marine environment from activities in the Area. Such rules, regulations and procedures shall be re-examined from time to time as necessary.
2. Subject to the relevant provisions of this section, States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from activities in the Area undertaken by vessels, installations, structures and other devices flying their flag or of their registry or operating under their authority, as the case may be. The requirements of such laws and regulations shall be no less effective than the international rules, regulations and procedures referred to in paragraph 1.

Article 210 Pollution by Dumping

1. States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment by dumping.
2. States shall take other measures as may be necessary to prevent, reduce and control such pollution.

3. Such laws, regulations and measures shall ensure that dumping is not carried out without the permission of the competent authorities of States.
4. States, acting especially through competent international organisations or diplomatic conference, shall endeavor to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control such pollution. Such rules, standards and recommended practices and procedures shall be re-examined from time to time as necessary.
5. Dumping within the territorial sea and the exclusive economic zone or onto the continental shelf shall not be carried out without the express prior approval of the coastal State, which has the right to permit, regulate and control such dumping after due consideration of the matter with other States which by reason of their geographical situation may be adversely affected thereby.
6. National laws, regulations and measures shall be no less effective in preventing, reducing and controlling such pollution than the global rules and standards.

Article 211 Pollution from Vessels

1. States, acting through the competent international organisation or general diplomatic conference, shall establish international rules and standards to prevent, reduce and control pollution of the marine environment from vessels and promote the adoption, in the same manner, wherever appropriate, of routing systems designed to minimise the threat of accidents which might cause pollution of the marine environment, including the coastline, and pollution damage to the related interests of coastal States. Such rules and standards shall, in the same manner, be re-examined from time to time as necessary.
2. States shall adopt laws and regulations for the prevention, reduction and control of pollution of the marine environment from vessels flying their flag or of their registry. Such laws and regulations shall at least have the same effect as that of generally accepted international rules and standards established through the competent international organisation or general diplomatic conference.
3. States which establish particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into their ports or internal waters or for a call at their off-shore terminals shall give due publicity to such requirements and shall communicate them to the competent international organisation.

   Whenever such requirements are established in identical form by two or more coastal States in an endeavor to harmonise policy, the communication shall indicate which States are participating in such cooperative arrangements. Every State shall require the master of a vessel flying its flag or of its registry, when navigating within the territorial sea of a State participating in such cooperative arrangements, to furnish, upon the request of that State, information as to whether it is proceeding to a State of the same region participating in such cooperative arrangements and, if so, to indicate whether it complies with the port entry requirements of that State. This article is without prejudice to the continued exercise by a vessel of its right of innocent passage or to the application of article 25, paragraph 2.
4. Coastal States may, in the exercise of their sovereignty within their territorial sea, adopt laws and regulations for the prevention, reduction and control of marine pollution from foreign vessels, including vessels exercising the right of innocent passage. Such laws and regulations shall, in accordance with Part II, section 3, not hamper innocent passage of foreign vessels.

5. Coastal States, for the purpose of enforcement as provided for in section 6, may in respect of their exclusive economic zones adopt laws and regulations for the prevention, reduction and control of pollution from vessel conforming to and giving effect to generally accepted international rules and standards established through the competent international organisation or general diplomatic conference.
6. (a) Where the international rules and standards referred to in paragraph 1 are inadequate to meet special circumstances and coastal States have reasonable grounds for believing that a particular, clearly defined area of their respective exclusive economic zones is an area where the adoption of special mandatory measures for the prevention of pollution from vessels is required for recognised technical reasons in relation to its oceanographical and ecological conditions, as well as its utilisation or the protection of its resources and the particular character of its traffic, the coastal States, after appropriate consultations through the competent international organisation with any other States concerned, may, for that area, direct a communication to that organisation, submitting scientific and technical evidence in support and information on necessary reception facilities. Within 12 months after receiving such a communication, the organisation shall determine whether the conditions in that area correspond to the requirements set out above. If the organisation so determines, the coastal States may, for that area, adopt laws and regulations for the prevention, reduction and control of pollution from vessels implementing such international rules and standards or navigational practices as are made applicable, through the organisation, for special areas. These laws and regulations shall not become applicable to foreign vessels until 15 months after the submission of the communication to the organisation.
   (b) The coastal States shall publish the limits of any such particular, clearly defined area.
   (c) If the coastal States intend to adopt additional laws and regulations for the same area for the prevention, reduction and control of pollution from vessels, they shall, when submitting the aforesaid communication, at the same time notify the organisation thereof. Such additional laws and regulations may relate to discharges or navigational practices but shall not require foreign vessels to observe design, construction, manning or equipment standards other than generally accepted international rules and standards; they shall become applicable to foreign vessels 15 months after the submission of the communication to the organisation, provided that the organisation agrees within 12 months after the submission of the communication.
7. The international rules and standards referred to in this article should include inter alia those relating to prompt notification to coastal States, whose coastline or related interests may be affected by incidents, including maritime casualties, which involve discharges or probability of discharges.

Article 212 Pollution from or through the Atmosphere

1. States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from or through the atmosphere, applicable to the air space under their sovereignty and to vessels flying their flag or vessels or aircraft of their registry, taking into account internationally agreed rules, standards and recommended practices and procedures and the safety of air navigation.
2. States shall take other measures as may be necessary to prevent, reduce and control such pollution.

3. States, acting especially through competent international organisations or diplomatic conference, shall endeavor to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control such pollution.

Section 11. Obligations under other Conventions on the Protection and Preservation of the Marine Environment

Article 237 Obligations under other Conventions on the Protection and Preservation of the Marine Environment

1. The provisions of this Part are without prejudice to the specific obligations assumed by States under special conventions and agreements concluded previously which relate to the protection and preservation of the marine environment and to agreements which may be concluded in furtherance of the general principles set forth in this Convention.
2. Specific obligations assumed by States under special conventions, with respect to the protection and preservation of the marine environment, should be carried out in a manner consistent with the general principles and objectives of this Convention.

ANNEX 7

Selection of relevant provisions under the London Convention

(concluded in 1972, in force since 1975)

Article I

Contracting Parties shall individually and collectively promote the effective control of all sources of pollution of the marine environment, and pledge themselves especially to take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.

Article II

Contracting Parties shall, as provided for in the following articles, take effective measures individually, according to their scientific, technical and economic capabilities, and collectively, to prevent marine pollution caused by dumping and shall harmonise their policies in this regard.

Article III

For the purposes of this Convention:

1 (a) "Dumping" means:

(i) any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;

(ii) any deliberate disposal at sea of vessels, aircraft, platforms or other man-made structures at sea.

(b) "Dumping" does not include:

(i) the disposal at sea of wastes or other matter incidental to, or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment, other than wastes or other matter transported by or to vessels, aircraft, platforms or other man-made structures at sea, operating for the purpose of disposal of such matter or derived from the treatment of such wastes or other matter on such vessels, aircraft, platforms or structures;

(ii) placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention.

(c) The disposal of wastes or other matter directly arising from, or related to the exploration, exploitation and associated off-shore processing of sea-bed mineral resources will not be covered by the provisions of this Convention.

[...]

3 "Sea" means all marine waters other than the internal waters of States.

4 "Wastes or other matter" means material and substance of any kind, form or description.

[...]

Article IV

1 In accordance with the provisions of this Convention Contracting Parties shall prohibit the dumping of any wastes or other matter in whatever form or condition except as otherwise specified below:

(a) the dumping of wastes or other matter listed in Annex I is prohibited;

(b) the dumping of wastes or other matter listed in Annex II requires a prior special permit;

(c) the dumping of all other wastes or matter requires a prior general permit.

[...]

Article VIII

In order to further the objectives of this Convention, the Contracting Parties with common interests to protect in the marine environment in a given geographical area shall endeavor, taking into account characteristic regional features, to enter into regional agreements consistent with this Convention for the prevention of pollution, especially by dumping. The Contracting Parties to the present Convention shall endeavor to act consistently with the objectives and provisions of such regional agreements, which shall be notified to them by the Organisation. Contracting Parties shall seek to co-operate with the Parties to regional agreements in order to develop harmonised procedures to be followed by Contracting Parties to the different conventions concerned. Special attention shall be given to co-operation in the field of monitoring and scientific research.

[...]

Annex I to the London Convention

[...]

11 Industrial waste as from 1 January 1996.

For the purposes of this Annex:

"Industrial waste" means waste materials generated by manufacturing or processing operations and does not apply to:

(a) dredged material;

(b) sewage sludge;

(c) fish waste, or organic materials resulting from industrial fish processing operations;

(d) vessels and platforms or other man-made structures at sea, provided that material capable of creating floating debris or otherwise contributing to pollution of the marine environment has been removed to the maximum extent;

(e) uncontaminated inert geologic materials the chemical constituents of which are unlikely to be released into the marine environment;

(f) uncontaminated organic materials of natural origin.

[...]

ANNEX 8

Selection of relevant provisions under the London Protocol

(concluded in 1996, since March 2006 in force)

Article 1 Definitions

For the purposes of this Protocol:

[...]

4 1. "Dumping" means:

1. any deliberate disposal into the sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;
2. any deliberate disposal into the sea of vessels, aircraft, platforms or other man-made structures at sea;
3. any storage of wastes or other matter in the seabed and the subsoil thereof from vessels, aircraft, platforms or other man-made structures at sea; and
4. any abandonment or toppling at site of platforms or other man-made structures at sea, for the sole purpose of deliberate disposal.

2. "Dumping" does not include:

1. the disposal into the sea of wastes or other matter incidental to, or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment, other than wastes or other matter transported by or to vessels, aircraft, platforms or other man-made structures at sea, operating for the purpose of disposal of such matter or derived from the treatment of such wastes or other matter on such vessels, aircraft, platforms or other man-made structures;
2. placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Protocol; and
3. notwithstanding paragraph 4.1.4, abandonment in the sea of matter (*e.g.,* cables, pipelines and marine research devices) placed for a purpose other than the mere disposal thereof.

3. The disposal or storage of wastes or other matter directly arising from, or related to the exploration, exploitation and associated off-shore processing of seabed mineral resources is not covered by the provisions of this Protocol.

[...]

7 "Sea" means all marine waters other than the internal waters of States, as well as the seabed and the subsoil thereof; it does not include sub-seabed repositories accessed only from land.

8 "Wastes or other matter" means material and substance of any kind, form or description.

[...]

10 "Pollution" means the introduction, directly or indirectly, by human activity, of wastes or other matter into the sea which results or is likely to result in such deleterious effects as harm

to living resources and marine ecosystems, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.

Article 2 Objectives

Contracting Parties shall individually and collectively protect and preserve the marine environment from all sources of pollution and take effective measures, according to their scientific, technical and economic capabilities, to prevent, reduce and where practicable eliminate pollution caused by dumping or incineration at sea of wastes or other matter. Where appropriate, they shall harmonise their policies in this regard.

Article 3 General Obligations

1 In implementing this Protocol, Contracting Parties shall apply a precautionary approach to environmental protection from dumping of wastes or other matter whereby appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects.

2 Taking into account the approach that the polluter should, in principle, bear the cost of pollution, each Contracting Party shall endeavor to promote practices whereby those it has authorised to engage in dumping or incineration at sea bear the cost of meeting the pollution prevention and control requirements for the authorised activities, having due regard to the public interest.

3 In implementing the provisions of this Protocol, Contracting Parties shall act so as not to transfer, directly or indirectly, damage or likelihood of damage from one part of the environment to another or transform one type of pollution into another.

[...]

Article 4 Dumping of Wastes or other Matter

1 1. Contracting Parties shall prohibit the dumping of any wastes or other matter with the exception of those listed in Annex 1.

2. The dumping of wastes or other matter listed in Annex 1 shall require a permit. Contracting Parties shall adopt administrative or legislative measures to ensure that issuance of permits and permit conditions comply with provisions of Annex 2. Particular attention shall be paid to opportunities to avoid dumping in favor of environmentally preferable alternatives.

[...]

Article 12 Regional Co-operation

In order to further the objectives of this Protocol, Contracting Parties with common interests to protect the marine environment in a given geographical area shall endeavor, taking into account characteristic regional features, to enhance regional co operation including the conclusion of regional agreements consistent with this Protocol for the prevention, reduction and where practicable elimination of pollution caused by dumping or incineration at sea of wastes or other matter. Contracting Parties shall seek to co-operate with the parties to regional agreements in order to develop harmonised procedures to be followed by Contracting Parties to the different conventions concerned.

[...]

Article 14 Scientific and Technical Research

1 Contracting Parties shall take appropriate measures to promote and facilitate scientific and technical research on the prevention, reduction and where practicable elimination of pollution by dumping and other sources of marine pollution relevant to this Protocol. In particular, such research should include observation, measurement, evaluation and analysis of pollution by scientific methods.

[...]

Annex 1 to the London Protocol

Wastes or other Matter that May be Considered for Dumping

1 The following wastes or other matter are those that may be considered for dumping being mindful of the Objectives and General Obligations of this Protocol set out in articles 2 and 3:

1. dredged material;
2. sewage sludge;
3. fish waste, or material resulting from industrial fish processing operations;
4. vessels and platforms or other man-made structures at sea;
5. inert, inorganic geologic material;
6. organic material of natural origin; and

[...]

ANNEX 9

Selection of relevant provisions under OSPAR

(concluded in 1992, in force since 1998)

Article 1 Definitions

For the purposes of the Convention:

(a) "Maritime area" means the internal waters and the territorial seas of the Contracting Parties, the sea beyond and adjacent to the territorial sea under the jurisdiction of the coastal state to the extent recognised by international law, and the high seas, including the bed of all those waters and its sub-soil, situated within the following limits [...]

(b) "Internal waters" means the waters on the landward side of the baselines from which the breadth of the territorial sea is measured, extending in the case of watercourses up to the freshwater limit.

(c) "Freshwater limit" means the place in a watercourse where, at low tide and in a period of low freshwater flow, there is an appreciable increase in salinity due to the presence of seawater.

(d) "Pollution" means the introduction by man, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea.

(e) "Land-based sources" means point and diffuse sources on land from which substances or energy reach the maritime area by water, through the air, or directly from the coast. It includes sources associated with any deliberate disposal under the sea-bed made accessible from land by tunnel, pipeline or other means and sources associated with man-made structures placed, in the maritime area under the jurisdiction of a Contracting Party, other than for the purpose of offshore activities.

(f) "Dumping" means

  (i) any deliberate disposal in the maritime area of wastes or other matter

    (1) from vessels or aircraft;

    (2) from offshore installations;

  (ii) any deliberate disposal in the maritime area of

    (1) vessels or aircraft;

    (2) offshore installations and offshore pipelines.

(g) "Dumping" does not include:

  (i) the disposal in accordance with the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto, or other applicable international law, of wastes or other matter incidental to, or derived from, the normal operations of vessels or aircraft or offshore installations other than wastes or other matter transported by or to vessels or aircraft or offshore installations for the purpose of disposal of such wastes or other matter or derived from the treatment of such wastes or other matter on such vessels or aircraft or offshore installations;

(ii) placement of matter for a purpose other than the mere disposal thereof, provided that, if the placement is for a purpose other than that for which the matter was originally designed or constructed, it is in accordance with the relevant provisions of the Convention; and

(iii) for the purposes of Annex III, the leaving wholly or partly in place of a disused offshore installation or disused offshore pipeline, provided that any such operation takes place in accordance with any relevant provision of the Convention and with other relevant international law.

(j) "Offshore activities" means activities carried out in the maritime area for the purposes of the exploration, appraisal or exploitation of liquid and gaseous hydrocarbons.

(k) "Offshore sources" means offshore installations and offshore pipelines from which substances or energy reach the maritime area.

(l) "Offshore installation" means any man-made structure, plant or vessel or parts thereof, whether floating or fixed to the seabed, placed within the maritime area for the purpose of offshore activities.

(m) "Offshore pipeline" means any pipeline which has been placed in the maritime area for the purpose of offshore activities.

(n) "Vessels or aircraft" means waterborne or airborne craft of any type whatsoever, their parts and other fittings. This expression includes air-cushion craft, floating craft whether self-propelled or not, and other man-made structures in the maritime area and their equipment, but excludes offshore installations and offshore pipelines.

(o) "Wastes or other matter" does not include:

(i) human remains;

(ii) offshore installations;

(iii) offshore pipelines;

(iv) unprocessed fish and fish offal discarded from fishing vessels.[...]

Article 2 General Obligations

1. (a) The Contracting Parties shall, in accordance with the provisions of the Convention, take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

(b) To this end Contracting Parties shall, individually and jointly, adopt programmes and measures and shall harmonise their policies and strategies.

2. The Contracting Parties shall apply:

(a) the precautionary principle, by virtue of which preventive measures are to be taken when there are reasonable grounds for concern that substances or energy introduced, directly or indirectly, into the marine environment may bring about hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even when there is no conclusive evidence of a causal relationship between the inputs and the effects;

(b) the polluter pays principle, by virtue of which the costs of pollution prevention, control and reduction measures are to be borne by the polluter.

3. (a) In implementing the Convention, Contracting Parties shall adopt their completion and which take full account of the use of the latest pollution fully.
   (b) To this end they shall:
   (i) taking into account the criteria set forth in Appendix 1, define with respect to programmes and measures the application of, *inter alia,*
      - best available techniques
      - best environmental practice

      including, where appropriate, clean technology;
   (ii) in carrying out such programmes and measures, ensure the application of best available techniques and best environmental practice as so defined, including, where appropriate, clean technology.
4. The Contracting Parties shall apply the measures they adopt in such a way as to prevent an increase in pollution of the sea outside the maritime area or in other parts of the environment.
5. No provision of the Convention shall be interpreted as preventing the Contracting Parties from taking, individually or jointly, more stringent measures with respect to the prevention and elimination of pollution of the maritime area or with respect to the protection of the maritime area against the adverse effects of human activities.

[...]

Article 3 Pollution from Land Based Sources

The Contracting Parties shall take, individually and jointly, all possible steps to prevent and eliminate pollution from land-based sources in accordance with the provisions of the Convention, in particular as provided for in Annex I.

Article 4 Pollution by Dumping or Incineration

The Contracting Parties shall take, individually and jointly, all possible steps to prevent and eliminate pollution by dumping or incineration of wastes or other matter in accordance with the provisions of the Convention, in particular as provided for in Annex II.

Article 5 Pollution from Offshore Sources

The Contracting Parties shall take, individually and jointly, all possible steps to prevent and eliminate pollution from offshore sources in accordance with the provisions of the Convention, in particular as provided for in Annex III.

Article 8 Scientific and Technical Research

1. To further the aims of the Convention, the Contracting Parties shall establish complementary or joint programmes of scientific or technical research and, in accordance with a standard procedure, to transmit to the Commission:
   (a) the results of such complementary, joint or other relevant research;
   (b) details of other relevant programmes of scientific and technical research.

2. In so doing, the Contracting Parties shall have regard to the work carried out, in these fields, by the appropriate international organisations and agencies.

Annex I

On the Prevention and Elimination of Pollution from Land-based Sources

[...]

Article 2

1. Point source discharges to the maritime area, and releases into water or air which reach and may affect the maritime area, shall be strictly subject to authorisation or regulation by the competent authorities of the Contracting Parties. Such authorisation or regulation shall, in particular, implement relevant decisions of the Commission which bind the relevant Contracting Party.
2. The Contracting Parties shall provide for a system of regular monitoring and inspection by their competent authorities to assess compliance with authorisations and regulations of releases into water or air.

Annex II

On the Prevention and Elimination of Pollution by Dumping or Incineration

Article 1

This Annex shall not apply to any deliberate disposal in the maritime area of:

(a) wastes or other matter from offshore installations;

(b) offshore installations and offshore pipelines.

[...]

Article 3

1. The dumping of all wastes or other matter is prohibited, except for those wastes or other matter listed in paragraphs 2 and 3 of this Article.
2. The list referred to in paragraph 1 of this Article is as follows:
   (a) dredged material;
   (b) inert materials of natural origin, that is solid, chemically unprocessed geologic material the chemical constituents of which are unlikely to be released into the marine environment;
   (c) sewage sludge until 31st December 1998;
   (d) fish waste from industrial fish processing operations;
   (e) vessels or aircraft until, at the latest, 31st December 2004.
3. (a) The dumping of low and intermediate level radioactive substances, including wastes, is prohibited.

[...]

Article 5

No placement of matter in the maritime area for a purpose other than that for which it was originally designed or constructed shall take place without authorisation or regulation by the competent authority of the relevant Contracting Party. Such authorisation or regulation shall be in accordance with the relevant applicable criteria, guidelines and procedures adopted by the Commission in accordance with Article 6 of this Annex. This provision shall not be taken to permit the dumping of wastes or other matter otherwise prohibited under this Annex.

Annex III

On the Prevention and Elimination of Pollution from Offshore Sources

Article 1

This Annex shall not apply to any deliberate disposal in the maritime area of:

(a) wastes or other matter from vessels or aircraft;

(b) vessels or aircraft.

Article 2

1. When adopting programmes and measures for the purpose of this Annex, the Contracting Parties shall require, either individually or jointly, the use of:

   (a) best available techniques

   (b) best environmental practice

   including, where appropriate, clean technology.

2. When setting priorities and in assessing the nature and extent of the programmes and measures and their time scales, the Contracting Parties shall use the criteria given in Appendix 2.

Article 3

1. Any dumping of wastes or other matter from offshore installations is prohibited.
2. This prohibition does not relate to discharges or emissions from offshore sources.

[...]

ANNEX 10

Selection of relevant provisions under the UNFCCC

(concluded in 1992, in force since 1994)

Article 1 Definitions

For the purposes of this Convention:

[...]

3. "Climate system" means the totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions.

[...]

7. "Reservoir" means a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.
8. "Sink" means any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.

Article 2 Objective

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Article 3 Principles

In their actions to achieve the objective of the Convention and to implement its provisions, the Parties shall be guided, inter alia, by the following:

[...]

3. The Parties should take precautionary measures to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. To achieve this, such policies and measures should take into account different socio-economic contexts, be comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors. Efforts to address climate change may be carried out cooperatively by interested Parties.

[...]

Article 4 Commitments

1. All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, shall:
   (a) Develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties;
   (b) Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and measures to facilitate adequate adaptation to climate change;

[...]

   (d) Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems;

[...]

2. The developed country Parties and other Parties included in Annex I commit themselves specifically as provided for in the following:
   (a) Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs

[...].

ANNEX 11

Selection of relevant provisions under the Kyoto Protocol

(concluded in 1997, in force since 2005)

[...]

Article 2

1. Each Party included in Annex I, in achieving its quantified emission limitation and reduction commitments under Article 3, in order to promote sustainable development, shall:
   (a) Implement and/or further elaborate policies and measures in accordance with its national circumstances, such as:
      (i) Enhancement of energy efficiency in relevant sectors of the national economy;
      (ii) Protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, taking into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation;
      (iii) Promotion of sustainable forms of agriculture in light of climate change considerations;
      (iv) Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies;
      (v) Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and application of market instruments;
      (vi) Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol;
      (vii) Measures to limit and/or reduce emissions of greenhouse gases not controlled by the Montreal Protocol in the transport sector;
      (viii) Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy;

[...]

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

2. Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.
3. The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.
4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide, for consideration by the Subsidiary Body for Scientific and Technological Advice, data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

[...]

Article 5

1. Each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. Guidelines for such national systems, which shall incorporate the methodologies specified in paragraph 2 below, shall be decided upon by the Conference of the Parties serving as the meeting of the Parties to this Protocol at its first session.
2. Methodologies for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol shall be those accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties at its third session. Where such methodologies are not used, appropriate adjustments shall be applied according to methodologies agreed upon by the Conference of the Parties serving as the meeting of the Parties to this Protocol at its first session. Based on the work of, inter alia, the Intergovernmental Panel on Climate Change and advice provided by the Subsidiary Body for Scientific and Technological Advice, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall regularly review and, as appropriate, revise such methodologies and adjustments, taking fully into account any relevant decisions by the Conference of the Parties. Any revision to methodologies or adjustments shall be used only for the purposes of ascertaining compliance with commitments under Article 3 in respect of any commitment period adopted subsequent to that revision.

ANNEX 12

Glossary and acronyms

Acid gas	Chemical species, principally oxides of sulfur (SO_x) and nitrogen (NO_x), contained in flue gas and other process streams that combine with water vapor or water droplets to form acid.
Anthropogenic	Source (*e.g.,* of greenhouse gases) which is man-made as opposed to natural.
Aquifer	Geologic structure containing water and with significant permeability to allow flow.
Baseline	The datum against which change is measured.
Caprock	Rock of very low permeability that acts as an upper seal to prevent fluid flow out of a reservoir.
Cleat structure	Coal seams are naturally fractured, with closely spaced, regular, planar fractures that are collectively known as cleats. The nature of the cleat structures determines the permeability of the coal seam.
Containment	Restriction of movement of a fluid to a designated volume (*e.g.,* reservoir).
CCS	CO_2 capture and storage
CDM	Clean development mechanism
CER	Certified emission reduction (used in the CDM)
CO_2	Carbon dioxide
CSLF	Carbon Sequestration Leadership Forum
Deep saline aquifer	A deep underground rock formation composed of permeable materials and containing highly saline fluids.
Depleted	Of a reservoir; one where production is significantly reduced.
ECBM	Enhanced coal bed methane recovery
EEZ	Exclusive Economic Zone
EOR	Enhanced oil recovery; the recovery of oil additional to that produced by standard production methods.
EU ETS	European Union emissions trading scheme
Formation	A body of rock of considerable extent with distinctive characteristics that allow geologists to map, describe and name it.
Formation water	Water that occurs naturally within the pores of rock foundations.

Fracture	Any break in rock along which no significant movement has occurred, but where the permeability may be significantly enhanced.
GEF	Global Environment Facility
Geologic time	The time over which geologic processes take place.
Geologic trapping	The retention of injected CO_2 by geochemical reactions.
GHG	Greenhouse gases; the main ones include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulphur hexafluoride (SF_6).
Hydro-geologic	Concerning water in the geologic environment.
IEA	International Energy Agency
IMO	International Maritime Organisation
Injection well	A well in which fluids are injected rather than produced.
Injectivity	A measure of the rate at which a quantity of fluid can be injected into a geologic formation.
IPCC	Intergovernmental Panel on Climate Change
Leakage	In the context of GHG reduction projects, leakage is used to describe the displacement of GHG emissions beyond the assessment boundary of the project. In the context of CO_2 storage, the escape of CO_2 from the storage formation into the water column and/or the atmosphere.
Matrix pore network	A solid permeated by an interconnected network of pores filled with a fluid (liquid or gas).
Migration	The movement of CO_2 out of the geologic storage site while remaining in the same geologic formation.
Mineralisation	A process whereby carbon dioxide injected into a geologic formation reacts with silicate minerals, forming stable carbonate minerals.
Monitoring	The process of measuring the quantity of CO_2 stored, it location and its behaviour.
NGO	Non-governmental organisation
OSPAR	The Convention for the Protection of the Marine Environment of the Northeast Atlantic.
Permeability	Ability to flow or transmit fluids through a porous solid such as rock.
Physical Leakage	Refers to the flow of CO_2 from the storage site to other places in the ground, to the atmosphere, or the ocean.
Reservoir	A subsurface body of rock with sufficient porosity and permeability to store and transmit fluids.

Saline formation	Sediment or other rock formation containing brackish water or brine.
SBSTA	United Nations Subsidiary Body for Scientific and Technological Advice
Seal	An impermeable rock that forms a barrier above or around a reservoir such that fluids are held in the reservoir.
Storage	A process for retaining captured CO_2 in deep geologic formations so that it does not reach the atmosphere.
Transmissivity	A measure of the capability of the entire thickness of an aquifer to transmit water.
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
Well	Manmade hole drilled into the earth to produce liquids or gases, to allow the injection of fluids or gases, or to enable observations of subsurface process.
WIPO	World Intellectual Property Organisation

ANNEX 13

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REFERENCES

Ahlert, I.B. (2003-2004), *Overcoming obstacles to patent harmonisation,* Managing Intell Prop 35.

van Alphen, K. et al. (2006), *Social acceptance of carbon dioxide sequestration in the Netherlands,* GHGT8 Conference, IEA, Trondeim.

van Arnam, R.C. (2001), *Business War: Economic Espionage in the United States and the European Union and the Need for Greater Trade Secret Protection,* 27 N.C.J. Int'l L. & Com. Reg. 95, 117.

Ashworth, P., A. Pisarski, *et al.* (2006), *Using Leximancer to Explore Community Dialogue about Low Emissions Technologies,* International Communication Association.

Bachu, S. and M.A. Celia (2006), *Assessing the Potential for CO_2 Leakage, Particularly Through Wells, From Geologic Storage Sites.* The Science of CO_2 Storage (B.J. McPherson and E. Sundquist, eds.), AGU Monograph Series, American Geographic Union, Washington, DC.

Barton, J. (2004), *Issues Posed by a World Patent System,* Journal of International Economic Law (2), 341-357.

de Best-Waldhober, M., D. Daamen and A. Faaij (2006), *Informed Public Opinions on CO_2 Capture and Storage Technologies,* GHGT8 Conference, IEA, Trondeim.

Bird, R.C. (2006), *Defending Intellectual Property Rights in the BRIC Economies,* American Business Law Journal, Volume 43, issues 2, 317-363.

Bode, S. and M. Jung (2004), *On the Integration of Carbon Capture and Storage into the International Climate Regime,* 9-10 (HWWA Discussion Paper 303).

Carbon Sequestration Leadership Forum (CSLF) (2007), *Task Force to review and Identify Standards for CO_2 Storage Capacity Estimation,* CSLF Meeting, Paris, available at www.cslforum.org/documents/Paris/Storage_Capacity_Estimation_TaskForce_Report_26March2007.pdf.

Clean Development Mechanism (CDM) Methodological Panel (2006), *Draft recommendation on CO_2 capture and storage as CDM Project Activities Based on the Review of Cases NM0167, NM0168 and SSC_038,* Bonn.

Council of Australian Governments (1985), *Principles and Guidelines for National Standard Setting and Regulatory Action by Ministerial Councils and Standard Setting Bodies,* Melbourne.

Dinwoodie, G.B. (2006), *The International Intellectual Property Law System: New Actors, New Institutions, New Sources,* 10 Marquette Intellectual Property Law Review 205.

de Figueiredo, M., *et al.* (2005), *Framing the Long-term in Situ Liability for Geologic Carbon Storage in the United States,* Mitigation Adapt. Strat. Global Change; 10:647-57.

de Figueiredo, M. (2007), *The Liability of Carbon Dioxide Storage,* Submitted to the Engineering Systems Division in Partial Fulfilment of the Requirements for the Degree of Doctor in Philosophy in Technology, Management and Policy at the Massachusetts Institute of Technology.

FutureGen Texas (2007), *Permitting and Regulatory Issues Fact Sheet,* see www.beg.utexas.edu/futuregentexas/pdf/FGT_permitting.pdf.

Gale, J. (2007), *Capture Ready Power Plants,* presented at the IEAGHG & CATO workshop on Impacts of Carbon Capture and Storage, Amsterdam; available at www.co2-cato.nl.

Gough, C., C, McLachlan and S. Shackley (2004), *The Public Perceptions of Carbon Capture and Storage,* Tyndall Centre for Climate Change Research.

Grice, J., M. K. Wegener, *et al.* (2003), *Genetically Modified Sugarcane: A Case for Alternative Products,* AgBioForm 6(4).

Haefeli, S., *et al.* (2004), *CO_2 Storage Issues, Accounting and Baselines under the UNFCCC,* OECD/IEA, Paris.

Harvey, I. and J. Morgan (2007), *Intellectual Property Rights in China: Myths Versus Reality,* published in Third Generation Environmentalism Ltd (April 2007).

Hayes, D. and J. Beauvais (2007), *Carbon Sequestration,* Chapter 19 of *Global Climate Change and U.S. Law,* [M. Gerrard, Ed.], American Bar Association, Section of Environment, Energy and Resources, Chicago.

Hendriks, C., M. J. Mace, R. Coenraads (2005), *Impacts of EU and International Law on the Implementation of Carbon Capture and Geologic Storage in the European Union,* European Commission, Directorate General Environment, Brussels.

International Energy Agency (IEA) (2004), *Prospects for CO_2 Capture and Storage, Energy Technology Analysis,* OECD/IEA, Paris.

IEA (2005), *Legal Aspects of Storing CO_2,* OECD/IEA, Paris.

IEA (2006), *World Energy Outlook,* OECD/IEA, Paris.

IEA (2006a), *Energy Technology Perspectives. Scenarios and Strategies to 2050,* OECD/IEA, Paris.

IEA Greenhouse Gas R&D Programme (2007), *Role of Risk Assessment in Regulatory Framework for Geologic Storage of CO_2,* Technical Study, Report No. 2007/2, London.

Intergovernmental Panel on Climate Change (IPCC) (2005), *IPCC Special Report on Carbon Dioxide Capture and Storage,* prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H.C. de Coninck, M. Loos, and L.A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2006), IPCC Guidelines for National Greenhouse Gas Inventories, IPCC/OECD/IEA, Paris.

Interstate Oil and Gas Compact Commission (IOGCC) (2005), *Carbon Capture and Storage: A Regulatory Framework for States,* 8-10, 28-35.

International Petroleum Industry Environmental Conservation Association (IPIECA) and American Petroleum Institute (API) (2007), Carbon Capture and Geologic Storage Emission Reduction Project Family.

Itaoka, K., A. Saito, and M. Akai (2005), *Public Acceptance of CO_2 Capture and Storage Technology: A Survey of Public Opinion to Explore Influential Factors,* GHGT7 Conference, Canada.

Kanagavel, P. (2003), *Intellectual Property Rights: A Comprehensive Overview,* 85 J. Pat. & Trademark Off. Soc'y 663.

Littleboy, A., P. Ashworth, et al. (2004), *Scoping Study: Understanding and Incorporating Stakeholder Perspectives to Low Emission Technologies,* Centre for Low Emission Technology.

London Protocol (2006), *A Risk Assessment and Management Framework for CO_2 Sequestration in Sub-seabed Geologic Formations,* London.

Massachusetts Institute of Technology (MIT) (2007), *The Future of Coal: An Interdisciplinary MIT Study Cambridge.*

McCarthy, J.T. (2005), *McCarthy on Trademarks and Unfair Competition* §29.1 (4th ed.).

McKinnon, R.J. (1998), *The Interplay between Production and Underground Storage Rights in Alberta,* The Alberta Law Review, 36(400).

Ministerial Council on Mineral and Petroleum Resources (2005), *Principles for engagement with communities and stakeholders,* Melbourne.

ter Mors, E., et al. (2006), *The Influence of (in)Congruence of Communicator Expertise and Trustworthiness on Acceptance of CO_2 Storage Technologies,* GHGT8 Conference, Trondeim.

Nadoury, A. (1998), *Legal Problems of Transferring Technology to the Third World,* Law Technology; 3rd Quarter 1998; 31, 3; Career and Technical Education p. 21.

National Consumer Council (2002), *Running Risks: Summary of NCC Research into Consumers' Views on Risk.*

Osman-Elasha and Pipatti (2005), *IPCC Special Report on Carbon Dioxide Capture and Storage - Chapter 9,' Implications of Carbon Dioxide Capture and Storage for Greenhouse Gas Inventories and Accounting,* IPCC, Bonn.

Petroleum Technology Research Centre (PTRC) (2004), *IEA GHG Weyburn CO_2 Monitoring and Storage Report,* available at www.ptrc.ca/siteimages/Summary_Report_2000_2004.pdf.

Reiner, D. (2006), *An International Comparison of Public Attitudes towards Carbon Capture and Storage Technologies,* GHGT8 Conference, Trondeim.

Saline Aquifer CO_2 Storage (SACS) (2002), *Best Practices Manual from SACS – Saline Aquifer CO_2 Storage Project,* Statoil Research Centre.

Sharp, J.D. (2005), *Public Attitudes toward Geologic Disposal of Carbon Dioxide in Canada,* Masters Thesis: Queens University, Canada.

Slovic, P. (2000), *The Perception of Risk,* Earthscan.

U.S. Department of Energy/National Energy Technology Laboratory (2006), *Carbon Capture and Storage Projects: Overcoming Legal and Regulatory Barriers.*

U.S. Environmental Protection Agency (2007), *Using the Class V Experimental Technology Well Classification for Pilot Carbon Geologic Sequestration Projects,* UIC Program Guidance #83, available at www.epa.gov/OGWDW/uic/wells_sequestration.html.

Vine, E. (2004), *Regulatory Constraints to Carbon Sequestration in Terrestrial Ecosystems and Geologic Formations: A California Perspective,* Mitigation and Adaptation Strategies for Global Change, 9, 77-95.

Wilson, E, and D. Gerard (2007), *Carbon Capture and Sequestration: Integrating Technology, Monitoring and Regulation*, Blackwell Publishing.

Wilson, E., T. Johnson and D. Keith (2003), *Regulating the Ultimate Sink: Managing the Risks of Geologic CO_2 Storage*, Environmental Science and Technology, 37, 3476-3483.

Zakkour, P., et al. (2005), *Developing Monitoring, Reporting and Verification Guidelines for CO_2 Capture and Storage under the EU ETS*, DTI R277.

RELATED WEBSITES

Australia Ministry of Industry, Tourism and Resources website on CCS, www.industry.gov.au/content/itrinternet/cmscontent.cfm?objectID=E7658BE4-E1E1-ECD4-33CCC3F91A257C9F

Carbon Sequestration Leadership Forum, www.cslforum.org

CATO Programme (Netherlands), www.co2-cato.nl

CO_2 Capture Project, www.co2captureproject.org

CO_2CRC (Australia), www.co2crc.com.au/

CO_2GeoNet (EU), www.co2geonet.com

CO_2Net (EU), www.co2net.com/home/index.asp

CO_2ReMoVe (EU), www.co2remove.eu

CO_2SINK (EU), www.co2sink.org/geninfo/theproject.htm

Department of Trade and Industry (UK) (2005), *A Strategy for Developing Carbon Abatement Technologies for Fossil Fuel Use,* www.dti.gsi.gov.uk/energy/coal/cfft/cct/pub/catreportlinked.pdf

EnergyINet (Canada), www.energyinet.com

European Commission Website on Geologic Carbon Sequestration, http://ec.europa.eu/environment/climat/ccs/index_en.htm

FutureGen Alliance, www.futuregenalliance.org

International Energy Agency, www.iea.org

IEA Greenhouse Gas R&D Programme, www.ieagreen.org.uk

IEA Working Party on Fossil Fuels (2003), *CO_2 Capture and Storage in Geologic Formations* www.iea.org/dbtwwpd/textbase/papers/2003/CO2_Storage_Fossil_Fuels.pdf.

International Maritime Organisation (includes information on London Convention framework and other international marine environment protection agreements), www.imo.org

National Energy Technology Laboratory (USA), www.netl.doe.gov/sequestration

National Energy Technology Laboratory, Carbon Sequestration Atlas of U.S. and Canada, www.netl.doe.gov/publications/carbon_seq/atlas/index.html

Natural Resources Canada, CO_2 capture and storage website, www.nrcan.gc.ca/es/etb/cetc/combustion/co2network/htmldocs/project_details_7_e.html

OSPAR, www.ospar.org

Technology Platform for Zero Emission Fossil Fuel Power Plants (EU), http://ec.europa.eu/research/energy/nn/nn_rt/nn_rt_co/article_2268_en.htm

UNFCCC, *Further Guidance Relating to the CDM,* par. 5-8. http://unfccc.int/files/meetings/cop_11

The Zero-Emission Coal Alliance, www.zeca.org/

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