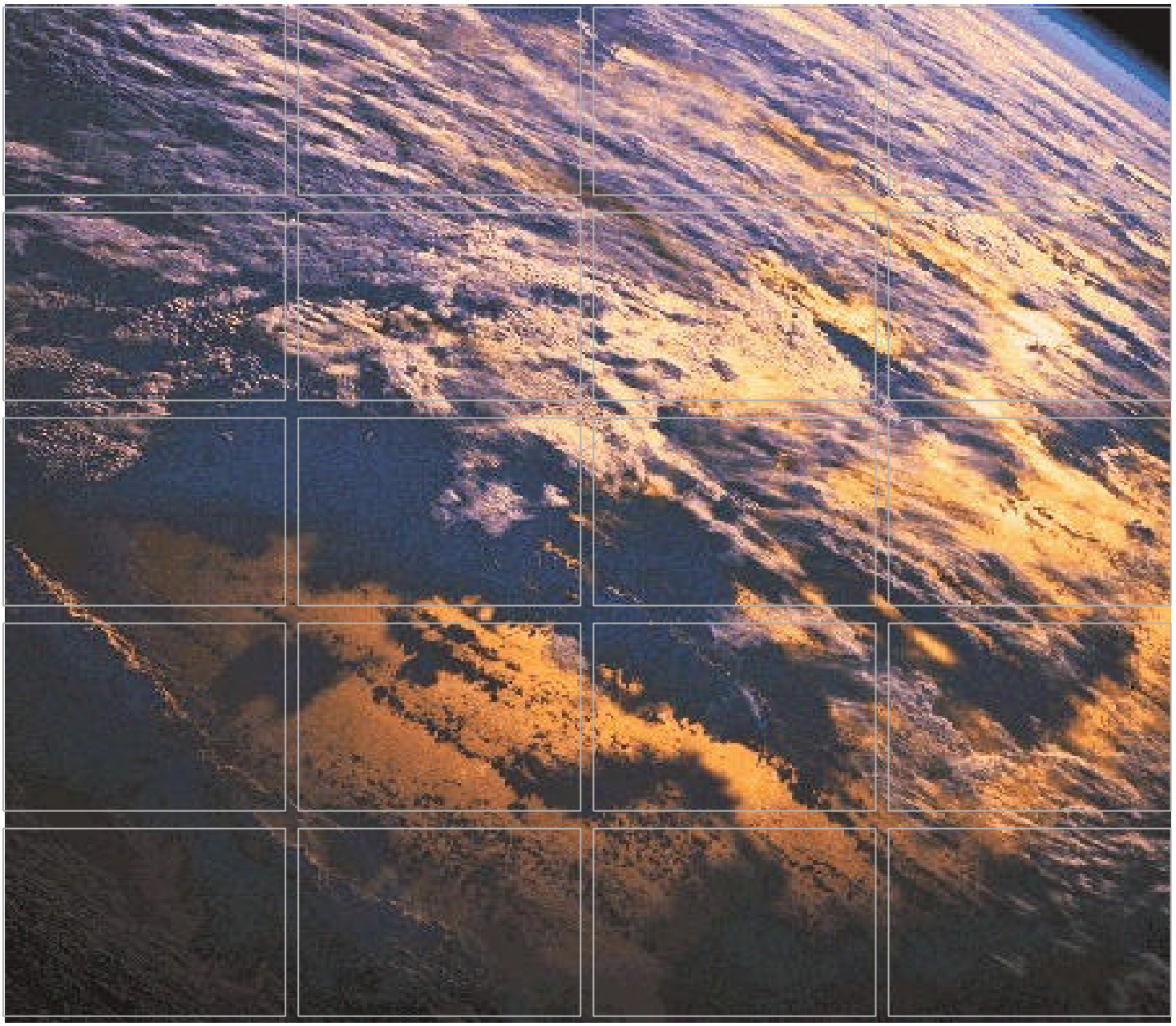

Update and Studies of Selected Issues Related to Government and Institutional Policies and Incentives Contributing to CO2 Capture and Geological Storage

CO_2 Capture Project

Final Report

January 2004

FINAL REPORT

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Update and Studies of Selected Issues Related to Government and Institutional Policies and Incentives Contributing to CO_2 Capture and Geological StorageDecember 2003

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1 EXECUTIVE SUMMARY

1.1 OBJECTIVES

The objective of the report is to review, analyse and compare existing incentives and public policies or regulations that allow, inhibit or stimulate the capture of CO_2 for geological storage.

The report focuses on policies, regulations, incentives, and planned near-term measures, including any likely linkages with the Kyoto flexible mechanisms. The report also highlights how official policies, regulations, and incentives treat CO_2 capture and geological storage (CCS) in comparison to other measures to reduce emissions of greenhouse gases and how this might be affected by the attitudes of non-governmental organisations (NGOs) to geological storage.

Given the lack of experience in most countries with developing either commercial or demonstration projects for CCS, the *lack* of specific regulations has also been considered to determine whether it is a constraint to future development of the technology.

In addition to the summary highlights provided below, see also *Section 4* which maps regulatory issues in Tables and provides an overall comparison of the issues for the different countries studied here.

1.2 HIGHLIGHTS OF THE REPORT

A clear forward momentum for developing CCS has been identified in this review, although it is important to note that policy and regulatory aspects of CCS are still at a comparatively early stage.

1.2.1 At the international level

Two major efforts have emerged from the international scene. The *IPCC Special Report on Capture and Storage* is underway (lead authors have started to work in teams and finished a "zero-order" or first draft at the end of 2003).

The US Departments of Energy and State hosted an inaugural international meeting for a new multi-lateral *Carbon Sequestration Leadership Forum*, 23-25 June 2003. This initiative aims to improve CCS technologies by coordinating research and development with international partners and industry.
The key international regulations likely to apply to CO_2 capture and storage are the 1972 London Dumping Convention, its 1996 Protocol and the OSPAR Convention. In addition, the EU Water Framework Directive and the EU Emissions Trading Scheme's Linking Directive also have the potential to affect the development of CCS.

This report covers countries and regions of significance to the CCP: the EU (in particular Denmark, The Netherlands, Italy, Germany and the UK); Norway; USA; Canada; Australia and China.

1.2.2 Policies and regulations

Several important developments have occurred in the countries reviewed in this study. The main developments in 2003 concerning CCS are summarised below.

In Denmark, the government officials interviewed believe that the Danish Subsoil Act and the Offshore Installations Act will be extended to cover CCS offshore; CO_2 storage on land will encounter more difficulties as there is a very high pressure to protect the groundwater in Denmark.

The issue of CCS is currently a burning topic in Germany: whereas the Federal Ministry of Environment expressed its fundamental opposition to the use of the technology in 2002, the Federal Ministry of Economics and Labour accepts that the German economy will be based on fossil fuel energy in the foreseeable future and sees the need for CCS.

This policy review highlights the fact that the Italian oil & gas industry has developed a significant focus on refinery and hydrocarbons processing R&D, including CCS technologies.

In the Netherlands, a new Electricity Act came into force on the 1st July 2003. The Act suggests that a tax exemption worth approximately €25-40 M in the first year and increasing every year by between €25-30 M will be established to support renewables, energy efficiency and climate neutral electricity, including CCS.

The UK White Paper on Energy Policy published in March 2003 recognises the need for investing in CCS. Also, the UK CO_2 Capture and Storage Feasibility Study Advisory Group has published its first study (September 2003). This paper is a significant step for CCS in the UK: it includes recommendations for the long-term implementation of the technology in the UK.

In Canada, on May 16 2003, Alberta announced a new royalty program to promote the development of a CO2 enhanced oil / gas recovery industry in Alberta. The Minister of Alberta Energy has announced a maximum of US$ 10 M is being provided over five years in the form of royalty credits to offset up to 30 per cent of companies' approved costs in approved CO_2 projects.

Interest in geosequestration in Australia is growing: the Australian Prime Minister recently stated: *"the production of electricity using coal gasification and sequestration of CO_2 in geological structures appears to offer the best chance of large scale GHG mitigation"*.

In general, at a domestic level, regulations developed for protection of aquifers and development of oil and gas and mining facilities apply to CCS development. The relevance of these existing regulations to CCS has been studied (e.g. Netherlands, Denmark) but is only starting to be applied to CCS. The classification of CO_2 storage is likely to be an issue: if CO_2 is treated as a waste, it may trigger various waste regulations and make storage in freshwater aquifer zones difficult.

1.2.3 Financial incentives and disincentives

The study also looks at which countries have existing or expected financial incentives, disincentives, program, funding, pilot or demonstration projects.

In terms of financial incentives in the EU, we identified that €25 M will be added to the current EU budget (€30M to date) by the end of 2003, for three or four additional projects on CCS.

In it's *"Proposal for a Climate Strategy for Denmark"*, the Danish government gave a cap of €13 / tCO_2 for initiatives that reduce GHG emissions (establishing that the cost of CCS implementation is between €6.7 and €35 / tCO_2). The proposal also lists CCS as one of the "*initiatives with large potential*".

In Germany, CCS is part of the concept COORETEC that was officially started on 3rd June 2003. The concept will receive €15 M per year from the Government and €15 M per year from industry (there is insufficient information to determine how much of this funding will be allocated to CCS). In addition to the national research activities, German companies and research institutes are very active in sending proposals to the European Commission. One of these, the CO_2 SINK project, has been accepted and is expected to have significant implications on the German Ministries' discussions on the subject.

In Italy, CCS is one of the main R&D activities in terms of the priority theme "*New Technologies for Energy Generation and Management*", in the context of the Public National Plan for Research. A test plant for R&D activities on hydrogen and clean fuels from Sulcis coal is currently being built in South East Sardinia (it will cost €12 M over 5 years and will start in 2003).

The Dutch government program covering CCS is The Clean Fossil Fuel Program. Together with the EU and funds from Industry, it has funded the NASCENT, SACS, GETSCO and CRUST projects.

In 2003, the Norwegian Government provided a total of €4.9 M towards CCS. The National Budget Proposal has been disclosed for negotiation on the 8th October 2003[1]; it was subject to a process of discussion between the Parliament and the Norwegian Committee on Finance, with the final National budget to

[1] A review (in English) of the Norwegian National Buget Proposal can be found on: http://www.statsbudsjett.no/2004/english.asp

be presented on 16th December 2003. The Ministry of Petroleum and Energy has been (€2.4 M in 2003) and will be providing research money towards CCS, although it is still uncertain how much money will eventually be provided in 2004.

The US budget for FY 2004 has been agreed upon. It includes funding of $62 million (an increase of $18 million over FY 2003) to the capture and disposal of CO2 emissions. This covers the funding of R&D and demonstration projects. Of the $62 million, the Focus Area for Carbon Sequestration Science will see a slight decrease from the FY2003 budget, from $7,425,000 to $6,930,000. Existing and expected pilot and demonstration projects in the US are continuing to develop and emerge.

This year, Natural Resources Canada has developed an Incentives Programme aiming to fund new CCS demonstration projects. Funding will be available from 1st April 2004. In addition to this, a lot of work is going on in Canada in terms of activity coordination.

The Australian Budget of 13 May 2003 allocated US € 6.5M ($7.7M) new funding over 4 years to identify specific sites and implement demonstration projects for geosequestration, through a special Cooperative Research Centre for Carbon Dioxide (CO_2CRC) under the Department of Industry, Science and Resources.

1.2.4 NGO opinion and public awareness

One of the main changes since the survey in 2002 is the fact that some NGOs have developed a more knowledgeable opinion on CCS and realise that a transition phase is needed before renewable energy could become the dominant energy form (e.g. Norwegian Bellona Foundation).

Public awareness of CCS technology is still low and it is as yet unclear whether CO_2 storage will be perceived as risky. In some places (e.g. UK, California, Denmark) CO_2 storage may face similar difficulties in obtaining planning permission that cogeneration plant, waste incinerators and renewables have faced.

2 INTRODUCTION

2.1 BACKGROUND

CO_2 capture and storage (CCS) has been in operation at the Sleipner field offshore Norway since 1996, and use of CO_2 injection for enhanced oil recovery has been used for many years in USA. However, the CCS technology and conditions for its safe operation as a means to mitigate climate change is at a relatively early stage, and a number of uncertainties still exist.

The CO_2 Capture Project team commissioned ERM to carry out an inventory and review of government and institutional policies and incentives influencing the development of policy in CO_2 capture and geological storage. The first ERM review was completed in January 2003 and identified a number of key issues of interest to the CCP. The current report is an update of the January 2003 study. In particular, it is meant to analyze the key issues identified by the first study and provide an analysis of the regulatory issues identified in 2002 and 2003.

2.2 OBJECTIVE AND SCOPE

The Objectives of this report are:

- to determine the fiscal incentives and disincentives for R&D, pilot, and demonstration projects in relation to CO_2 capture and geological storage;
- to describe the policies and regulatory context, in selected countries, influencing the acceptance or rejection of CO_2 capture and geological storage;
- to analyse the implications of the key issues identified in 2002 for CO_2 capture and geological storage in more depth. These include CO_2 capture and storage positions with respect to international treaties and EU regulations and directives.
- to map regulatory issues and compare them between countries.

This paper is intended to aid members of the CO_2 Capture Project (CCP) to understand the implications of current and future policies in the EU[1], Canada, and the US, for the future development of CO_2 capture and geological storage technologies.

[1] Including the Netherlands, Italy, Germany, the UK, Norway, and Denmark

2.3 *APPROACH*

The work on this study has been carried out through a combination of document research and review, e-mail exchange of information, telephone and face-to-face personal interviews.

In preparing this report, ERM has carried out interviews with representatives of governmental agencies and non-governmental organisations, and those involved in R&D and demonstration projects for CO_2 capture and storage. While the focus has been on understanding the current regulatory context and fiscal incentives for development of the technology, a critical element has also been to understand the potential barriers to development. These could include both specific regulations and taxes which would discourage CO_2 capture and storage and, potentially, the absence of a specific regulatory framework which can create uncertainty and act as a barrier to investment.

In conducting the research, particular emphasis has been placed on those countries where most has happened or is happening on the subject, or where the implications are greater because of their size or their relevance to CCP.

This final report incorporates (still relevant) findings presented in ERM's prior report of January 2003, as well as developments that have occurred since (throughout 2003). The preliminary results of this study were presented at the IPIECA workshop on Carbon Dioxide Capture and Geological Storage, 21-22 October 2003[1]; and at the Massachusetts Institute of Technology, 6-7 November 2003.

2.4 *STRUCTURE OF THE REPORT*

Section 2 includes a review of current international activities on CO_2 capture and geological storage; relevant international treaties (UNFCCC; the Kyoto Protocol; UNCLOS; OSPAR; the London Convention) and the EU Water Framework Directive. It also provides an overview of the main findings on national-level policies and regulations which may influence CO_2 capture and geological storage technologies. *Section 3* is an overview of the main findings on fiscal incentives for R& D, pilot and demonstration projects. *Section 4* Maps regulatory issues in Tables, and provides a comparison of the issues recorded for the different countries studied here. *Section 5* summarises the major findings and implications for CCP.

A country-by-country review of ERM's findings is presented in *Annex A*. A review of NGO reactions to the issue is presented in *Annex B*. A copy of the questionnaire used to interview government officials in this review is

[1] The outcomes of this workshop are included throughout this report. All presentations given at the workshop are available on www.ipieca.org

provided in *Annex C*. Finally, *Annex D* includes documents useful to the CCP team, such as new policies and regulations, white papers, existing regulations which might be extended to include CO_2 capture and storage, etc.

Table 2.1 provides a list of acronyms used in this report.

Table 2.1 Acronyms used in this report

	Definition
AAU	Assigned Amount Unit under Annex B of the Kyoto Protocol
CDM	Clean Development Mechanism (Article 12 of the Kyoto Protocol)
CER	Certified Emission Reduction (Article 12 of the Kyoto Protocol)
CCS	CO_2 capture and geological storage
ERU	Emission Reduction Unit (Article 6 of the Kyoto Protocol)
JI	Joint Implementation (Article 6 of the Kyoto Protocol)
LULUCF	Land Use, Land Use Change and Forestry (under the Kyoto Protocol)
NIMBY	'Not In My Backyard': opposition to a development due to its perceptions of risk as a result of its proximity. This is particularly current in the UK, which has a high population density.

3 POLICY AND REGULATORY CONTEXT: HIGHLIGHTS

3.1 INTRODUCTION

CO_2 capture and geological storage (CCS) is a technology at a relatively early stage of development. A number of uncertainties still exist about different techniques. These are currently being researched by CCP.

A regulatory framework for CO_2 capture and geological storage is slowly emerging, in parallel to R&D, pilot and demonstration projects. The regulatory uncertainty around CCS is seen as a barrier to its development; however, it is also widely recognised that a regulatory framework will emerge as the technology develops and pilot projects are implemented.

At the international level, the relevant multilateral environmental agreements provide the basis for any assessment of the legal position. This section reviews the position of CO_2 capture and geological storage with respect to the UNFCCC, the Kyoto Protocol, the UN Convention on Law of the Sea, the London Convention and OSPAR. Other international level activities are also described here.

At a national and EU-wide level, the key issues for determining how supportive the regulatory environment is for CO_2 capture and storage appear to be: whether it is considered an integral part of a national climate change strategy (and eligible under associated fiscal instruments) and how it is classified for permitting purposes.

So far, government policy and regulators appear to be broadly supportive, but positions vary according to the relative significance of the oil and gas sector, climate change mitigation commitments and public attitudes (to risk and new development) in each country. Attitudes of informed Non-Governmental Organisations (NGOs) and the general public may be key in determining the future operating environment for the technology. This section therefore summarises:

- The international regulatory context;
- Federal and state government attitudes and policies to CO2 capture and storage;
- Regulatory frameworks for pilot programmes and commercialisation of the technology; and
- Public attitudes and stated positions of NGOs.

Box 3.1 summarises the key issues and barriers to the development of CO_2 capture and geological storage paused by policies and regulations.

Box 3.1 Key issues and barriers posed by policies and regulations

No country has yet fully developed strategies for the role of CO_2 capture and storage in their overall energy or climate change strategies. In most countries, the lack of regulatory framework would be expected to serve as a barrier to the application of CO_2 capture and storage. However, this lack of specific regulations was not seen by the officials interviewed to present a serious obstacle to the development of the technologies involved.

Indeed, most policy makers interviewed considered that the regulatory framework will evolve in a generally positive manner, through cooperation between government and industry as the number of demonstration and commercial projects increases.

Determining whether CO_2 will be considered (and regulated) as waste is one of the main issues to be resolved. If CO_2 is considered as waste, laws on discharge of effluents to groundwater are particularly strict (in order to protect the integrity of freshwater aquifers) which could make it difficult to obtain permits for storage of CO_2 in aquifer zones, while geological storage in oil and gas reservoirs not located in aquifer zones could be considered more favourably.
Governments have clearly not given full attention to this technology at the *political* level. The government officials interviewed for the purpose of this study were those in charge of this issue. The senior level officials with overall responsibility for climate change typically had little or no knowledge of the issue. Whether this lack of attention at more senior levels poses a barrier to the development of the technologies involved, or is simply a matter of sharing more information with senior officials, remains to be determined.

3.2 INTERNATIONAL AND REGIONAL POLICY CONTEXT

3.2.1 International Conventions and Agreements

This section provides an overview of the main issues linked to CO_2 capture and storage in key international regulations.

UNFCCC and Kyoto Protocol

The United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol both anticipate the practice of carbon sequestration:

"Parties to the Convention are obliged to promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases (…) including (…) oceans, as well as other terrestrial, coastal and marine ecosystems" (Article 4.1 (d), UNFCCC).

"The protocol requires its Parties to implement and/or further elaborate policies and measures such as research on, and promotion, development and increased use of (…) carbon dioxide sequestration technologies" (Article 2.1 (a) (iv), Kyoto Protocol).

CO_2 capture and storage is not currently covered by the Kyoto mechanisms (i.e. Emissions Trading, Joint Implementation and the Clean Development Mechanism). Our survey reflects that this is all very new. It is not high on the agenda of regulators considering the use of Emissions Trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI). Several of the government officials interviewed considered that, in the future, CO_2 stored in

geologic formations should be eligible for carbon credits under emissions trading, and for compliance in a domestic GHG regime. However, it is not clear if that will happen. However, the Marrakesh Accords to the UNFCCC and Kyoto Protocol, which were signed at COP 7, 2001 state:

"Encourages nations to cooperate in the development, diffusion and transfer of less greenhouse gas-emitting advanced fossil-fuel technologies, and/or technologies relating to fossil fuels, that capture and store greenhouse gases, and requests advanced industrialized nations to facilitate the participation of the least developed countries and other developing countries in this effort"

Additionally, the Delhi Declaration, which was signed at COP 8, 2002 includes the following paragraph, which may be applicable to CO_2 capture and storage:

"International cooperation should be promoted in developing and disseminating innovative technologies in respect of key sectors of development, particularly energy, and of investment in this regard, including through private sector involvement and market-orientated approaches, as well as supportive public policies"

The UNFCCC's ninth meeting of the Conference of Parties took place between the 1st and 12th December 2003. A pre-session of the UNFCCC discussions was carried out on Friday 28th November: Statoil and a few other industry representatives were asked to present studies on CO_2 capture and geological storage. Following the industry contributions, a discussion between UNFCCC and IPCC representatives was carried out: this discussion did not result in official decisions; however, delegates agreed that the UNFCCC and the IPCC will need to work further on this topic.

EU Emissions Trading Scheme and its Linking Directive

Most interviewees abstained from giving an opinion on the issue of whether CO_2 capture and geological storage will be compliant with the EU implementation of the Kyoto mechanisms. In the Netherlands, the Ministry believes that CO_2 capture and storage should be eligible for trading at the EU level and internationally, and that without this the technology will not become fully viable. In all the countries reviewed, the international treatment of CO_2 capture in relation to the Kyoto mechanisms is recognised as a key issue.

In the UK, no decision has yet been made on how CO_2 capture and storage will be treated under the Climate Change Levy and broader Emission Trading Scheme, although the UK government is generally quite favourable to CCS.

The European Commission's DG Environment is currently developing implementation guidelines for monitoring and reporting requirements under the EU Emissions Trading Directive. These guidelines will include a paragraph specific to CO_2 capture and geological storage. It is expected that the use of CO_2 capture and geological storage will be accepted by the guidelines to the EU ETS. This conclusion has been made following a number of informal discussions with members of the UK DTI and DEFRA. The EC DG Environment was also contacted on this subject, but no formal statement could be made on this issue at this stage, pending release of these guidelines.

It is interesting to note that European interviewees for this report did not stress monitoring and verification issues, even though reliable monitoring and reporting of carbon captured, transported and stored is likely to be very important to the technical operation, crediting and public acceptance of the practice. The inference is, therefore, that monitoring and reporting issues are not seen to pose significant barriers, even though details remain to be decided.

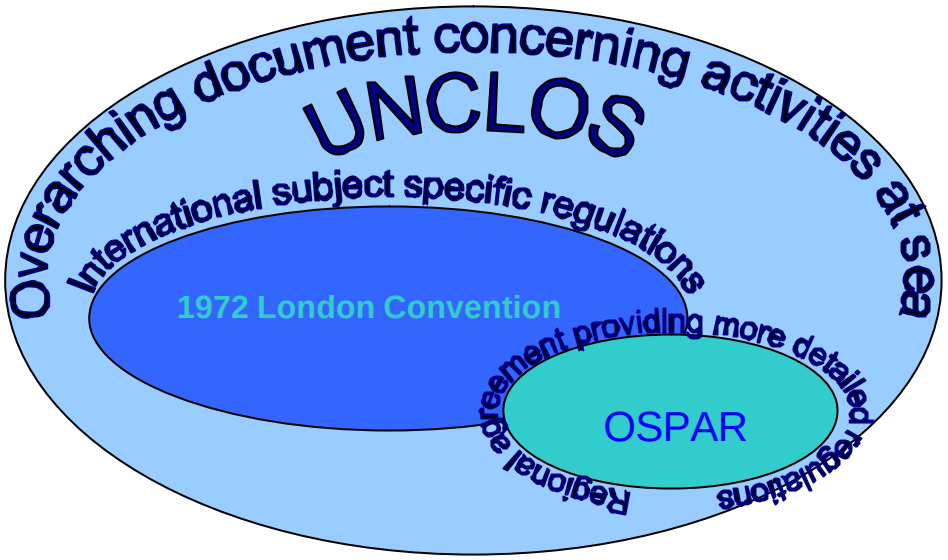
This issue was raised at the October 2003 IPIECA workshop: views were expressed on the importance of developing a Monitoring and Registration framework (the similarity with long term storage of nuclear waste was mentioned). It was suggested that there is not enough scientific knowledge on CO_2 capture and storage, leakage and geology of the sites to develop a guideline on Monitoring and Registration at this stage. For instance, some leakage is inevitable, so criteria for how much leakage is acceptable need to be developed. As for the issue of who will be required to pay for the Monitoring and Registration, the IPIECA participants expressed the view that it is important to concentrate on the development of the guidelines as a first step.

In its recent Linking Directive (which allows certain carbon reduction credits from outside the EU to be converted into EU Allowances under the EU ETS), the EU means to exclude (or limit) LULUCF, not CO_2 Capture and Storage, when they refer to the treatment of tonnes from carbon sequestration under the EU Emissions Trading Scheme. The fact that the EU Linking Directive leaves open the consideration of CCS as a source of recognised carbon credits is encouraging, but not conclusive. No special requirements have been placed on CCS projects in the CDM, thus suggesting that criteria for evaluating CCS projects in the CDM will be the regular ones that apply to all CDM projects.

United Nations Convention on the Law of the Sea, the 1972 London Dumping Convention, its 1996 Protocol and the OSPAR Convention

The United Nations Convention on the Law of the Sea (UNCLOS) is the most significant international marine convention. It is an international framework document concerning activities at sea. UNCLOS relies on other marine treaties (subject specific and regional treaties, agreed upon by UNCLOS State Parties) to provide more detailed regulations. In other words, UNCLOS is an overarching convention, which leaves precise rules to be elaborated in other more specific international conventions. In the case of marine pollution, these rules are contained in the London Convention 1972 and the 1996 Protocol to the London Convention. In turns, both of these anticipate the creation of regional agreements to further their objectives: the most relevant regional agreement to this study is the OSPAR Convention, which is applicable to the North Sea. Figure 3.1 illustrates the interactions between these Conventions.

Figure 3.1 Interactions between marine Conventions



Source: ERM, 2004

UNCLOS is not directly relevant to CO_2 capture and geological storage. Instead, it needs to be viewed in light of its subject and region-specific conventions.

Box 3.2 provides an overview of three multilateral environmental agreements with potential relevance to CO_2 capture and geological storage: OSPAR, the 1972 London Convention and its 1996 Protocol.

Box 3.2 Summary of the London and OSPAR Conventions

The London (Dumping) Convention

The 1972 international Convention makes provisions for wastes that can be dumped at sea. The new 'Guidelines for the assessment of wastes and other matter that may be considered for dumping', adopted in 2000, provide specific guidance for specific classes of wastes, including offshore platforms. The Convention deals with the dumping of industrial waste, sewage sludge, dredged material, incineration at sea, radioactive materials, and other wastes. It administers a black-list containing substances, the dumping of which is prohibited and a grey-list containing substances the dumping of which is only permitted under strict control and provided certain conditions are met. There are 80 parties to the Convention. As with other international conventions, responsibility for enforcement lies within individual states.

The London Protocol

The London Protocol of 1996 is designed to be a successor of the London Convention. When it enters into force, it will be binding on those London Contracting parties that are also Parties to it.

The OSPAR Convention

This international convention governs marine disposal in the North East Atlantic (from the Arctic to Gibraltar and from the East coast of Greenland to the west coast of continental Europe). It came into force in 1992 and replaces the 1972 Oslo Convention on dumping from ships and the 1974 Paris Convention on discharges from land. The Convention deals with the specific areas of prevention and elimination of pollution from land-based sources (especially toxic substances; by dumping or incineration and from offshore sources, and assessment of the quality of the marine environment. Since 1998 and following the Brent Spar affair, any disposal at sea of offshore structure is no longer permitted. Currently, the main working issues are (a) the protection and conservation of ecosystems and biological diversity; (b) hazardous substances; (c) radioactive substances; (d) eutrophication. Similar Conventions govern other seas, such as BARCOM for the Mediterranean and HELCOM for the Baltic sea.

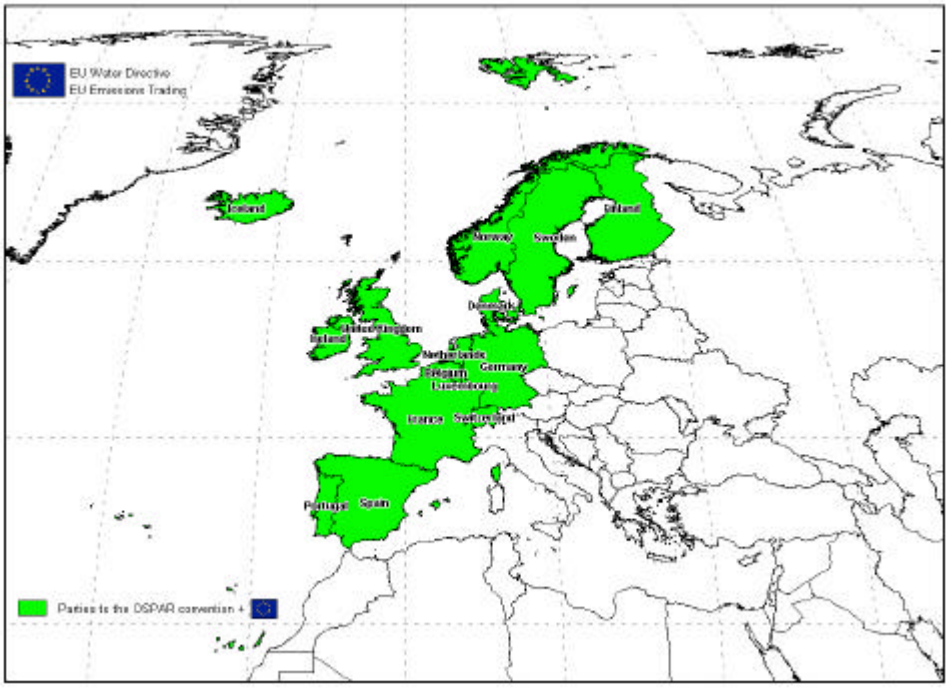
Sources: http://www.londonconvention.org; http://www.ospar.org/

OSPAR

The OSPAR commission is divided into 5 sub-committees (hazardous waste, eutrophication, offshore oil and gas industry, radioactive substances and biodiversity) and a general committee dealing with assessment monitoring and verification. The sub-committee on biodiversity includes a branch dealing with human impacts on the environment: in a first step, the discussions on CO_2 capture and storage will be dealt with under this branch.

Figure 3.2 illustrates the extent of geographical coverage of the OSPAR convention.

Figure 3.2 Parties to the OSPAR Convention



OSPAR held a ministerial meeting on the 25 and 26 June 2003, in Bremen, Germany. The outcome of the meeting consists of 5 recommendations (e.g. dispersal of mercury from crematoria). ERM interviewed officials from the UK Department for Environments, Food and Rural Affairs (DEFRA), Marine and Water Division, for an analysis of the outcomes of the OSPAR ministerial meeting. The executive secretary of the OSPAR commission was also contacted.

The Group of Jurists and Linguists (JL) were asked to provide preliminary views on the compatibility of CO_2 capture and storage with the OSPAR Convention. However, no agreement on the legal position for CO_2 capture and storage was reached in Bremen. The main issues raised in the draft report of the JL are summarised in *Box 2.3*: it is important to note that this report is not in the public domain. The report was scheduled to be finalised and publicly available by November 2003. However, the OSPAR secretariat is still working on the final report and it is now thought that the report will be made available in February 2004, in time for the forthcoming meeting of the OSPAR Biodiversity committee. The results of the final JL report should feed into the next OSPAR committee meeting which will take place in early July 2004. Still, the role of interpreting the Convention is down to individual contracting parties. Also, where CO_2 capture and storage will be allowed under OSPAR, the Convention still states that it is only allowed if it is regulated and controlled, so as to stay within the aims of the Convention to protect the natural environment.

Box 3.3 Placement of Carbon Dioxide in the OSPAR Maritime Area: some questions identified by the Group of Jurists and Linguists as needing further consideration.

The *propositions* of the JL are still *under discussion*. In summary, the main issues tackled by the JL are:

- **The maritime area**: the JL raised a question as to whether, under the OSPAR convention, there will be a distinction between pumping CO_2 in the sea or in the sea bed. In the case of offshore oil and gas and land based sources, it could be very relevant as to the placement in the sea or in the sea bed. The distinction may prove to be less relevant in the case of dumping from ships and aircrafts.
- **Possible methods and purposes of placement:** three separate regimes for CO_2 storage were identified under OSPAR. These are from land based sources; dumping from ships and aircrafts; and offshore oil and gas installations. The purpose of placement of CO_2 will be relevant to whether CO_2 storage is consistent with the convention.
- **Considerations relating to land based sources**: the transport of CO_2 from a land based source, by pipeline could be allowed, although this is not stated in the convention, which states that discharges into sea or sea bed[1] should be subject to regulations preventing the discharges to harm the environment. CO_2 is regulated under the same provisions as the discharge of sewage into the sea. Consequently, as long as it can not be proven that the placement of CO_2 by pipeline from a land base source has adverse effects on the environment, this should be permitted under the Convention.
- **Considerations relating to the dumping from vessels**: shipment of CO_2 for placement from a vessel will be described as deliberate disposal of CO_2 and prohibited, unless it is clearly done for the purpose of a scientific experiment.
- **Considerations relating to offshore installations**: two options would be acceptable under OSPAR. There is no doubt that EOR is legal under the Convention: whereas this is not stated as such in the Convention, the Convention says nothing about the means used for production purposes, except for the most general terms of causing harm to the environment (i.e. if there is no evidence that CO_2 used for production purposes harms the environment, it will be allowed). Similarly, immediate injection of CO_2 which was emitted on site only appears to be consistent with the Convention, provided that there is no evidence that this will harm the marine environment.

Source: personal communications, DEFRA Marine and Water division, OSPAR secretariat.

The UK Department for Environment, Food and Rural Affairs (DEFRA) and the Department for Trade and Industry (DTI) have been holding a workshop aiming to promote a discussion between representatives of OSPAR Contracting Parties on the issues for the marine environment, in order to begin to develop the UK's policy on the regulation of this activity and in order to help OSPAR to decide what work, if any, it needs to do on this subject. A report of the proceedings has been presented at the recent meeting of the OSPAR sub-committee on Human Impacts on the Marine Environment on the 25th November 2003.

Whereas some parties stated that OSPAR should not be considering the issue of legality of CO_2 capture and storage under the Convention at this early stage of the use of the technology, others argue that it is essential to establish a clear legal framework before the technology becomes widespread. In this frame of mind, the UK Government (DEFRA) organised a seminar in October 2003,

[1] In the JL draft report, the seabed includes everything below the seabed as well (i.e. extending far below the mere seabed). Consequently, this applies to operations taking place 1000 m or more under the sea bed.

inviting other Parties to OSPAR to discuss what needs to be done by OSPAR on the issue of CO_2 capture and storage. The outcome of this seminar was reported to the OSPAR at the last Environmental Impacts of Human Activities Working Group meeting (25th November). The OSPAR Working Group has published the meeting's outcome: this document is available on the OSPAR website (only to members of OSPAR). A draft copy of the outcomes of this workshop is included in *Annex D*.

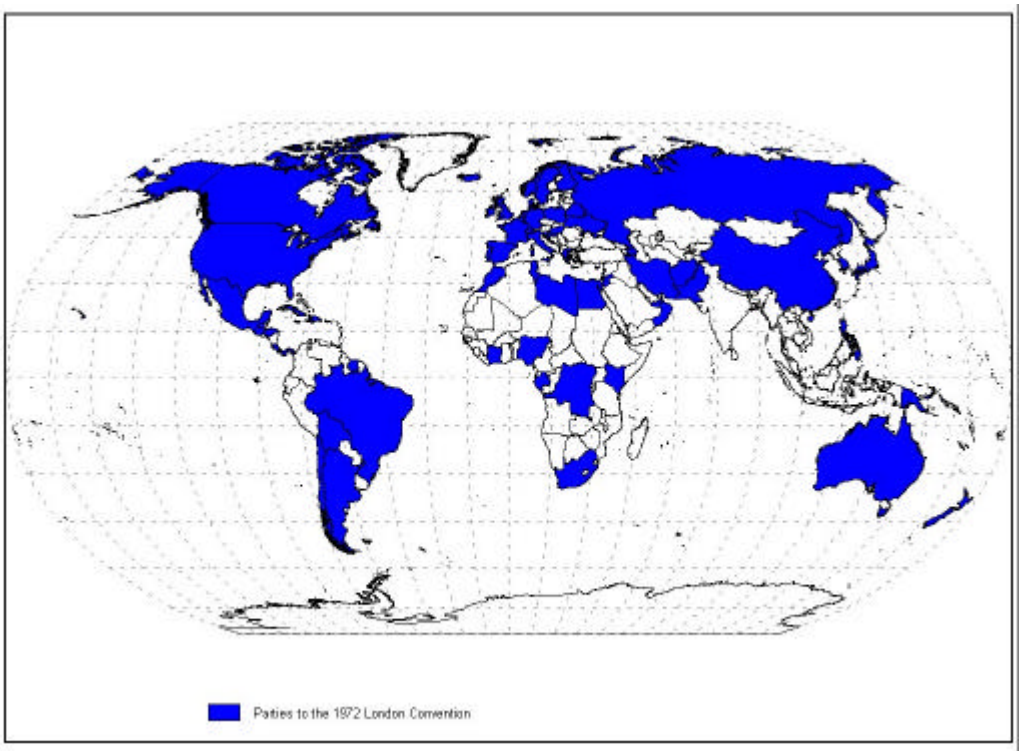
In sum, there is still a fundamental lack of clarity as to the applicability of OSPAR to offshore CO_2 storage. If OSPAR is applicable, then some experts believe it might suggest offshore storage is inconsistent with the Convention, hence creating a potentially significant barrier to offshore carbon storage.

Until such clarifications have been received and agreed by the necessary parties to OSPAR, it must be said that OSPAR represents a potential barrier to offshore geologic sequestration of CO_2. In the absence of clarity and consensus on OSPAR in this context, opponents to offshore geologic sequestration of CO_2 can easily refer to OSPAR as supporting their case against the option.

The London Convention and the London Protocol

Figure 3.3 illustrates the geographical coverage of the London Convention.

Figure 3.3 Parties to the London Convention



The 1996 Protocol to the London Convention covers a wider geographic area than OSPAR (EU), and requires some more thought on the subject: it will be long before an agreement can be reached at that level. The issue of dumping is

central to the way CO_2 storage will be dealt with under the London Convention and its Protocol.

The London convention defines dumping as: *"Any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea, but not placement for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of the Convention"* (Article III.1, London Convention).

The main issues of interpretation of the London Convention with respect to "dumping":

- the Convention does not define where "disposal" is made. It only refers to pollution of the marine environment by dumping (Article 1.1(4)(5), Article 210). Therefore, it can be argued that "disposal" is made either in the water column or in the seabed and its subsoil.
- there may be an argument as to whether "storage" is equivalent to "disposal". Depends on the period of storage, or the dispersal rate, of the CO_2; "storage" suggests a temporary activity with a further ultimate use for the recovered CO_2, whilst "disposal" is suggestive of something more permanent.[1] CO_2 might fall under the '*industrial waste*' category in the list of wastes prohibited for disposal under the London Convention: if it is not classed as industrial waste, CO_2 disposal will not be prohibited.

The discussions around the relevance of the London Convention to CO_2 capture and storage have begun, however, whereas the issues mentioned above are being identified and analysed, it will be long before an international agreement is reached on the interpretation of the London Convention and its Protocol with respect to CO_2 capture and geological storage.

In Conclusion

Three factors are relevant to the interpretation and application of multilateral environmental agreements (i.e. treaties) to CO_2 capture and geological storage:

- Whether the captured CO_2 is being stored or is, in effect, being disposed of;
- Whether the CO_2 is being placed in the water column or in the seabed and its subsoil as part of a scientific experiment as a prelude to CO_2 capture and storage or as part of the CO_2 capture and storage process;
- Whether the CO_2 contains impurities resulting from the capture stage (e.g. H_2S).[2]

[1]Jolyon Thompson, CO_2 Capture and Storage: the position under international treaties, Presentation at IPIECA workshop, October 2003.

[2] Jolyon Thompson, CO_2 Capture and Storage: the position under international treaties, Presentation at IPIECA workshop, October 2003.

These issues are dealt with at different levels under UNCLOS, the 1972 London Dumping Convention and its 1996 Protocol and the OSPAR convention.

A key legal question is whether captured CO_2 is being stored or is, in effect, being disposed of (i.e. whether CO_2 is a *waste*, and whether it is being *dumped*). Marine conventions either list all the wastes that are prohibited for disposal (London Convention), or have a general prohibition on the dumping of all wastes except those listed (1996 Protocol, OSPAR Convention).

It is clear that CO_2 would probably not fall under the categories approved for dumping in the 1996 Protocol or OSPAR Convention, and could therefore be considered as waste. In addition, the definition of "dumping" is a decisive factor in determining whether CO_2 storage is covered in the conventions. "Dumping" is defined in all the marine conventions as disposal, which is left undefined, but is often interpreted as the action of permanently getting rid of a substance.

3.2.2 The EU Water Framework Directive

The people who were interviewed include Peter Horrocks, DG Environment, Climate Change and Helmut Blöch, DG Environment, Water.

3.2.3 Aim of the directive

The aim of the EU Water Framework Directive is to 'maintain and improve the aquatic environment in the Community'. With this in mind, the Directive has two main objectives:

- To achieve and maintain water quality ('good status') by the deadline of 2015;
- To ensure that the quality of all ground and surface water does not deteriorate below present status.

In addition, the purpose of the Directive is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:

- Prevents further deterioration;
- Promotes sustainable water use;
- Aims at enhanced protection and improvement of the aquatic environment, inter alia, through specific measures;
- Ensures the progressive reduction of pollution of;
- Groundwater and prevents its further pollution, and
- Contributes to mitigating the effects of floods and droughts.

The above purposes need to contribute to the following:

- The provision of the sufficient supply of good quality surface water and groundwater;

- A significant reduction in pollution of groundwater;
- The protection of territorial and marine waters, and
- Achieving the objectives of relevant international agreements, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances.

3.2.4 Stage of implementation

The next stages towards the implementation of the Directive are the designation of the outer boundaries of river basins (due by December 2003), the first environmental analysis of pressures and impacts on all waters and the first economic analysis of water use (both due by December 2004), and the formal transposition of the Directive into National legislation. Work is on track to transpose the Directive into National legislation e.g. in Scotland this has already been done.

According to Mr Blöch, the implementation of the Directive is the subject of unprecedented cooperation of European Commission, Member States including new ones and stakeholders.

3.2.5 CO_2 capture and storage

The Directive defines a pollutant as:

> *"the direct or indirect introduction, as a result of human activity, of substances or heat into the air, water or land which may be harmful to human health or the quality of aquatic ecosystems or terrestrial ecosystems directly depending on aquatic ecosystems which result in damage to material property, or which impair or interfere with amenities and other legitimate uses of the environment."*

The list of possible pollutants is listed in Annex VIII of the Directive, and CO_2 is not on the list. In addition to the list of pollutants, there is a list of dangerous substances ('priority substances') and CO_2 is not included in that list either.

The Directive does not specifically mention CO_2 capture and storage, however it addresses all impacts on waters. This is the area that could cover CO_2 capture and storage (if it involves storage in aquifer zones regulated under the Directive).

Another area that could cover CO_2 capture and storage is that one of the purposes of the Directive is to prevent any significant and sustained upward trend in the concentration of any pollutant in groundwater should be identified and reversed. According to Mr. Blöch, CO_2 has the potential to change the chemistry of groundwater if it is in contact with it. It has the potential to dissolve substances thus the provisions of Article 11 of the Directive apply.

These provisions, amongst other things, prevent the discharge of pollutants into the groundwater. Mr. Horrocks mentioned a specific example of CO_2 affecting groundwater, which is through affecting the pH, and indirectly – via a changed pH – on the solubility of substances in affected waters. Authorities are going to have to decide case by case whether the CO_2 is 'polluting' the groundwater or not. This will be dependent on the method of CO_2 storage, the technology used, the hydrology and geology of the surrounding area etc. Permits would then be granted, or not granted by the relevant authority. However, as CO_2 will be stored in large quantities, in most cases it will influence groundwater pH. For this reason, CCS is unlikely to target the use of potable groundwater reservoirs.

Transposition of the Water Directive by each Member State, as well as individual permits, is subject to scrutiny by the European Commission.

3.2.6 Key operational instruments

The key operational instrument to be developed in order to ensure the implementation of the two objectives are river basin management plans and programmes of measures; these are to be developed by 2009, under full participation of all interested and involved parties (including, inter alia, relevant industries, local communities, water suppliers, NGOs etc.) Activities and measures with a potential impact on waters will require a permit or authorisation. Beyond the Water Framework Directive as EU legislation, relevant national, regional and local legislation would remain applicable.

3.2.7 Similar regulations elsewhere

Existing regulations on pipelines, underground storage facilities and injection of gas and national legislations requiring Environmental Impact Assessments for major developments are expected to be extended to CO_2 capture and geologic storage projects.

3.2.8 Other International Activities

IPCC Special Report on Geological Carbon Storage.

The United Nations Intergovernmental Panel on Climate Change (IPCC) is currently preparing the *IPCC Special Report on Capture and Storage.* The start up meeting for this project took place in Canada, between the 19th -21st of November 2002. *Preliminary discussions with IPCC officials confirm the lack of readily available information on the subject of the policy and regulatory framework surrounding the issue. The lack of international criteria for establishing a tonne of carbon dioxide in a geological structure has been flagged as a major issue for this meeting.* The meeting resulted in a scoping paper, timetable and detailed outline for a Special Report on Carbon Capture and Storage. The Panel at its 20th session (Paris, 19-21 February 2003) decided to prepare an IPCC Special Report and approved the outline. The Special Report will cover emission sources, CO_2 capture, transport, geological and ocean storage. It will also look at the cost and market potential of the technologies and its implications for emissions inventory and accounting under the UNFCCC.

The report will be prepared by IPCC Working Group III and should be completed in the first half of 2005. The first Lead Authors Meeting was held from 2-4 July 2003 in Oslo, Norway; two more will be held in 2004. This first lead author meeting was a very early phase of the IPPC report. The outcome of this meeting was a proposed table of contents for the IPCC Special Report.

Lead authors have started to work in teams and have completed a "zero order" (or first) draft, which was discussed at an IPCC meeting in Canberra, Australia, in December 2003. Authors are now producing a first order (second) draft, which will be sent out to reviewers in March 2004. The final report is scheduled to be presented at COP 11, in November 2005.

The IEA GHG R & D programme

The IEA GHG R & D programme has published a *Review of International Conventions Having Implications for CO_2 Storage in the Ocean and Under the Sea Bed*, which it published in March 2003. The report is currently available internally, to the countries member of the IEA GHG R&D programme[1].

The report reviews the implications of the following conventions for CO_2 Capture and storage:

- The UNFCCC
- Global Conventions (e.g. UNCLOS; The London Convention; The MARPOL 73/78 Convention; International Transport Regulations; etc.).
- EU Directives (e.g. Water Framework directive; Waste Directive; Hazardous Waste Directive; Environmental Impact directive; etc.)
- Regional Conventions and agreements (e.g. OSPAR; Helsinki Convention 1992; Antarctic Treaty 1961; etc.)

A key conclusion reached by the IEA GHG R&D report on the use of CCS in the UNFCCC context was:

> *"Article 4 imposes, among other things, a responsibility for Parties to the Convention to protect and enhance sinks and reservoirs for greenhouse gases, including (Art. 4.1 (d)) ocean sinks and reservoirs. In this context, the FCCC defines "reservoir" as "a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored" and "sink" as "any process, activity or mechanisms which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere."*
>
> *This provides legitimacy to the consideration of the storage of CO_2 in the ocean, both in the oceanic hydrosphere and in subseabed strata. (…) The legitimacy of enhancing ocean sediments as a medium of CO_2 storage appears the more sound subject to confirmation from legal perspectives*."

[1] A version of this report is provided in Annex D, although it does not include the appendices of the report (containing the texts of the conventions).

Concerning conventions and agreements applicable to the storage of CO_2 under the seabed, the IEA GHG R&D report reflects the outputs of and is consistent with this CCP review.

The review of EU Directives and Policy papers also reflects the findings of this study. The report concludes:

> *"Contemporary EU Directives impose no prohibitions on the options for ocean and seabed storage of CO_2. They do, however, impose requirements that would have to be satisfied for any practical implementation of this practice within the European Union. These include the conduct of prior environmental impact assessments to ensure that effects on the environment would be limited and acceptable in a social and economic context. The one area in which current EU Directives may impose constraints on ocean and seabed storage options for CO_2 is in relation to the nature and levels of any hazardous impurities in the CO_2 sequestered from fossil fuel combustion sources".*

The Carbon Sequestration Leadership Forum

The Carbon Sequestration Leadership Forum held an inaugural meeting, hosted by the U.S. Departments of Energy and State, in Washington, 23-25th June 2003. The initiative has been designed to improve carbon capture and storage technologies through coordinated research and development with international partners and private industry.

Three types of cooperation are currently envisioned within the framework of the Forum: data gathering, information exchange, and joint projects. Data gathered from participating countries will be aggregated, summarized, and distributed to all of the Forum's participants.

Member countries will identify joint projects, with the Forum serving as a mechanism for bringing together government and private sector representatives from member countries.

The Carbon Sequestration Leadership Forum is a ministerial-level organization. The member countries are the United States, United Kingdom, Australia, Brazil, Canada, China, Colombia, India, Italy, Japan, Mexico, Russian Federation, Norway and the European Union. Current plans call for government officials to convene formally twice a year.

The aim of the Carbon Sequestration Leadership Forum (CSLF) is to provide a platform for international cooperation in R&D projects essentially on CO_2 capture and geological storage. Several projects exhibiting examples of international cooperation are already underway and were flagged as an example of what the CSLF is aiming to achieve. The CCP stress that it is of utmost importance that the authorities coordinate their efforts in OSPAR, the London Convention and other CCS initiatives as, for example, the CSLF.

One of the most notable projects is the Weyburn oil recovery project in Saskatchewan, Canada, where scientists from 18 nations are monitoring the project to determine if the carbon dioxide remains entrapped in the field. A similar monitoring effort is taking place in connection with the Sleipner Project in the North Sea off the coast of Norway.

The inauguration meeting consisted of:

- Presentations by government, the private sector and non-governmental organizations on the status of sequestration research and the technical, economic and public policy challenges that must be addressed;

- A Ministerial Roundtable discussing the Carbon Sequestration Leadership Forum and what each country hopes to achieve through its participation and;

- The organizational meeting for technical level discussions of participating countries.

The next meeting of the Carbon Sequestration Leadership Forum will be hosted by the Italian Government on 19-23 January 2004. A Ministerial level meeting of the Forum is planned for late 2004.

The websites where further background information can be obtained are: http://www.fossil.energy.gov/coal_power/cslf/cslf_factsheet.pdf; Agenda: http://www.fossil.energy.gov/events/cslf/agenda_jun2003.html; Press release: http://www.fe.doe.gov/techline/tl_cslf.shtml; Opening remarks: http://www.state.gov/g/rls/rm/2003/21916.htm.

3.3 NATIONAL POLICIES IN RELATION TO CO_2 CAPTURE AND STORAGE

This section reviews the status of development of national policies and regulations on CO_2 capture and geologic storage in the European Union, in particular in Denmark, The Netherlands, Italy, Germany, The UK; Norway; the United States; Canada; and Australia.

Table 3.1 provides an overview of the current status of development in national CO_2 capture and storage policy and regulatory framework.

Table 3.1 Overview of Existing Policies and Regulations Affecting CO_2 Capture and Geological Storage

Country	Supportive Policies or Regulations *specific* to CO_2 capture and storage	Restrictive Policies or Regulations *specific* to CO_2 capture and storage	Supportive Policies or Regulations *extended* to CO_2 capture and storage	Restricting Policies or Regulations *extended* to CO_2 capture and storage	Will lack of regulatory framework restrict CCP projects development ? (Yes/ No)	Limited awareness, Negative (-ve) or Positive (+ve) NGO actions?	Limited awareness, Negative (-ve) or Positive (+ve) public opinion?
EU	×	×	✓	✓	Yes	+ve	Limited
Denmark	×	×	✓	✓	No	-ve	Limited (potentially –ve)
Germany	×	×	×	×	Yes	-ve	-ve
Italy	×	×	×	✓	No	+ve	+ve
Netherlands	✓	×	✓	✓	No	-ve	Limited
Norway	×	×	✓	✓	No	-ve[1]	Limited
The UK	✓	×	×	✓	Yes	-ve and +ve	-ve
USA	×	×	✓	✓	Yes	Limited	Limited
Canada	✓	×	✓	✓	Yes	Limited	Limited
Australia	×	×	✓	✓	Limited	-ve	-ve
China	×	×	×	×	-	Limited	Limited

×: no existing Policies or Regulations; v: Policies or Regulations exist;

3.3.1 EU Regional Policy

The European Climate Change Programme (2001) sees CO_2 capture and storage as a medium term option for delivering CO_2 emissions reductions. Specifically, the programme states that "*adequate R&D effort is required to develop clean and efficient technologies for achieving CO_2 reduction objectives by 2010 and in the future (...) The following technologies require support: (...) CO_2 capture and sequestration towards power generation with zero CO_2 emissions*"[2]. Consequently, the ECCP tasks Working Group 2 (Energy Supply) investigating CO_2 capture and storage or reutilisation [3], and specifies as a medium term (2001-2010) R&D priority the "*development of small and large scale CO_2 capture, transport and sequestration technologies*"[4].

3.3.2 National Policies and Policy developments in EU countries

The overall context within Europe for CO_2 capture and storage projects is set by the OSPAR and London Conventions, plus the EU Environmental Impact Assessment Directive. No EU country has yet fully developed strategies for the role of CO_2 capture and storage in their overall energy or climate change

[1] The current negative NGO attitude in Norway is related to ocean disposal, rather than geological storage.

[2] European Climate Change Programme, p. 26.

[3] European Climate Change Programme, p. 39.

[4] European Climate Change Programme, p. 139

strategies, but the issue is likely to be addressed in new or revised national energy laws, White Papers and ministerial statements.

For instance, in Europe, the position is being clarified in Energy White Papers (Germany, UK, Norway, Denmark), Electricity Laws (Netherlands) and climate change strategies and white papers (Denmark, Netherlands) in relation to both the regulatory framework and the financial instruments which will apply to CO_2 capture and storage.

National and State attitudes to CO_2 capture and storage appear to vary between those with significant oil and gas production sectors and those without. Oil and gas producing countries tend to have better information and more developed regulations. In both oil and gas producers and non-producers however, Energy / Finance Ministries tend to have different views than Environmental regulatory authorities: whereas the former tend to see the technology as a potentially cost effective part of meeting Kyoto Commitments, the latter tend to have technical concerns about the technologies available.

In the Netherlands, Norway and Denmark, attitudes are broadly positive since these countries would like to continue benefiting from North Sea oil production and tax revenues while meeting Kyoto commitments. CO_2 capture is likely to be a significant element of these countries national climate change strategies. In the three countries, significant storage capacity exists in gas and oil reservoirs; in the Netherlands and Norway there is a strong knowledge base which represents an opportunity to obtain a technological lead.

The same views are prevalent in the US, Canadian and Australian oil producing states. In the USA, interviewees reported that carbon capture and storage is likely to be an important element of meeting the 'Clear Skies Act' commitments. While in Australia, recent lease negotiations for lignite extraction in the state of Victoria have specifically required successful tenderers to undertake research into geological storage of CO_2.

Of the countries reviewed, Germany was the only country where major oppositions to the development of the technology were recorded: the Federal Ministry of Environment expressed its fundamental opposition to the use of the technology in 2002; however, the Federal Ministry of Economics and Labour has a tendency to accept the fact that the German economy will be based on a fossil fuel energy in the foreseeable future, thus accepting the need for CCS.

On the other hand, in the Netherlands, the Ministry stresses that carbon capture and storage is an interim or bridging technology to an economy based on renewables, rather than a long-term solution to a fossil fuel based economy. *Box 3.4* provides an example of a positive policy framework development.

Box 3.4 A Positive Policy Framework Developing in the Netherlands

Two new laws are establishing the basic legal and fiscal framework:
The Mining Act came into force 1 Jan 2003 and establishes provisions on storage of CO_2 and other gases, enabling developers to obtain licenses for underground storage.
The Electricity Act entered into force 1 July 2003. Current drafts of the Act suggest that a tax exemption worth approximately €25-40 m in the first year and increasing every year by between €25-30 m will be established to support renewables, energy efficiency and climate neutral electricity, including CO_2 capture and storage.

A White Paper on Clean Fossil Fuels was released on 24 September by the Ministry of Economic Affairs. The White Paper recognises that developing CO_2 capture / storage is an option to be considered, to assist the transition phase from fossil fuel dependency to a renewable energy economy over the next 30 years, as more stringent CO_2 emission reductions are required..

3.3.3 Regulatory Frameworks

As mentioned in *Section 3.3.2*, the regulatory framework in Europe is set by the OSPAR and London Conventions and the Environmental Impact Assessment Directive, transposed throughout Member States into National Legislation requiring Environmental Impact Assessments for major facilities including oil and gas developments and pipelines, and, to some extent, the EU Water Framework Directive. In several countries, there are also more detailed existing regulations on injection of liquids and wastes underground which have been applied to Enhanced Oil Recovery (EOR) or underground storage of natural gas.

Europe

Throughout Europe, existing Environmental Impact Assessment regulations would apply to the capture facilities and associated pipelines and development. In a number of countries additional permitting systems also exist for oil and gas facilities and, where there is experience of natural gas storage or Enhanced Oil Recovery (EOR), this is covered by such systems.

For instance in the Netherlands, natural gas storage facilities are regulated by the Mining Act, which allows developers to obtain licenses for underground storage. Associated pipelines are also covered by EIA legislation.

In Denmark, existing petroleum laws provide the framework for permitting of pipelines, storage facilities and injection of gas. It should not be difficult for a company to obtain the necessary permits to carry out a CO_2 capture and storage project within this regulatory context.

USA

In the US, regulations have been in place since the 1980's in all oil-producing states for licensing of EOR projects under federal EPA / State Underground Injection Control (UIC) programs under the auspices of the Safe Drinking Water Act (SDWA, 1974). The same system is expected to apply to Enhanced

Gas Recovery (which is currently at the research and development stage) by the US Department of Energy (DOE).

What is not yet clear is how CO_2 capture and storage wells would be classified. Under the UIC system, Class II includes wells used to dispose of fluids associated with the production of oil and natural gas, enhanced oil recovery (using water or CO_2) and storage of liquid hydrocarbons. The other two options would be Class I (wells used to inject either hazardous or non-hazardous liquid wastes below the lowermost sources of potable ground water) which might apply to pre-production CO_2 in brine formation or Class V (miscellaneous injection wells that do not fall under Classes I to IV including geothermal wells, subsidence control wells, drainage wells, aquifer recharge etc). Class V tends to be applied to experimental procedures and it seems likely that this will also be applied to CO_2 storage until the technology is proven. For instance in a pilot project being developed by the University of Texas for CO_2 sequestration, the well is being treated as a Class V installation for permitting purposes.

The pipelines and associated development for CO_2 capture and storage will fall under the state EIA and permitting processes. In some states, such as California which has adopted standards higher than Federal EPA standards through its California Environmental Quality Act (CEQA) this is likely to mean that developments are subject to long planning delays, as other large scale energy projects such as pipelines and cogeneration plants have been in the past.

Projects undertaken in collaboration with a federal agency, such as the Department of Energy, are subject to National Environmental Policy Act (NEPA) procedures which require an Environmental Assessment involving public participation. The pilot project for CO_2 capture in Texas is currently going through NEPA procedures.

Canada

There are currently no regulations *specific* to CO_2 capture and geologic storage in Canada. At present, existing regulations are being extrapolated to include CO_2 capture and storage. For example, transportation of CO_2 by pipeline is likely to be governed by the same regulations as gas pipelines which, in the case of Alberta, are governed by the Energy Utilities Board.

Still, the Canadian Government understands the importance of developing a regulatory framework, and the fact that its absence may present an important barrier to the development of the technologies. It is currently aiming to develop a framework by working closely with industry on the subject. One of the options the Canadian government is considering is to develop CO_2 capture and geologic storage through MOUs with industry.

Australia

In Australia, the Commonwealth permitting procedures apply to offshore oil and gas activities while onshore oil fields are overseen by State governments. An environmental impact statement is required, but the stringency of the permitting procedure depends on whether surface or groundwater would be affected and whether or not CO_2 is considered as waste. Underground storage of waste which could leach and potentially cause environmental damage would be prohibited in all states. CO_2 is not currently being defined as a waste but this has not yet been clarified. The South Australia Petroleum Act is currently being amended to clarify the position on gases re-injected for both enhanced recovery and CO_2 for storage.

Key issues

The regulators interviewed agreed that a lack of regulatory framework for CO_2 capture and geologic storage does present a barrier for the development of the technologies. However, most added that this lack of specific regulations is temporary, and will not present an insurmountable obstacle to the development of the technologies involved. Indeed, most policy makers considered that the regulatory framework will evolve through cooperation between government and industry, as the number of demonstration and commercial projects increases.

However, a number of key issues do need to be resolved in most countries. The major issue under US Federal / state UIC, Australian and European legislation is whether or not CO_2 should be considered as industrial waste and, if so, whether it is hazardous or non-hazardous. In most countries, stringent laws on discharge of effluents to groundwater would make it extremely difficult to obtain permits for storage of CO_2 in freshwater aquifers while geological storage in saline aquifers and oil and gas reservoirs is likely to be considered more favourably.

3.3.4 Public Attitudes to CO_2 Capture and Storage

This section summarizes the policies and positions of key environmental NGO's and other stakeholders that may exert an influence over the future acceptance of geological storage.

In general, the level of public awareness and NGO interest in the technology appears limited so far. For instance, in the Netherlands, the Ministry of Environment reports that the general public is very pro-renewables, less keen on energy efficiency and largely unaware of CO_2 capture technologies. A research project is underway looking at how the public understand complex environmental technologies, and how they react to them.

Likewise, in Denmark, there is currently limited public awareness, but the Department of Environment consider that public opinion may become anti - CO_2 storage as commercial applications are made if they are associated with

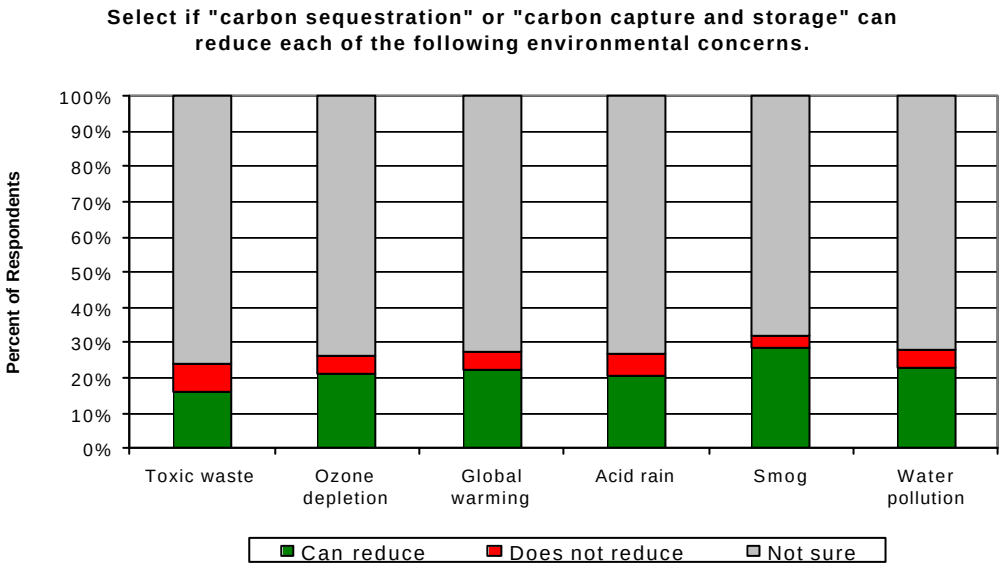
freshwater aquifer storage: in early 2002, a proposed natural gas storage facility (using a freshwater aquifer) in the south of the country was blocked as a result of public protests.

Howard Herzog and Tim Curry of the MIT Laboratory for Energy and the Environment have shared the preliminary results of an ongoing study entitled *Public Survey of Opinions on Carbon Capture and Storage* with the CCP team. The report essentially concludes that public awareness of CO_2 capture and storage technology is low to non-existent; therefore gaining public acceptance will be a very steep uphill effort. *Figures 3.4* and *3.5* present the preliminary results from the survey.

Figure 3.4 presents the preliminary results obtained from a general public survey, based on the following question:
"Please select if "carbon sequestration" or "carbon capture and storage" can reduce each of the following environmental concerns?"

	Can reduce	Does not reduce	Not sure
Toxic waste			
Ozone depletion			
Global warming			
Acid rain			
Smog			
Water pollution			

Figure 3.4 ***Public perception survey: environmental issues targeted by CCS***



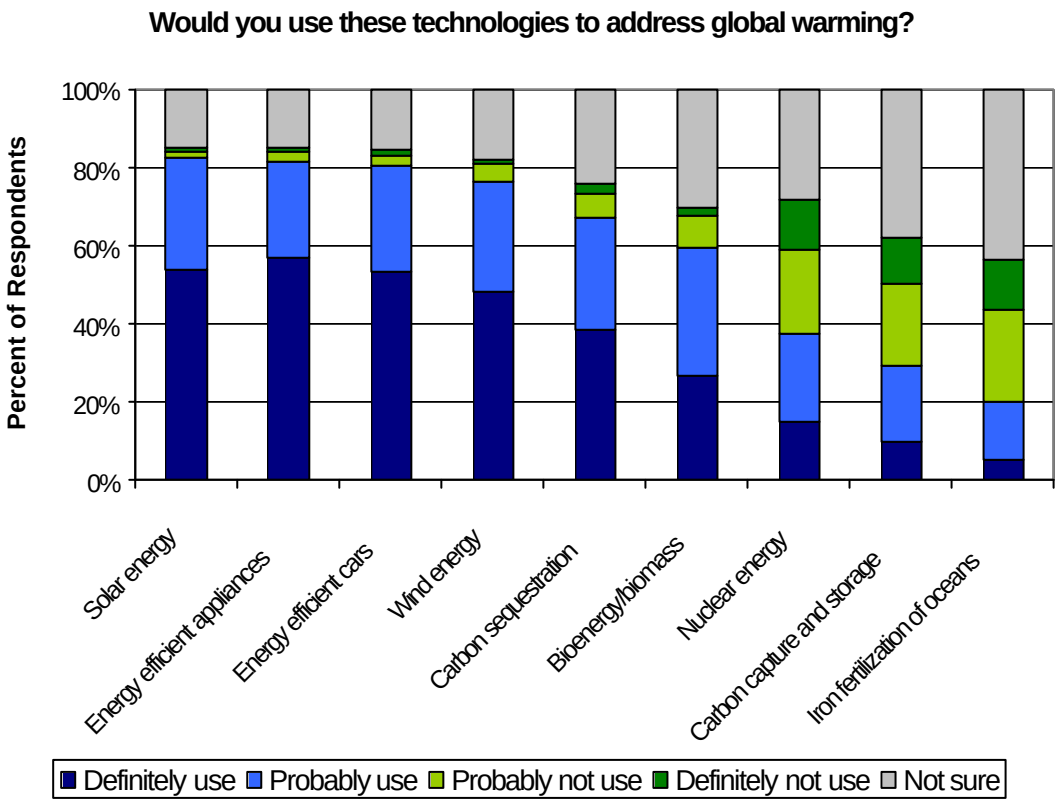
Source: Presentation by Tom Curry, Carbon Sequestration Initiative, Sponsor Meeting, November 5, 2005.

Figure 3.5 presents the results of the survey, based on the following question:

"The following technologies have been proposed to address global warming. If you were responsible for the design of a plan to address global warming, which of the following technologies would you use?

Bioenergy/ biomass: Producing energy from trees of agricultural waste.
Carbon sequestration: Using trees to absorb carbon dioxide from the atmosphere.
Carbon capture and storage: Capturing carbon dioxide from power plant exhaust and storing in underground reservoirs.
Iron fertilisation of oceans: Adding iron to the ocean to increase its uptake of carbon dioxide from the atmosphere.
Energy efficiency appliances: Producing appliances that use less energy to accomplish the same tasks.
Energy efficiency cars: Producing cars that use less energy to drive the same distance.
Nuclear energy: Producing energy from a nuclear reaction.
Solar energy: Using the energy from the sun for heating or electricity production".

Figure 3.5 Public perception survey: technologies to address global warming



Source: Presentation by Tom Curry, Carbon Sequestration Initiative, Sponsor Meeting, November 5, 2005.

The CCP conducted an NGO survey (2001), followed by two workshops. It concluded that NGOs did not exhibit positive attitudes towards CO_2 capture and storage, although most took an open attitude.

One US based NGO, Natural Resources Defence Council (NRDC), made positive statements. In particular, David Hawkins, NRDC, stated:

"A comprehensive program like the Clean Power Act will allow a full range of techniques to be used, including use of cleaner fuels, supply and demand-side efficiency programs and repowering existing plants with new technologies whose CO_2 can be geologically sequestered."[1]

The major environmental NGOs have taken different positions on the technology. Whereas green NGOs generally keep an open mind, some take a sceptical approach towards the issue.

For example, on the one hand, the World Wildlife Fund keeps an open mind towards any technology which takes CO_2 out of the system, including CO_2 capture / storage, whilst expressing a concern over the fact that the technology will undermine the energy industry's move towards a renewables based system. However, WWF are slowly changing their opinion to that of accepting the technology, recognising that the technology has its place in the transition phase that is needed before renewable energy is the dominant form of energy.

One NGO -- the Bellona Foundation in Norway -- is actively campaigning for the use of the technology.

On the other hand, Greenpeace exhibits a very sceptical attitude towards the technology, and expresses concern, not only on the fact that the technology will undermine the move towards renewables, but also on the fact that carbon storage could (in their view) be used as a long term strategy for the oil and gas industry to continue its development on a business as usual basis. Finally, many NGOs expressed their concern over the long-term reliability of geological storage.

Environmental NGOs in the Netherlands have so far opposed the technology on the basis that it may hinder the development of renewables and the move from a fossil fuel based economy. In Canada and the US the technology has so far attracted minimal attention from the NGOs. The principle concern, where there is any, is that carbon storage will be used as a long-term strategy for a 'business as usual' fossil fuel based economy.

[1]David Hawkins, Global Warmind, Indepth testimony, http://www.nrdc.org/globalWarming/tdh0602.asp, November 2002.

3.4 SUMMARY AND CONCLUSIONS

On an international scale, the London Dumping and OSPAR conventions (*Section 2.2.1*) are the key conventions applying to CO_2 geological storage. At a domestic level, regulations developed for protection of s and development of oil and gas facilities generally apply, but have not yet been tested for CO_2 capture and storage projects. The classification of CO_2 storage is likely to be an issue: if CO_2 is treated as a waste, it would likely make storage in freshwater aquifer zones difficult due to stricter disposal restrictions.

On balance, most of the government officials interviewed in this study displayed a positive attitude towards this new option, with some uncertainties about exactly how CO_2 capture and storage will be classified and therefore how it will be dealt with from the regulatory point of view.

However, it should be noted that governments have not necessarily given full attention to this technology at the political level. Indeed, it is important to recognize that the government officials interviewed for the purpose of this study were those in charge of this issue. At a more senior level, officials ERM first contacted had little or no knowledge of the issue. In sum, CO_2 capture and storage is not a mature issue at the political level. However, some government officials recognize that the technology should be given appropriate legal treatment, because of the role of the technology in the transition towards a less fossil-fuel intensive energy regime.

Most of those interviewed during this study reported that the long-term economic feasibility of the technology was likely to be the major constraint to its future uptake.

4 FISCAL INCENTIVES FOR R& D, PILOT AND DEMONSTRATION PROJECTS: HIGHLIGHTS

4.1 INTRODUCTION

This section describes the current fiscal incentives for R&D, pilot and demonstration projects for CO_2 capture and geological storage. The following sections summarize any existing tax incentives or subsidies either specifically developed for CO_2 capture and storage or for which the technology would be eligible.

In addition this section summarizes current thinking in individual countries about the relation between CO_2 capture and storage and domestic greenhouse gas regimes, project-based mechanisms (Joint implementation and the Clean Development Mechanism) and for emissions trading. Eligibility for these schemes as a way of giving an economic value to the captured carbon is likely to be a key factor in the long-term viability of the technology.

There is a clear momentum for developing CO_2 capture and storage. Particularly, in the EU, Australia, Canada and the US, additional efforts for R&D programs and other financial incentives have emerged in the last year.

Box 4.1 Research into CO_2 Capture and Storage Funded under National Grant Programmes

- **Norway** hosts the only commercial test to date, at the Sleipner field, where 1 million tonnes of CO_2 a year are being injected into the Utisira Formation at 800-1000 m below the sea floor. The Government also handed out €1.9 M (16 M NOK) for early demonstration projects in summer 2003. The money went to Statoil, NorskHydro and several other smaller projects. These projects aim to study power production, CO_2 capture and CO_2 sequestration. More funding is to be allocated to the technology following negotiations of the National Budget Proposal and by the Ministry of Petroleum and Energy.

- **Denmark**: In the spring of 2002, Elsam (energy supplier) carried out a review of the financial feasibility of offshore CO_2 capture / storage projects in the North Sea. However, funding for an energy research program has recently been reduced considerably and the money for the CCS project proposed under the program was withdrawn.

- **Netherlands**: Clean Fossil Fuels' Programme, run by TNO-NITG (the Netherlands Institute of Applied Science), has obtained national and EU funding for projects looking at issues such as: observation, monitoring and analysis of CO_2 sources in the subsurface (NASCENT); simulation models for CO_2 injection in aquifers (SACS), coal beds (CBM) and depleted oil and gas fields (EOR); inventory and analysis of CO_2 sources and transport / storage capacity in the subsurface (GESTCO). In addition, the Government's CRUST (CO2 Re-use through Underground Storage) program has approved two feasibility studies in (a) storage of CO2 from a chemical factory in an empty gas field, led by NAM; and (b) separation of offshore, on site CO2 from methane and its storage, led by Gaz de France . € 500,000 financial support was allocated by the Ministry of Economic Affairs for these feasibility studies.

- **Canada**: Research is underway on EOR, enhanced coal bed methane recovery, and storage of commercial acid gases. In Alberta, a new royalty program is providing CAN$15 over five years for CO_2 projects.

- **USA:** Research studies are being carried out at Lawrence Berkley Laboratory and Cal Tech on escape paths of CO_2 from injection points and to the near surface and at atmospheric monitoring techniques, respectively. Existing and expected pilot and demonstration projects in the US are continuing to develop and emerge, despite the lack of clarity on the FY2004 budget allocation. The NETL is currently involved in two pilot-scale programs in the southern US that focus on monitoring of CO_2 plumes in the subsurface. The Texas Bureau of Economic Geology (with NETL) is about to conduct a pilot program at an abandoned oil field by injecting CO_2 into a deep saline aquifer. Strata Oil Company has recently completed a pilot injection program in New Mexico (with NETL), injecting approximately 2100 tons of CO_2 to monitor behavior and migration in an abandoned oil field. NETL is also involved in a program to evaluate geologic conditions in a deep saline aquifer below AEP's Mountaineer Plant in West Virginia, for CO_2 sequestration.

Note: See *Annex A* for further detail.

Table 4.1 ***Overview of Incentives and Disincentives for CO_2 capture and geological storage***

Country	Existing or expected financial incentives?	Existing or expected financial disincentives?	Existing or expected program or funding?	Existing or expected Capture and storage pilot or demonstration projects?[1]
EU	✓	×	✓	✓
Denmark	×	✓	✓	✓
Germany	✓	×	✓	✓
Italy	✓	×	✓	✓
The Netherlands	✓	✓	✓	✓
Norway	✓	×	✓	✓
The UK	✓	×	✓*	✓
USA	✓	✓	✓	✓
Canada	✓	×	✓	✓
Australia	✓	×	✓*	✓*
China	×	×	×	×

×: non existent; ✓: existent; * expected

4.2 FINANCIAL INCENTIVES/ DISINCENTIVES FOR CARBON MANAGEMENT

4.2.1 Tax Incentives

At present there are no tax incentives or disincentives specifically targeted at CO_2 capture and storage in the countries reviewed since the technology is barely at the commercialisation phase. In the Netherlands, a new Electricity Act came into force on the 1st July 2003. Current drafts of the Act suggest that a tax exemption worth approximately €25-40 m in the first year and increasing every year by between €25-30 m will be established to support renewables, energy efficiency and climate neutral electricity, including CO_2 capture and storage.

In Canada, the Environment department of Alberta announced on May 16 2003 a new royalty program to promote the development of a CO_2 enhanced oil/gas recovery industry in Alberta. The Minister of Alberta Energy has announced a maximum of US$ 10 m (CAN $15 m) is being provided over five years in the form of royalty credits to offset up to 30 per cent of companies' approved costs in approved CO_2 projects.

4.2.2 Subsidies and Grants

There are currently no direct subsidies for CO_2 capture and storage projects due to the lack of experience in large-scale projects. Most financial support has taken the form of research grants and support for demonstration projects.

[1] See Annex A, in particular Table A1.1, sections A1.8, A1.9 and A1.10.

In several countries CO_2 capture and storage would be eligible for Climate change related programmes (such as the Greenhouse Gas Abatement Program in Australia, the 'Ecology, Economy and Technology' fund in the Netherlands, and KLIMATEK , technology for reducing GHG emissions fund in Norway). In practice no demonstration or commercial carbon capture projects have yet been funded and the agencies responsible for these schemes think it unlikely that they will encourage large scale investment in the technology.

Research Grants

In Europe, the major source of research and development (R&D) support is the EU Sixth Framework Programme for Research and Technological Development, which became operational in 2002, through which €50 million will be available across the EU for research over the next five years.

The only other sizeable national funds are those available through the CRUST (CO_2 Reduction and Underground Storage) project in the Netherlands which is providing €1 million for two feasibility studies on different techniques for gas field storage; offshore storage by Gaz de France; and onshore storage by Shell. A further €11 million has been earmarked for implementation from early 2003 if the feasibility studies look favourable. In the UK, small research grants are being considered by the Tyndall Centre (University of East Anglia) and the Carbon Trust, subject to a European Commission judgement on "state aid".

In the US, the only source of research funds identified is the Department of Energy, which has a budget of $40M for geologic sequestration for 2002/3. The National Energy Technology Laboratory (NETL) of the US Department of Energy is involved in a few demonstration projects (see *Annex A*). A pilot project is currently being developed by the University Of Texas Bureau Of Economic Geology and Department of Energy facilities for a sequestration project in high permeability sandstones of the Frio Formation along the Texas Gulf Coast. In the longer term, some form of financial support for carbon sequestration may be forthcoming in support of the Clear Skies Act (which undertakes to reduce US GHG amounts by 18% -specific emissions by $ GNP- by 2012).

The US budget for FY 2004 has been agreed upon. It includes funding of $62 million (an increase of $18 million over FY 2003) to the capture and disposal of CO2 emissions. This covers the funding of R&D and demonstration projects. Of the $62 million, the Focus Area for Carbon Sequestration Science will see a slight decrease from the FY2003 budget, from $7,425,000 to $6,930,000.

In Canada, the Climate Change Central Office provides support for R&D to reduce GHG emissions and boost the efficiency of energy production (including CO_2 separation, transportation and sequestration). Pilot Emissions Reduction and Removals (PERRL) is a fund with $9 million for research.

In Australia, a research programme on Geological Disposal of Carbon Dioxide (GEODISC) has been in place since 1999. Funding of $10 million is provided by the Australian Greenhouse Office (AGO), the Australian Petroleum Cooperative Research Centre (APCRC), and the oil and gas industry. The partner organisations have applied for funding to launch a demonstration plant for CO_2 capture, separation and storage in 2005.

4.2.3 Tax Disincentives

ERM has identified no specific financial disincentives in most countries, although policies which affect the operating costs or capital investment incentives in the offshore oil and gas industry are seen by some as a disincentive in CO_2 capture and storage[1].

In all the countries reviewed, the current economics of capture and long-term storage may pose a considerable barrier. While other comparable technologies are economic because they improve resource efficiency, this is not necessarily the case with CO_2 capture and storage. EOR is widely used in the oil and gas sector and the enhanced recovery of the oil makes it financially viable. R&D in CO_2 injection for enhanced coal bed methane recovery suggests that enhanced gas recovery (EGR) will also become financially viable in the medium term.

However, without capturing a monetary value for the stored CO_2, the economics of CO_2 capture and storage is unlikely to be economic even at the wellhead. The economics will be even less attractive where sectors which could benefit from CO_2 capture have other issues that would make the economics of CO_2 capture projects even less attractive[2].

CCS projects require increased investment, which means there must be a recognised financial value for tonnes of CO2 stored in those projects. Therefore, a key issue for the viability of CCS will be the financial value that can be realised from storing the tonnes of CO2 in the project.

4.3 SUMMARY AND CONCLUSIONS

There are not yet any specific subsidies for commercial scale CO_2 capture and storage projects, although the lack of demonstration of commercial viability is widely recognised. Grants for R&D and pilot projects are available mainly through the EC, and through clean energy programmes in the Netherlands, Denmark, UK, Norway, Australia, Canada and the US.

[1] In the UK a tax was imposed on the offshore oil industry in April 2002. This, coupled with current low oil prices is likely to reduce incentives for capital investment in facilities nearing the end of their life.

[2] Eg in the UK the NETA (New Electricity Trading Arrangement), which has led to a fall in prices of 30-40% since its introduction in April 2002, is also likely to depress investment in new generating capacity suitable for CO_2 capture, while retro-fitting is unlikely on old plants since payback on CO_2 capture equipment is unlikely within the lifetime of existing coal fired plants.

In those countries which anticipate CO_2 capture and storage as an important component of their strategies, the major problem with advancing the technology is the economics of the technology. Without attributing a value to the carbon stored (most likely through 'crediting' of tonnes stored in national emissions inventories and applicable emission trading or project-based credit schemes), it appears unlikely that the technology will be economic in the medium term. Indeed, in the absence of direct subsidies, the critical issue will be whether or not the technology is eligible for credits under the Kyoto mechanisms.

5 MAPPING AND COMPARING REGULAORY ISSUES BETWEEN COUNTRIES

5.1 MAPPING POLICIES AND REGULATIONS

Regulations on geological storage will be developed at the national or the regional (e.g. OSPAR Convention) level. In order to illustrate how different countries value similar issues on geological storage, this section presents a number of tables which map the information on policies and regulations relevant to CO2 capture and storage gathered through interviews to government officials and literature research.

Table 5.1 describes the relevant policies and regulations in the countries of interest to the CCP team. This first table is most detailed; it presents the advantage of comparing and contrasting the policies and regulations in each country being reviewed in this study. For an 'at-a-glance' overview of the situation on CO_2 capture and storage, ERM has compiled two tables:

- A “ticks and crosses” table, summarising whether the country’s interpretation or implementation of specific policies and regulations relating to CO2 capture and geological storage are positive, negative, or neutral. See Table 5.2.
- A country mapping table, which provides an overview of which country is acting on CO2 capture and geological storage in the context of specific regulations. This table is colour coded, to indicate whether the country is taking positive or negative action on CO2 capture and storage. See Table5.3.

All documents relevant to the CCP team are provided in *Annex D* of this report. This includes White Papers, regulations, National Climate Strategies and relevant reports.

Table 5.1 Mapping policies and regulations relevant to CO_2 capture and storage

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations
EU	OSPAR covers all EU countries.		White Papers in the Netherlands and The UK.	Water Framework Directive: CO_2 is not listed as a pollutant under Annex VIII of the WFD. However, CO_2 has the potential to dissolve substances in the water, so the provisions of Article 11 (preventing discharges of pollutants into the groundwater) of the WFD may apply. It is too early to determine how each Member state will interpret the WFD with respect to CCS. The individual government officials interviewed for this study could not answer the question on the WFD. Existing regulations relating to waste management: If CO_2 becomes classified as a waste, a number of current waste regulations (at the national and EU level) will apply to CCS.				See the Netherlands and Norway.	Most government officials interviewed have said that the lack of a unified regulatory framework at the EU level hinders development of CCS: reaching a consensus on OSPAR would be a major step for the development of CCS.
Netherlands	Party to OSPAR	Party to LC	Government White Paper on Clean Fossil Fuels (24/09/03). CCS was put forward as a long-term option.	Yes	Pipeline NEN standards	Yes	The most relevant existing legislation in the Netherlands is the Mining Act.	New Electricity Act (01/07/03). Tax exemption worth €25-40 M in the first year.	A regulatory framework for CCS will emerge as projects are developed. The Dutch Government will add Articles to the Addition to the Mining Act when necessary.

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations
Italy	Party to OSPAR	Party to LC	No	To date, there are no existing policies likely to be extended to include CCS technologies.				No	The lack of regulations neither favours nor restricts the development of CCS.
Germany	Party to LC	Party to LC	No	The discussions on the regulatory framework for CCS in Germany is a burning topic, but no decision has been reached to date. The recent approval for a CCS project in Germany (CO_2 SINK) signifies that, for the first time, Public Authorities will have to deal with a concrete project. The project will begin with a request for permissions: decisions will have to be taken as to whether existing regulations can be extended to include CCS.				No	The lack of regulatory framework presents a barrier to the development of CCS technologies. Still, the technology and its regulatory framework are likely to develop hand in hand.
UK	OSPAR Workshop 13th-14th Oct. Recent *Performance and Innovation Unit Energy Review* states *"the UK should take the lead to establish international cooperation on the issues surrounding OSPAR and the London Convention"*.		UK White Paper on Energy Policy 02/03: *"large-scale deployment of CCS being required from 2020"*.					No	Lack of regulatory framework could result in only small pilot projects being possible during the continued period of regulatory uncertainty.

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations
Norway	Party to OSPAR	Party to LC	Norwegian White Paper on Emissions Trading: CO_2 tax is to be replaced by an ETS (2008). CCS not specifically mentioned.	The Norwegian Energy and Water Authority gives concessions for power plants. It is speculated that power plants with CCS will be given permission to build. The usual environmental regulations to such projects: IEA, regulations relating to gas storage, aquifers, pipelines will apply. E.g. Norway has a lot of experience on installing pipelines, so pipeline transport of CO_2 will not present a major challenge.				CO_2 stored in geological structures is exempt from the Norwegian CO_2 tax.	Sleipner is proof that the lack of regulation. is not affecting the development of CCS.
Denmark	Party to OSPAR	Party to LC	No White Paper. However, the *Proposal for a Climate Strategy for Denmark* (02/03) includes CCS.	The Danish Subsoil Act and the Danish Workers Protection Act cover natural gas and will apply to CO_2 Storage.	Offshore installations act will apply to CO_2 pipeline transport.	A lot of pressure to protect groundwater: expected to be a big issue, the problems will emerge at the EIA level.	No	No	There is enough of a regulatory framework for CCS to develop in Denmark.
USA	No	Party to LC	No	California Environmental Quality Act (CEQA) may be an impediment to future	They are extended to CCS.	Safe Drinking Water Act (SDWA, 1974). Under the SDWA, Underground	Not yet.	No	Not yet focused on legal and regulatory issues needed for CCS under the UIC: once a regulatory framework is established, technology advances will follow. US

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations
				development of CO_2 sequestration projects. Also required to complete a National Environmental Policy Act (NEPA) review		Injection Control (UIC) Program. UIC includes regulations establishing minimum standards of performance for injection wells.			Department of Energy expects to have a monitoring and verification program for CCS in pace in the next 3-5 yrs.
Canada	No	Party to LC	No	The Energy Utilities Board has designed regulations to ensure safety of gas transport through pipelines: the same regulations will apply to CO_2. In the Orion EOR project's EIA, the major regulation considered were the Water Act; the Public Lands Act; the Canadian Fisheries Act; the Navigable Waters Protection Act.				CO_2 Project Royalty Credit Program in Alberta (16/05/03). CAN$ 15M over 5 years.	The lack of regulatory framework presents a barrier to the development of the technology. There is a clear need for streamlining regulations that exist (at the federal and the international level).
Australia	No	Party to LC	No	Natural gas regulated under petroleum acts. Onshore fields under state jurisdiction;	The South Australian Petroleum Act, recently been re-written to	Any activities that may affect surface water or groundwater are subject to	No	No	The limited specific regulations in Australia are not currently regarded as a major impediment to CCS development.

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations
				offshore fields under Commonwealth jurisdiction.	cover CCS	strict impact assessments.			
China	No	No	No	No	No	No	No	No	The lack of regulatory framework may imply that there will be little development on CCS in the foreseeable future.

Table 5.2 Overview of country actions on policies and regulations relevant to CO_2 capture and storage

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations (✓=not a barrier to CCS; ×=a barrier to CCS; - = neutral)
Netherlands	✓	✓	✓	✓	✓	×	✓	×	✓
Italy	×	✓	×	×	×	×	×	×	-
Germany	✓	✓	×	×	×	×	×	×	×
UK	✓	✓	✓	✓	✓	✓	✓	×	×
Norway	✓	✓	✓	✓	✓	✓	✓	✓	✓
Denmark	✓	✓	×	✓	✓	✓	×	×	✓
USA	N/A	✓	×	✓	✓	✓	×	×	×
Canada	N/A	✓	×	✓	✓	✓	✓	✓	×
Australia	N/A	✓	×	✓	✓	✓	×	×	×
China	N/A	N/A	×	×	×	×	×	×	×

Table 5.3 Summary table for policies and regulations

Country	OSPAR	London Convention	Energy White Papers/ Climate Strategies	Existing regulations relating to gas storage	Existing regulations relating to pipelines	Existing regulations relating to aquifers	Existing Regulations relating to mining	Tax exemptions	Implication of lack of regulations
A lot on CC&S	**UK, NOR**	**UK**	**UK, NL, DK, NOR, CAN,**	**DK, NOR, CAN, NL, USA**	**DK, NOR, CAN, NL, USA**	*DK,* **NOR, CAN, NL, USA**	**CAN, NL**	**NOR, CAN**	**NOR, DK**
Something on CC&S		**CAN, USA, AU**	**USA**	UK	UK	UK	UK		**NL**, *GR, UK*
A little on CC&S	**IT, GR, DK, NL**		GR, AU	GR	GR	GR	GR, **NOR**		*CAN*, **USA**
Nothing on CC&S	CH, CAN, USA, AU	CH, NL, DK, GR, NOR, IT	IT, CH	IT, CH	IT, CH	IT, CH	IT, CH, DK, **USA**	*NL, IT, GR, UK, DK, USA, AU, CH.*	IT, *CH*

Note: Countries represented in **green** are taking positive actions, countries represented in *red* are taking negative actions for CO_2 capture and storage and countries represented in black are neutral, with respect to the policy or regulation listed.

5.2 MAPPING R&D PROGRAMMES

In order to illustrate how different countries invest in CO_2 capture and geological storage R&D, *Table 4.4* describes the various types of R&D programmes e favoured in each country. As it is often impossible to get information on how much governments are spending on R&D for CO_2 capture and storage specifically, this matrix concentrates on determining what type of projects governments are investing in.

As in *section 5.1, Table 5.4* is supported by two summary tables, *Table 5.5* is a ticks and crosses table, providing an at-a-glance overview of availability of R&D programmes for CO_2 capture and storage and *Table 5.6* is a country mapping table indicating which countries invest in R&D programmes for CO_2 capture and storage. The latter provides an indication of which type of projects are invested in.

Table 5.5 looks at which countries have existing or expected financial incentives, disincentives, program, funding, pilot or demonstration projects. By financial disincentives, we mean measures such as targeted tax cost, the need for special planning permissions. It is possible to have both financial incentives and disincentives in a country.

In the US, there are a number of state funded and federal incentives for R&D and pilot CCS projects. At the same time, disincentives for underground injection are present through state and federal programs designed to regulate and monitor environmental impacts from industrial operations. For all these countries, the economics of CCS currently present a financial disincentive.

Table 5.4 Mapping R&D programmes for CO_2 capture and storage

Country	EU 6th R&D Framework Programme	Government initiative	Industry R&D initiative
EU	Sixth framework programme for Research and Technological Development. The programme *"will have a priority for medium to long term energy research on CO_2 disposal associated with cleaner fossil fuel power plants"*. In the past, emphasis has been placed on research on geological storage. The flow of funding resources from FP 6 is expected to move towards capture of CO_2. FP6 provides funding for: Sleipher, SACS, NASCENT, Recopol, Castor, CO_2 SINK, Zeplin Grace, Weyburn, GESTCO, CRUST, Sotocabo.		
Netherlands	Funding for NASCENT; Simulation models for SACS, CBM, EOR; GETSCO, CRUST (€0.14 M for feasibility study, €11M earmarked for implementing pilot projects).	Clean Fossil Fuel Program (managed by Novem)	Ecofys; NAM; Shell; Gaz de France are working on CRUST. Industry also working on NASCENT, and the SACS, CBM and EOR projects.

Country	EU 6th R&D Framework Programme	Government initiative	Industry R&D initiative
Italy	Sotocabo	CCS is one of the main priorities under the Public National Plan for research, under the *New Technologies of Energy Generation and Management* theme, which accounts for €90M of public funding. Additional incentive could come from Fund for R&D on the Electricity System. The Ministry of research recently funded Sotacarbo, total cost estimated at €12M.	The test facility will be carried out by Sotacarbo Spa (Societa Tecnologie Avanzate Carbone S.P.A), with the collaboration of Ansaldo Ricerche, ENEA and the Department of Mechanical Engineering of Cagliari University.
Germany	REPOCOL, NASCENT, CASTOR, CO_2SINK (co-funded by the EU, with €8.7M over 5 years).	Federal Ministry of Economics and Labour, Federal Ministry of Education and Research, Federal Ministry of the Environment, Nature Conservation and Nuclear Safety are leading an initiative called COORETEC "Ways to the zero-emission fossil fired power plant". It is receiving €15m / yr from the Government, but it is impossible to say how much will go to CCS.	CO_2SINK is lead by GeoforshungsZentrum Potsdam (GFZ Potsdam). Its major participants are Shell, Statoil, Norsk Hydro, Det Norsk Veritas. COORETEC also receives €15M / yr from industry. It is lead by the research center Projekttrüger Julich and consists of members from Industry.
UK		There have been no pilot or demonstration projects in the UK to date, and none are planned for the near future. However, the recent DTI report states: "*The ultimate goal should be a full-scale demonstration of CCS that will showcase UK technology and capabilities. It is recommended therefore that a new fossil fuel carbon management technology programme be developed (...) to include development activities for [CCS] technologies*".	

Country	EU 6th R&D Framework Programme	Government initiative	Industry R&D initiative
Norway	Sleipner project	CCS is exempt from Norwegian CO_2 tax. Ministry of Petroleum and Energy has promised financial support for CCS demonstration projects. National budget for R&D support for CCS amounts to €6 M.. Total Government funding in 2002 was €4.9M. Government also handed out €1.9M for early demonstration projects in summer 2003. The money went to Statoil, Norsk Hydro, and other smaller industry projects.	Sleipner project is still the only existing demonstration project in Norway. It is operated by Statoil, other partners Esso Norge, Norsk Hydro, Elf Petroleum Norge and Total Norge.
Denmark		A Government program including CCS proposals was established a couple of years ago. However, the money for CCS was recently withdrawn, as the Government funding was dramatically reduced. The Danish Proposal for a Climate Strategy may have established a disincentive for R&D development by placing a limit on the mitigation measures to be considered in Danish domestic reduction policies.	A Danish Industry program including CCS ran for 10 yrs. before recently subsiding.

Country	EU 6th R&D Framework Programme	Government initiative	Industry R&D initiative
USA	N / A	C sequestration program US$62 M proposed for FY 2004, CCS will see a slight decrease from the 2003 budget. 2002: US$ 5 M; 2003: US $7.4 M; 2004: US$ 6.9M (proposed). CCS studies under way at Battelle, University of Utah, Texas Tech University, and the University of Texas. Coal bed methane capture and production using CO_2 was field tested at Allison Unit in New Mexico (1990). Research programs on enhanced coal bed methane production and CO_2 sequestration are under way at Battelle, ORNL, BP, the Geologic Survey of Alabama, Penn State, and Oklahoma State University.	IEA Weyburn CO_2 Monitoring and Storage Project- CAN$ 20.5M from Governments, as well as equal amount of contributions from Industry. It is one of four projects in the US, out of 74 EOR projects, where anthropogenic CO_2 is sequestered. The others use naturally occurring CO_2 from hydrocarbon recovery. AEP, NETL, Battelle, BP, Schlumberger, and others undertaking a program to evaluate geologic conditions in a deep saline aquifer below the plant for CCS. NETL currently involved in two pilot-scale programs in the southern US (monitoring of CO_2 plumes in subsurface). Texas Bureau of Economic Geology (and NETL) is about to conduct a pilot program at an abandoned oil field by injecting CO_2 into a deep saline aquifer.

Country	EU 6th R&D Framework Programme	Government initiative	Industry R&D initiative
Canada	N/A	Sustainable Development Technology Canada (CAN $ 100M, part of which will go to CCS); Natural Resources Canada- NRCan initiative (CAN$ 25M, available for the development of commercially established CO2 initiatives, essentially CCS); Canada's Climate Change Action Plan 2000- PERRL (CAN $15M, includes CCS); ADOE, Alberta Department of Energy, $15MM as well that is available for CCS demonstration projects. Incentive Programme from NRCan (CAN$ 15M), available from 01/04/04. Activity coordination work such as CO_2 Hub (Canada and Norway each commit CAN $ 0.5 M/yr. for funding of bilateral research projects), Technology Roadmap Process, GHG7 conference, and many more are constantly emerging. See ERM's 2002 Report for a complete list of R&D pilot and demonstration projects in Canada.	IEA Weyburn Project (see USA). Activity coordination: the Petroleum Technology Advisory Committee is heavily involved in coordinating these initiatives, e.g. Petroleum Technology Alliance Canada Workshop (1st-2nd Oct.)

Country	EU 6th R&D Framework Programme	Government initiative	Industry R&D initiative
Australia	N / A	The Australian Budget (13 / 05 / 03): AU$11.6 M new funding over 4yrs. for CCS, through a special Cooperative Research Centre (CRC) for Carbon Dioxide (CO_2CRC) under the Department of Industry, Science and Resources. CO_2CRC is part of the Geological Storage of Carbon Dioxide (GEODISC) research program.	Initial direct funding for GEODISC (AU $10 M) was provided by the Australian Greenhouse Office (AGO), the Australian Petroleum Co-operative Research Centre (APCRC) and Industry, including BHP Petroleum, BP Amoco, Chevron, Gorgon1 Shell and Woodside.
China	N / A	No financial incentives / disincentives, pilot or demonstration projects on CCS for the foreseeable future.	

[1]Gorgon is a joint venture between Chevron, Texaco, Mobil and Shell, to develop the Gorgon gas field in Western Australia, and produce liquefied natural gas (LNG). The Gorgon field has high levels of CO_2. [Note: ERM will work with the companies behind CCP (ChevronTexaco, ExxonMobil, and Shell) to update this information].

Table 5.5 Overview of country actions on R&D programmes for CO_2 capture and storage

Country	EU 6th R&D Framework Programme	Government R&D initiative	Industry R&D initiative	Pilot or Demonstration project in place?
Netherlands	✓	✓	✓	✓[1]
Italy	✓	✓	✓	✓[1]
Germany	✓	✓	✓	✓[1]
UK	×	✓	✓	×
Norway	✓	✓	✓	✓
Denmark	×	×	×	×
USA	N/A	✓	✓	✓
Canada	N/A	✓	✓	✓
Australia	N/A	✓	✓	✓
China	N/A	×	×	×
India	N/A	×	×	×

Table 5.6 Summary table on R&D programmes

Gradation	FP 6	Government R &D initiative	Industry R&D initiative	Pilot or Demonstration project in place?
A lot on CC&S	NOR, NL	NL, UK, NOR, USA, CAN, AU	CAN, USA, NOR, UK, NL	NOR, CAN, USA,
Something on CC&S	GR, IT	IT, GR, DK	IT, GR	NL, IT, GR, AU
Little on CC&S	UK		DK	UK
Nothing on CC&S	DK	CH, IND	CH, IND	CH, IND

[1] CO_2 SINK (GR), CRUST (NL), and Sotacarbo- implementation of pilot project has not started / is at its initial stage.

6 CONCLUSIONS

6.1 SUMMARY OF FINDINGS

There are currently almost no regulations specific to CO_2 capture and storage. However, existing regulations on pipelines, underground storage facilities and injection of gas, and national legislations requiring Environmental Impact Assessments for major developments are extended to CO_2 capture and geologic storage projects. Most policy makers consider that the regulatory framework will evolve as the number of pilot, demonstration, and commercial projects increase.

Uncertainties remain about how projects will be classified (i.e. whether CO_2 will be considered as waste, toxic waste, or neither), but this issue is likely to be addressed as more pilot projects arise.

There are few specific disincentives, other than the planning and permitting systems which are equally onerous for other climate change mitigation measures such as renewable energy installations, gas pipelines, cogeneration plants.

A number of research and development funds for new research and pilot / demonstration projects are available in the EU, the Netherlands, the UK, Norway, Denmark, the US, Canada, and Australia.

However, since the technology is at such a relatively early stage, few countries have developed supporting tax incentives or subsidies for CO_2 capture and storage operations.

To fully appreciate the depth and breadth of the survey of country actions, it is important to refer to the country-by-country breakdown Annex A in more detail.

Most NGOs have not considered the issues involved yet, and are only just beginning to form an opinion on the issue. Whereas some keep an open mind about the development of new CO_2 storage technologies, most approach the issue with scepticism.

There is currently limited public awareness of the technology, but some negative experience with related technologies (such as injection of waste water in freshwater aquifers), and a presumption against major new developments in some places (e.g. the UK and California) lead to the conclusion that, as public awareness develops, it may present some negative opinions.

Finally, it is clear that the greatest barrier to the future development of the technology appears to be the economics. Without some means of capturing a monetary value for stored CO_2, it is unlikely that the technology will be commercially feasible for retrofitting to existing oil and gas facilities or for coal fired power stations. Including this economic/commercial point in a study which otherwise focuses on policies and regulations is not incongruent, because the value of carbon will be determined by *regulatory* definitions.

It is the regulatory constraint on carbon emissions and the regulatory definition for the validity of carbon credits that will determine the price of carbon in the market. If the status of carbon capture and storage in such regulatory regimes is unclear, then its validity and value will remain unclear and, in the worst case analysis, NIL– if there is no recognition of the tonnes sequestered in the market defined by such regulations.

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Annex A

Country Reviews

A1.1 THE EUROPEAN UNION (EU-WIDE REQUIREMENTS)

A1.1.1 *Overview*

The European Climate Change Programme includes *"capture and storage of CO_2 associated with cleaner fossil fuel plants"* in its medium to long-term plan.

Several officials from the European Commission were interviewed for this section of the report: Mr. Peter Horrocks and Mrs Olivia Hartridge, DG Environment, Mr. Peter Vis, Climate Change Unit, DG Environment, and Mr. Dennis O'Brien, DG Research, and Pierre Dechamps, DG-RTD.

A1.1.2 *Financial Incentives*

In the EU, there are several ongoing funding programmes for R&D under the EU's Sixth Framework Programme (FP 6) for Research and Technological Development. The programme runs from 2002-2006 and is worth €17.5 billion to be invested in seven key research areas: genomics and biotechnology for health; information society technologies; nanotechnologies and nanosciences; aeronautics and space; food safety; sustainable development; and economic and social sciences. The programme *"will have a priority for medium to long term energy research on CO_2 disposal associated with cleaner fossil fuel power plants"* and will look to foster co-operation between Member States on the issue. There are still no specific funding allocations for CO_2 capture and storage under FP 6 to date.

Financial Incentives for R&D, pilot and demonstration projects

To date, Existing R&D, pilot and demonstration projects in the EU have received in the order of €30 m in funding, and proposals are currently being reviewed to extend the projects. Three or four additional projects will be added to the value of €25 m by the end of 2003.

In the past, emphasis has been placed on research on geological storage. Dennis O'Brien expects the flow of funding resources to move towards capture of CO_2. This is due to the fact that capture technologies need to be rendered economically viable before CO_2 capture and geological storage can be considered as a possible mitigation option.

Table A1.1 Existing R & D, pilot and demonstration projects in the EU

Project name	Description	Project developers
Sleipner	The Sleipner project is the world's first commercial-scale storage of CO_2, with CO_2 injected into a large, deep saline reservoir, the Utsira formation, 800m below the bed of the North Sea.	Operated by Statoil, other partners Esso Norge, Norsk Hydro, Elf Petroleum Norge and Total Norge.

Project name	Description	Project developers
SACS	The Saline Aquifer CO2 Storage Project (SACS) project has been established to monitor and research the storage of CO2 in the Sleipner field. The main areas of work under SACS are description of the reservoir geology; reservoir simulation; geochemistry; assessment of need and cost for monitoring wells; and geophysical modelling. The project was completed in April 2002 and its results can be found on the official SACS website: http://www.iku.sintef.no/projects/IK23430000/	Main funding partners are Statoil, BP Amoco, Mobil, Norsk Hydro, Saga, Vattenfall; R&D providers include British Geological Survey, BRGM, GEUS, Institut Français du Pétrole, NTIG-TNO, SINTEF Petroleum Research and Nansen ERS Centre.
NASCENT	The project addresses he following issues: Do natural accumulations provide confidence that long-term sequestration of CO_2 is a safe and valuable mitigation option? Assess which geological structures have effectively trapped CO_2. Assess what geological situations cause CO_2 to be leaked. Assess which hazards may be associated with CO_2 sequestration. Assess whether these reservoirs can be used to calibrate reservoir models for long-term storage.	Funded by the European Commission; Managed by British Geological Survey; Partners from France, Germany, Greece, Hungary, Italy, Netherlands, Norway, the UK.
RECOPOL	Reduction of CO_2 Emission by Means of CO_2 Storage in Coal Seams in the Silesian Coal Basin of Poland. By November 2003, the project was at an advanced stage of development: the wells had been drilled, and CO_2 injection would begin within the following two weeks.	Coordinated by the Netherlands institute of applied geoscience TNO-NITG. Funding partners are the Aachen University of Technology (Germany); Air Liquide (France); Delft University of Technology (The Netherlands); Central Mining Institute (Poland); Institut Francais du Pétrole; CISRO (Australia); DBI-GUT (Germany); Gaz de France; Gazonor (France); IEA GHG R&D Programme.
Weyburn	The project aims to enhance the knowledge and understanding of the mechanisms by which CO_2 is sequestered in an onshore oil field during CO_2 enhanced oil recovery projects.	This project is supported by the EC (and others, *Table A2.2*), and involves a group of European scientists specialized in reservoir geochemistry. The project is managed by the Petroleum Technlogy Research Center (PTRC) in Canada.

Project name	Description	Project developers
GESTCO	GESTCO aims to study the distribution and coincidence of thermal CO_2 emission sources and location / quality of geological storage capacity. The study will be thematic in nature and will investigate the storage potential of four main storage types in selected areas, using these as representative settings which, at a future time, could provide the backbone of an atlas of European geological storage capacity. The four storage types are: onshore / offshore saline aquifers with or without lateral seal; low enthalpy geothermal reservoirs; deep methane-bearing coal beds, and abandoned coal and salt mines; and exhausted or near exhausted hydrocarbon structures.	A joint research project conducted by eight national geological surveys (Germany, Belgium, the Netherlands, Denmark, UK, Greece, France and Norway) in co-operation with Ecofys (the Netherlands Energy and Environment agency), funded by the 5th and 6th Framework Programmes on Research and Development.
STORE	This is a new project that will be beginning in 2003 (within the next few months). It will be a follow up of the work done by SACS. It will aim to look for several possibilities for CO_2 storage throughout the EU.	It will be led by Sentas International.
PICOR	Storage in Aquifers / CO_2 Storage in Hydrocarbon Reservoirs (without enhanced recovery) / Natural Analogues for CO_2 storage. The project is expected to run from 2002 to 2004 and may be extended. The project costs € 1,800,000 per year.	Project funded by the French Ministry of Industry and private sources. Partners include IFP (Institut Français du Pétrole); BRGM (Bureau de Recherches Géologiques et Minières); GEOSTOCK University of Bordeaux (ICMCB); University of Grenoble (LGIT); University of Montpellier (ISTEEM); University of Toulouse (LMTG); TOTAL-FINA-ELF
ICBM	Investigation into the Basic Scientific Phenomena of CO_2 Injection and Retention in Coal for CO_2 Storage and Enhanced Coal Bed Methane Recovery. The project is examining a range of technical challenges associate with enhanced coal bed methane recovery coupled with CO_2 sequestration.	Project funded by European Community and industry sources. Partners include Imperial College; BP Exploration Operating Company Ltd.; Technical University of Delft; Deutsche Steinkohle Aktiengesellshaft Wardell Armstrong; Institut Francais du Petrole.

Project name	Description	Project developers
JOULE II	The project was completed in 1995 and cost £1.8 m. It was a wide ranging project that examined a range of issues associated with underground disposal of CO_2. It concluded that underground storage was feasible for CO_2 disposal from large-scale sources. Findings of the project can be found on http://www.cordis.lu/en/home.html	British Geological Survey, UK CRE Group Ltd, UK RWE Aktiengesellschaft, Germany TNO Institute of Applied Geoscience, The Netherlands BRGM, France IKU Petroleum Research, Norway Statoil, Norway University of Sunderland, UK
NGCAS	This project consists in the *Development of Next Generation Technology for the Capture and Geological Storage of Carbon Dioxide from Combustion Processes*. The project is working towards establishment of carbon dioxide storage generated from fossil fuel combustion as a viable technological option within the European Union.	The project is funded by the European Comission and industry sources including: BP; AEA Technology Institut Francais de Petrole; British Geological Survey Statoil. The IEA GHG Programme is also a partner in the project.
Snohvit	In October 2001, Statoil and its partners filed a formal development plan for the Snohvit Field, the first offshore gas field found in the Barents Sea and the point of supply for Europe's fist LNG export project. This is a demonstration project on storage of CO_2 in hydrocarbon reservoirs. The overall cost of the project is budgeted at $US 5.2 billion.	The Norwegian government finances 30% of the project, the rest of financing is provided by Statoil and its partners: Petoro; TotalFinaElf; Gaz de France; Norsk Hydro; Amerada Hess Norge; RWE-DEA Norge; Svenska Petroleum; Exploration.

Source: IEA Greenhouse Gas R & D Programme, Greenhouse Issues, n. 53, 2001; http://www.co2sequestration.info/

A1.1.3 *Financial or Other Disincentives*

The technologies involved are at an early stage of investigation: to date, no financial or other disincentives targeting CO_2 capture and storage have emerged in our research.

A1.1.4 *Regulations and Policies*

At the moment, there are no regulations *specific* to CO_2 capture and storage favouring its development.

Several existing policies and regulations in the EU may apply to CO_2 capture and storage projects: these include the forthcoming *Water Framework Directive* (which must be transposed into national law across the 15-nation bloc by the end of 2003) in particular requirements on groundwater[1], safety regulations on gas storage, and the need for an Environmental Impact Assessment at the start of each project.

The London Disposal and OSPAR Conventions are the key conventions at the international level. However, there is a fundamental lack of clarity as to the applicability of OSPAR to offshore CO_2 disposal. If OSPAR is applicable, then some experts believe it might suggest offshore disposal is inconsistent with the Convention. In all EU countries, a consensus from the OSPAR Convention could provide a welcome EU-wide framework to the development of a regulatory framework for CO_2 capture and geological storage. The UK is taking the lead in pushing for such consent: the UK DEFRA's OSPAR conference (13-14th October 2003) aimed to steer various EU Member States towards a consensus on the issues still to be resolved (see *Section 3.2.1* of the main body of this report).

The EU Emissions Trading Directive was finally adopted on 9 July. It will create an active emissions trading market in the EU for EU "allowances" under that scheme from 1 January 2005 onwards; however, it remains to be seen whether, as currently drafted, tonnes of CO_2 captured and stored would be eligible for credits under the EU allowance scheme.

The EU "Linking Directive" which deals with EU rules for handling project-based credits under JI and CDM under the EU Allowance scheme was released as a draft by the European Commission on 23rd July. In this Linking Directive, the EU means to exclude (or limit) LULUCF, not CO_2 Capture and Storage, when they refer to sequestration.

It can be argued that, provided that the Linking Directive does not specifically block the technology, then it will automatically be included. Indeed, the Norwegian Sleipner project pioneered the establishment of a protocol agreed by the UNFCCC. This is a situation in which CO_2 can be removed from an inventory, consequently yielding AAUs which will be convertible to ERUs and CERs. As a consequence, CO_2 emissions reductions from CO_2 Capture Project could be eligible for credits under the CDM and JI.

DG Environment is currently developing implementation guidelines for the EU ETS. These guidelines will include a paragraph specific to CO_2 capture and geological storage. Olivia Hartridge, DG Environment, was contacted regarding this issue. However, the wording of this paragraph is not yet publicly available, pending release of the EU ETS guidelines, expected to be published in January 2004.

In principle, it is expected that the use of CO_2 capture and geological storage will be accepted by the guidelines to the EU ETS. This conclusion has been made following a number of informal discussions with members of the UK DTI and DEFRA involved in the discussions.

A1.1.5 ***Use of stored carbon as carbon credits, or for compliance in a domestic GHG regime***

Mr. Peter Horrocks believes that instruments such as emissions trading should favour CO_2 storage, if it could be certified that the CO_2 is taken "permanently" out of the atmosphere. However, at the moment, the lack of rules on monitoring and certification of such projects means that project developers would not get credits for CO_2 stored. Peter Vis added: "*the first step is to put in place an emissions trading scheme that creates scarcity, and then, gradually, over time, credits for permanent sequestration will follow.*"

A1.1.6 *NGO/Public Awareness*

NGOs in Europe generally have a negative outlook on the issue, as they believe that CO_2 storage gives the fossil fuel sector a new lease of life (which engenders other environmental problems), and distracts from the development of renewable energy. However, some NGOs are developing a more realizing opinion on carbon capture and storage and realize that a transition phase is needed before renewable energy is the dominant energy form (e.g. Bellona Foundation, Norway, is actively campaigning for the use of CO_2 capture and geological storage). WWF were against CO_2 capture and storage until about a year ago, and they are slowly changing their opinion to that of accepting the technology. See *Annex C* for information on individual NGO views.

The public is not very aware of the issue. Where the public is aware of the issue, through the media, they are more aware of the issues of CO_2 deep-sea storage.

"A key observation is that the issue of CO_2 storage has so far mainly been addressed in relation to ocean storage, rather than underground storage. However, there does seem to be a clear distinction between these two issues, in relations to discussions under the relevant conventions"[2]

A1.2 *DENMARK*

A1.2.1 *Overview*

The Danish Government has yet to articulate a clear policy on CO_2 capture and storage, and has not introduced any fiscal/regulatory incentives on the issue. The Government is participating in IPCC/EU discussions on CO_2 capture and storage, and is likely to support the use of the technology as a CO_2 reduction measure, but so far has adopted a 'wait-and-see' policy rather than taking a proactive stance on the issue.

The government officials interviewed in Denmark were Mrs. Ulla Benson, from the Danish Environmental Protection Agency (DEPA), Mr. Niels Peter Christensen, from the Geological Survey of Denmark and Greenland (GEUS), and Mr. Frederiksen of the Danish Energy Authority.

A1.2.2 *Financial Incentives*

An energy research program (including a proposal on CO_2 capture and geological storage for which the Government was willing to grant money) was established several years ago. However, the funding for this program has recently been dramatically reduced from more than €13.46 million (100 million DKK) to €4 million (30 million DKK). The money for the CO_2 capture and storage project proposed under this program was withdrawn.

A Danish industry program including a proposal for a CO_2 capture and storage project ran for more than 10 years before subsiding.

There are a small number of pilot projects currently being implemented in Denmark:

- Elsam A/S, an energy supplier, is assessing the feasibility of using CO_2 capture and storage technologies in Enhanced Oil Recovery (EOR). The project is called CENS (CO_2 for enhanced oil recovery in the North Sea) is a project carried out jointly by Elsam and overseas partners from the UK and Norway. The project involves sequestering CO_2 in the North Sea fields.
- Statoil obtained funding from the European Commission as well as a number of major energy companies and national governments around the North Sea to investigate how CO_2 from the Kalundborg refinery can be injected into a formation to the north of the site.

Denmark has operated a CO_2 emissions trading system (for its electricity generation sector only) since April 2001, based on an emissions cap which declines year-by-year to 2003. However, stored CO_2 is not covered by the scheme at present, and interviewees did not know how stored CO_2 might be treated in the future.

A1.2.3 *Financial or Other Disincentives*

There are no specific disincentives relating to CO_2 capture and storage projects, although the fact that stored CO_2 is not covered by the carbon trading scheme (and therefore has no financial value) means that companies have less reason to invest in the technology.

The Danish Government's "*Proposal for a Climate Strategy for Denmark*" states that more investment is needed in CO_2 capture and storage technology and that the technology is currently too expensive to implement. According to the *Proposa*l, CCP is more expensive to implement as a mitigation option, compared to emission reduction at source. The Government has given a cap of $16 (120 DKK) per tonne CO2 for initiatives that reduce GHG emissions. The same report established that the cost to implement CO2 capture and storage is between $8 (60 DKK) and $41.7 (310 DKK) per tonne CO2. The *Proposal* states that:

"*In order to ensure cohesion in reduction initiatives across sectors, the government has set an indicator of DKK 120 (€16.16) per tonne CO_2 to be used as a basis for implementing domestic initiatives outside the area covered by the EU quota system. The indicator expresses the value of the CO_2 reduction to be included in calculations for specific initiatives. The value of any other benefits from an initiative can be added, for example other environmental benefits. Cost-effective reductions efforts require that initiatives are only implemented when the value of the benefits is greater than the costs*."[3]

The definition of CO_2, i.e. whether the gas will be defined as a waste or not also presents a possible barrier to its development: if CO_2 becomes listed as a waste in international treaties (or Domestic Regulations), the storage of CO_2 on and offshore will require more care and encounter more resistance from existing Waste disposal regulations, NGOs, and the general public.

NGO action and public perception are to be considered seriously by project developers in Denmark. There is an interesting precedent to be mentioned: approximately 6 years ago, DONG (the only Danish transmission company) undertook natural gas storage in an onshore geological structure; the operator lost the project to protests and vandalism due to poor handling of public sentiment.

A1.2.4 *Regulations and Policies*

The current lack of specific regulations on CO_2 capture and storage in Denmark was not seen to be a significant barrier by interviewees, as interviewees believed that existing regulations should be sufficient to regulate the technology and one interviewee suggested that regulatory authorities / the relevant Ministries would respond to any company wishing to propose specific projects in Denmark, but would not proactively address the issue in advance of specific proposals.

For example, there is adequate legislation for CO_2 injection: the Danish Subsoil Act is a general act providing guidelines for projects carried out on Danish Subsoil. Project developers may ask for approval to use the Danish Subsoil Act for various types of projects (this is specifically mentioned in the Act). Mr. Frederiksen of the Danish Energy Authority explained that the project developers for CO_2 capture and geological storage in Denmark would be able to use the guidelines provided by the Danish Subsoil Act.

Although there are no specific regulations on gas storage in Denmark, two Natural Gas storage facilities have been developed in Denmark. They based their regulations on the Danish Subsoil Act and the Danish Workers Protection Act. Whereas these do not contain details on Natural Gas, they contained enough guidelines on storage to develop the projects.

For CO_2 capture and storage projects, there will need to be an environmental and safely assessment. It is still too early to determine exactly how the assessment will be dealt with. However, the issue of environmental assessment is included in the Danish Subsoil Act. The project developer will also need to take regulations specific to pipelines; gas storage; waste disposal regulations; groundwater regulations into account.

It is certain that offshore geological storage of CO_2 is currently possible in Denmark, under the existing regulatory framework.

Whereas the government officials interviewed believe that the Danish Subsoil Act and the Offshore Installations Act will be extended to cover CO_2 capture and geological storage offshore, CO_2 storage on land will encounter more difficulties as there is a very high pressure to protect the groundwater in Denmark. The stringency of groundwater regulations linked to the lack of regulatory framework specific to CO_2 geological storage on land will present a significant barrier to project developers in Denmark.

One precedent of this is the construction of a natural gas facility on land in Denmark at the end of 1990. The contamination of Groundwater appeared as a major issue then and the environmental impact assessment regulations were not as stringent then than they are now. For example, the public hearing is taken into account more seriously now, and public awareness of risks to groundwater (or rather concerns on groundwater contamination) has increased. Additionally, storage of natural gas is a temporary measure as the gas is then extracted from the storing facility; it is uncertain how long the CO_2 stored into a geological structure will need to remain there: this could be another cause for protest from NGOs and the general public.

DONG developed these Natural Gas facilities and will be able to provide more details on the issue. ERM will contact DONG for their input in the final report.

A report from the Danish Government, February 2003, "*Proposal for a Climate Strategy for Denmark*" was compiled by a group of 5 ministries, namely; The Ministry of Finance, Environmental Protection Agency, Tax Ministry, Foreign Ministry and Economic and Business Affairs. The report looks at all methods for reducing emissions in line with Kyoto protocol commitments (21% reduction below 1990 levels), including CO_2 capture and storage.

As well as explaining how the Government will use flexible mechanisms (primarily Joint Implementation) to achieve Kyoto commitments, the Proposal gives the first clear indication of what Danish Government policy on CO_2 capture and storage is likely to be.

In this *Proposal*, CO_2 capture and geological storage was put on the agenda, although it does not result in the establishment of a legal / policy framework designed to promote the development of the technology in Denmark. No further action has been taken since the publication of this Proposal.

Interviewees suggested that, although the situation is still relatively fluid, the Government is likely to support the technology, as:

- The Government is keen to continue oil / gas extraction in the North Sea;
- The Government is very 'pro-technology' in general;
- There is considerable storage capacity in North Sea reservoirs; and
- It is expected that the technology will be cost effective when compared to some other alternative / renewable energy technologies (despite the fact that wind power is very well developed).

The Danish Subsoil Act will be extended to CO_2. Consequently, the government officials interviewed did not view the lack of regulatory framework as a barrier to the development of the technology:

- Mr. Christiensen, of the Geological Survey of Denmark and Greenland, also believes that the regulations for offshore storage of CO_2 are currently sufficient not to hinder the development of the technology. However, development of onshore storage of CO_2 projects could be hindered by a lack of regulation. Both on and offshore storage projects could face significant barriers if CO_2 is later defined as a waste.

- Mr. Frederiksen's personal view is that the lack of regulatory framework will not hinder or slow down the development of CO_2 capture and geological storage. As long as the technology exists, the projects will be developed and regulations will evolve around them.

Whereas the Government is not currently actively pursuing the development of the technology, the government officials interviewed for this study believe that there will be opportunities for such projects in Denmark.

A1.2.5 ***Use of stored carbon as carbon credits, or for compliance in a domestic GHG regime***

The government officials ERM interviewed would not speculate on stored CO_2 would be eligible for carbon credits, as it was felt that Denmark would follow developments at the EU and international level, rather than take a lead on the issue (despite the fact that Denmark has already established a carbon trading system).

The Danish Government has not expressed that it is against the development of this mitigation option.

The *Proposal* focused on the economic feasibility in determining the extent to which carbon credits from CCS can be used for Kyoto compliance. It specifically mentions CO_2 capture and geological storage in a table listing the initiatives with large potential and initiatives with less potential: "*storage in the underground on land or in oil fields*" is listed as one of the "initiatives with large potential", with a socio-economic cost of € (160-310 DKK) / tCO_2 and the reduction potential to cover all of Denmark's reduction commitments.[4]

As regards the domestic GHG trading regime, there is no real answer possible to this issue yet: the issue is still being debated and it is too soon to say whether the developer of such project would receive carbon credits for the carbon stored. No such project has been proposed under the Danish JI fund yet, so it is too early to say how it would be dealt with. Still, the personal opinion of several government officials interviewed was that this could be a possible outcome.

With respect to monitoring and certification of projects, Mr. Christiensen did not believe that the lack of rules would necessarily mean that the developer will not get carbon credits: it is fairly sure that operators of a storage facility will develop robust measures to monitor and develop rules for certification. There is certainly a large amount of work to be done on the subject, but the technology for monitoring these projects exists.

A1.2.6 ***NGO/Public Awareness***

It is very likely that CO_2 Capture and storage project developers will face a lot of opposition from local NGOs and local branches of major international NGOs.

Public awareness and NGO reaction has been negative towards a proposal to store natural gas in an aquifer in the south of Denmark. Interviewees anticipated that CO_2 storage in aquifers would also be opposed.
A new gas storage facility was proposed in Denmark, the extent of NGO opposition was such that the project had to be cancelled. Mr. Frederiksen expects NGO responses to onshore CO_2 capture and geological storage to be in the same magnitude, if not worst.

The Danish government has recently changed and announced that Denmark should aim to reduce its emissions in the cheapest possible way (e.g. buy hot air from Russia). This led to an uproar from NGOs.

Public Awareness on this subject is limited. There was a mention of a possible CO_2 capture and storage project 2 yrs ago in the press, but this hasn't been developed, and there have been no mention since. However, once the issue becomes more accessible to the public, negative reactions should be expected.

A1.3 *GERMANY*

Up until recently, CO_2 capture and storage was not an important topic in Germany. This is due to the fact that Germany only has small oil and gas production, and thus Enhanced Oil Recovery (EOR) and Enhanced Gas Recovery (EGR) were not developed.

A few authorities (such as the General Parliament of the Energy Liberalisation Committee, a cross party organisation), have been discussing the issues surrounding CO_2 capture and geological storage in more detail, due to the development of several international research projects, including:

- R&D projects of the EU commission with German partners; and
- The IEA Zero Emission Technology Strategy with Germany as a member of the IEA Working Party on Fossil Fuels.

The issue is now a burning topic of debate between several German Ministries, hence the reluctance of German officials to make a public comment on the topic of CO_2 capture and geological storage at this stage. Indeed, it is difficult to pinpoint Ministry officials willing to provide information on the issue of CO_2 capture and geological storage in Germany. For the purpose of this review, ERM has interviewed a member of the Projekttrüger Julich research centre and Mr. Patrick Graichen of the Federal Ministry of Environment.

Although there is still no agreed government position on the topic of CO_2 capture and geological storage in Germany, there has been a lot of progress on the issue. In Germany, the Federal Ministry of Environment is now responsible for all issues linked to renewable energy (including R&D) and the Ministry of Economics and Labour is responsible for all issues of Energy (including R&D).

In 2002, the Federal Ministry of Environment mentioned its fundamental opposition to any CO_2 storage strategy. This is still the case: the Ministry of Environment has a tendency to push for a shift towards a renewable energy economy. All renewable energy policies (including renewable energy research) have been taken over by the Ministry of Environment. However, topics related to the rational use of energy and to fossil power plants remain the responsibility of the Federal Minister for Economics and Labor. The latter has a tendency to accept that the German economy will be based on fossil fuel energy in the foreseeable future.

A1.3.1 *Financial Incentives for R&D, pilot and demonstration projects*

Germany is currently involved in two ongoing EU wide projects which include a CO_2 capture and storage component: RECOPOL and NASCENT.

Germany also has two new projects in the pipeline: CO_2 SINK, which focuses on CO_2 sequestration (and has been accepted by the EC) and CASTOR, which focuses on CO_2 capture in power plants.

CO_2SINK is a project, lead by GeoforschungsZentrum Potsdam (GFZ Potsdam), to set up a practical CO_2 capture and sequestration test site at Ketzin, located near

Berlin in Germany. Ketzin has been the site of a natural gas storage reservoir that will be abandoned for commercial reasons, and whose infrastructure will partly be used by CO_2SINK. The project encompasses injection of CO_2 into a saline aquifer at depths of 700m and deeper. Extensive research into the effects of the sequestration will be undertaken with the objective of understanding the long term fate of the CO_2, how to simulate the effects and how to improve the assessment of risks and safety relating to seal integrity and invasion of other formations. In addition to Shell, major participants are Statoil, Norsk Hydro, and Det Norske Veritas. The funding proposal submitted by this consortium to the 6th R&D Framework Programme of the European Commission received top ranking. In July, the EU Commission agreed to co-fund the project with € 8.7 million over 5 years.

The EU Commission has approved CO_2SINK. It has important implications for the issue of CO_2 capture and geological storage in Germany: for the first time, Public Authorities will have to deal with a concrete project. For instance, the project will need to begin with a request for permission. This will require an Environmental Impact Assessment and the Government will need to decide which Public Authorities should be responsible for granting permission to develop such projects. For instance, the Federal State of Brandenburg has recently been identified as the relevant authority to approve CO_2 injection on the site chosen; and has very recently approved injection.

The CO_2SINK project is likely to speed up the decision making process of German Ministries, as they will need to make concrete decisions in stead of discussing the issues on a theoretical level.

The Federal Minister of Economics and Labor founded an initiative on developing an R&D concept towards the zero-emission fossil fired power plant in 2001. The details of this concept are still under discussion. It is due to be published, but has still not been officially released (several issues still need to be agreed between Ministries).

CO_2 capture and storage is part of the concept COORETEC [5] that was officially started on 3rd June 2003 (other features included by the COORETEC concept are improving efficiency of steam cycle power plants or gas turbines, development of new power plants processes, etc.). The initiative is led by the BMBF (Federal Ministry of Education and Research), BMWA (Federal Ministry of Economics and Labour) and the BMU (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety). The project lead is done by the research center Projekttrüger Julich and consists of members from research institutes and industry (constructors and operators of power plants). The members have worked out an R&D concept called "Ways to the zero-emission fossil fired power plant".

In the concept, the role of increasing efficiency is pointed out as a short and mid-term option for CO_2-reduction with high importance. For reduction levels above 30 %, CO_2 capture and storage can become a viable option.

The concept will be funded with €15 M annually by the Government. It is not possible to assign a certain amount of these €15 M to CO_2 capture and storage, as the published data are not detailed enough. Another €15 M is expected to be funded by industry, so that the total budget for research projects is €30M.

National research activities in the framework of the new concept are expected to begin soon. In addition to the national research activities, German companies and research institutes are very active in sending proposals to the European Commission. This demonstrates companies and researchers' big interest on the topic of CO_2 capture and geological storage.

Finally, Germany's sustainability council (RNE) has recently urged the government to invest more in carbon capture and sequestration. Having pointed out that it did not support coal as an energy source, the RNE has accused the government of failing to adopt a sustainable energy policy. RNE added that, because of its failure to make renewables an economically viable alternative to coal, the government should now ensure that the fossil fuel had a minimal environmental impact.[6]

A1.3.2 *Implications of the Lack of Regulations*

The lack of regulatory framework presents a barrier to the development of the technologies. However, the lack of concrete CO_2 capture and geological storage projects has lead to a highly theoretical debate between German Ministries and the emergence of concrete projects to work on is likely to speed the decision making process in Ministries, thus steer the Government towards a unified decision eventually leading to a regulatory framework. The development of the technology and its regulatory framework in Germany are likely to be pursued hand in hand.

A1.3.3 *NGO/ Public Awareness*

CO_2 capture and storage is likely to encounter some opposition, as the Federal Minister of Environment has expressed his opinion on storage of CO_2 publicly. It is likely that several German NGOs will follow this view.

Whilst working on the COORETEC concept, some attention was given to the issue of public awareness. There is a widely recognised problem: the public is pro-renewables but is unwilling to pay a higher price for energy. Energy efficiency improvement is less recognised by the public as an abatement measure; it is possible that the issue of CO_2 capture and storage will also be essentially unnoticed by the general public. Nevertheless, some efforts to convince the public and NGOs of the advantages of CO_2 capture and storage in the framework of COORETEC will become necessary. A communication strategy and funds (no indication of magnitude available) have been provided in the context of the COORETEC concept for such activities.

A1.4 *ITALY*

Mrs. Mara Gamberale, of the Ministry for the Environment and Territory , Mr. Marcello Capra Directorate-General for Energy and Mineral Resources of the Italian Ministry of Productive Activities, Mr. Eugenio D'Ecole from the company Sotacarbo and Mr. Giuseppe Girardi in the Energy Plants and Processes Division of ENEA (Italian National Agency for New Technology, Energy and Environment) were interviewed for this review.

A1.4.1 ***Overview***

Hydrogen production from fossil fuels and RES is a long tem priority for Italy's energy R&D policy and CO_2 capture and storage is a very important complementary subject to hydrogen. Italy also sees CO_2 capture and storage as a significant opportunity for industry to utilise towards its GHG emissions reductions. In particular, it would seem possible to develop Capture and Storage of CO_2 in deep salt aquifers, oil and gas depleted fields, and unmineable geothermal fields.

A1.4.2 ***Financial Incentives for R& D, pilot and demonstration projects***

CO_2 capture and storage is one of the main R&D activities in terms of the priority theme "New Technologies for Energy Generation and Management" in the context of the Public National plan for research. This theme accounts for about €90 m of public funding.

In addition to the above incentive, other incentives could come from the "Fund for R&D on the Electricity System" which obtains its funding from electricity tariffs (<0.052 c€/kWh). In this context, the Ministry of Productive Activities will ask for demonstration projects in the field of new technologies for power generation.

The first project on this topic has been recently funded by Ministry of Research; it is aimed at a coal gasification test plant in Sardinia, at the SOTACARBO research centre. The project is for developing gasification technologies to produce hydrogen from coal.

The Ministry of Research recently asked for projects in the area of technology development, equipment and systems for hydrogen production and the separation of hydrogen/CO_2 in order to reduce environmental impacts and the study of CO_2 geological storage and associated technologies.

In the context of the Italian Public National Plan for Research, an association of Italian companies (Sotacarbo, as project coordinator, with Ansaldo Ricerche, ENEA and DIMECA) has started a test plant for R&D activities on hydrogen and clean fuels from Sulcis coal[7]. This research project involves design, construction and testing of a pilot plant for the production of high environmental value fuel gas such as hydrogen from Sulcis coal. The test facility is currently under construction in the Sotacarbo Research Centre, Carbonia, South East Sardinia.

The research project will involve coal gasification (Ansaldo Ricerche technology), Syngas gas cleaning, desulphurisation, CO-shift conversion, CO_2 and hydrogen separation, and energy production (Internal combustion engine), control and analysis equipment. Its main purpose is to develop, test and tune the processes of all pilot plant sections. These processes are aimed at producing clean fuel gas and/or hydrogen from Sulcis coal.

At present, the bureaucratic activities are being concluded and the 5-year research project will start in 2003. The total cost of the research project is estimated at €12 m.

A1.4.3 ***Financial disincentives for R & D, pilot and demonstration projects***

There are currently no disincentives in Italy.

A1.4.4 *Regulations and Policies*

There are no existing or forthcoming regulations favouring, or restricting the development of CO_2 capture and storage technologies. Also, there are no existing policies likely to be extended to include CO_2 capture and storage technologies.

This lack of regulatory framework may present a problem for the development of the technology. Mrs. Mara Angeloni added that it is necessary to promote a new regulation at National and Regional scale, according to the different authority on the territory, this aspect is enclosed in the National feasibility project on CO_2 capture and storage. Finally, it is interesting to note that Mrs. Mara Angeloni stated that CO_2 couldn't be considered a waste.

A1.4.5 *NGO/Public Awareness*

Italian NGOs display an open attitude towards the issue, but have recently also considered the issue at a technical level. In particular, Italian industry has a significant Oil & Gas sector focused on refinery and hydrocarbons processing R&D that could be relevant for the issue. Public perception of CO_2 capture and geological storage in Italy is understood to be positive.

A1.5 *THE NETHERLANDS*

A1.5.1 *Overview*

The Netherlands aims to achieve its climate change / CO_2 reduction policies through (in order of priority) energy efficiency, use of renewable, and clean fossil fuels. CO_2 capture and storage is regarded as part of the long-term solution by the Netherlands government. It is seen as a transition in the process towards a sustainable society with a focus on energy efficiency and renewable energy.

Representatives of the following organisations were interviewed for this report:

- Messrs. Bert Stuij, Stollwerk and Schreurs from the Netherlands Agency for Energy and the Environment (Novem), which manages Government initiatives on energy efficiency and the introduction of renewables, as well as clean fuels technology;
- Mr. Fokke Rispens, from the Ministry of Economic Affairs (Minez), which aims to ensure the reliable, affordable and clean supply of energy; and

A1.5.2 *Financial Incentives for R&D, pilot and demonstration projects*

A number of CO_2 capture and / or storage R&D and pilot projects have been funded through Government programmes, with increasing EU financial assistance. Besided Ecofys, TNO and The Netherlands Institute of Applied Science, have obtained national (The Clean Fossil Fuel Program, managed by Novem) and EU funding for projects looking at issues such as:

- observation, monitoring and analysis of CO_2 sources in the subsurface (NASCENT);

- simulation models for CO_2 injection in aquifers (SACS), coal beds (CBM) and depleted oil and gas fields (EOR);
- inventory and analysis of CO_2 sources and transport / storage capacity in the subsurface (GESTCO).

In addition, the CRUST (CO_2 Reduction and Underground Storage) project[8] has carried out two feasibility studies looking at different technologies for gas field storage, one project is a Gaz de France project looking at offshore storage in the North Sea; the other looks at CO_2 storage in a depleted gas field onshore. It is on an experimental basis and one of the projects is expected to be carried out in 2004. The completed feasibility studies received a subsidy of € 0,143 million, and a further €11 million of funding has been earmarked for implementing the pilot project(s).

Box A1.1 is a summary of the existing studies carried out on the legal aspects of the CRUST project.

Box A1. 1 Legal aspects of underground CO_2 storage

Legal aspects of underground CO_2 buffer storage, CRUST Legal Task Force

As part of the feasibility studies for the CRUST project, the legal and regulatory aspects of underground CO_2 injection and storage in the Netherlands have been studied. The most comprehensive of these studies is the legal analysis of legislation and regulations relating to the CRUST project[9]. It was drawn up in collaboration with lawyers from the Dutch Ministries of Economic Affairs and Housing, Spatial Planning and the Environment, InfoMil and the CO_2 Reduction Plan Project Office (the CRUST Legal Task Force). It reflects the joint view based on the applicable Dutch legislation and regulations, case law and interpretation of the law. The main findings of this study are summarised below.

The purpose of CRUST is that " the CO_2 is stored temporarily (buffered) into the deep underground, with an option of reuse". Three different phases lead to the buffer storage of CO_2: conducting a scouting study; exploring for a suitable reservoir by means of drilling wells; and the storage.

The Dutch Mining Legislation and the Environmental Legislation form the legal framework for CO_2 buffer storage. The Mining Act and the Environmental Management Act; The new Mining Act; The existing Mining Legislation and the OSPAR Convention are considered the most relevant legislations for the CRUST project.

The Mining Legislation
The Dutch Mining act came into force on the 1St Jan 2003. It applies to the Dutch part of the continental shelf and territorial waters (i.e. it covers onshore and offshore storage).

Scouting study
Conducting a scouting study for CO_2 buffer storage does not require a licence under the Mining Act. Seismic surveys are allowed and cannot be tied to conditions on the grounds of the Mining Act. However, an agreement under private law between the party conducting the seismic survey and the landowner is required in order to carry out seismic activities. There may also be rules relating to seismic surveys on the basis of other regulations, such as the local authority byelaws.

Exploring for a suitable reservoir
The difference between a scouting study and exploration is that in exploration use is made of a borehole. Exploration for minerals requires, among other things, an exploration licence. This licence gives the licensee exclusivity in relation to exploring for minerals in a particular area during a particular period using a borehole.

Storage
The CRUST Legal Task Force's study concludes that the rules for storage from chapter 3 of the Mining Act are applicable to the CO_2 buffer project. Chapter 3 of the Mining Act specifically addresses the

licensing system for the storage of substances. It is prohibited to place substances underground without permission from the Minister of Economic Affairs (article 26 of the Mining Act). The grounds for refusing to grant a storage licence are referred to in article 28 of the Mining Act. These include such matters as the capacities and the qualities of the applicant and issues in the interests of safety, national defence and the systematic management of accumulations of minerals or geothermal energy.

In the context of storage, the study also looks at ownership in the case of storage, the duty of care, the mining environmental permit, soil movement, liability and claim settlement, as well as supervision and enforcement of the Mining Act. Further detail can be found in the document , which ERM has in its possession and will include in the list of documents sent to the CCP team as part of Task 4.

Environmental Aspects of underground CO_2 buffer storage

Waste
The study aims to determine what type of substance CO_2 falls under in the legal framework. In order to do so, the review analyses whether, in the case of CRUST, CO_2 comes into the classification as being waste. It concludes, "CO_2 can be classified as a waste in the context of underground storage". However, it further concludes, "CO_2 is (…) not a hazardous waste". The legal implication of this outcome is that after the Act of 21 June 2001 to amend the Environmental Management Act came into force, legally speaking the underground buffer storage of CO_2 is treated as an installation for the processing of waste – and will be stated as such by means of an order in Council – for which a declaration of no objections will have to be issued by the Minister of Housing, Spatial Planning and the Environment. According to article 8.1 of the Environmental Management Act, the Minister of Economic Affairs is the competent authority for granting a permit in so far as it concerns mining works in accordance with article 1 of the Mining Act.

Environmental Impact Assessment
With respect to the activities to be undertaken in the context of the CRUST project that there is an environmental impact assessment obligation in relation to setting up an installation for the placement deep underground of non-hazardous waste, and an environmental impact assessment appraisal obligation with respect to conducting deep drilling. The rules for environmental impact assessments can be found in chapter 7 of the Environmental Management Act and the Environmental Impact Assessment Decree. These regulations represent implementation of European Directive 85/337 relating to environmental impact assessments (as amended by Directive 97/11). It is stated in the Environmental Impact Assessment Decree that some activities require (unconditionally) an environmental impact assessment (appendix, part C), and that in relation to other activities the competent authority has an appraisal obligation (N.B. Dutch: 'beoordelings plicht') (appendix, part D). The preparation of an environmental impact assessment is always linked to an administrative decision.

Soil Protection Act
The decontamination regulation and the duty of care in article 13 of the Soil Protection Act apply to underground buffer storage of CO_2. Consequently, the study concludes, "all possible measures must be taken to prevent contamination. If there is nevertheless contamination, it must be cleaned up as quickly as possible whereby the quality of the soil has to be restored."

Other legal and regulatory framework assessments carried out on CRUST, by industry

Gaz de France
The assessment made by Gaz de France has shown that there are no weighty legal or social impediments against under-ground CO_2 injection. There are a few pending points that need to be addressed in the course of the project as well as some points that need further clarification, in particular the issue of the ownership of the injected CO_2. These legal considerations, combined with the remote location with no hindrance to third parties, will most probably result in short procedures and will thus enable the swift realization of a CO_2 injection facility. [10]

Shell and Nederlandse Aardolie Maatschappij (NAM)
According to the Shell/NAM's assessment, it is possible to discuss and deal with the existing legal barriers. One issue nevertheless remains a clear potential constraint: the operator's long-term liability for the storage location. Though NAM is prepared to operate safely and carry out control and monitoring activities, NAM wants to be able to transfer the liability to another party after a certain period of monitoring once injection into the storage facility has been stopped.[11]

A1.5.3 *Financial and Other Disincentives*

Mr. Cahens believed that one of the barriers to future CO_2 capture and storage development in the North Sea is the OSPAR convention, which makes experimental projects on a small scale feasible, but not projects at a large scale.

The main financial disincentive to the application of CO_2 capture and storage technology is the absence of a carbon trading system which would put a long-term value on each unit of stored CO_2. There appears to be little or no chance that such a system will be established in the Netherlands independent from the rest of the EU. The Dutch Government is supporting the establishment of an EU-wide system, as it is not felt that a national system would operate successfully at present.

The main barrier is the economics of the technologies involved. In order to overcome this barrier, a system must be established whereby stored CO_2 valued. This is only likely to happen if the Kyoto Mechanisms are set up at the EU, or the international level, and CO_2 capture and storage is reorganised in that system. The Netherlands is therefore likely to aim to influence the EU very strongly towards accepting CO_2 capture and storage in these Kyoto Mechanisms (*Section 1.1.4*).

A new Electricity Act is likely to come into force in January 2003. Current drafts of the Act suggest that a tax exemption worth approximately €140m / year will be established to support renewables, energy efficiency and climate neutral electricity, including CO_2 capture and storage.

A1.5.4 *Regulations and Policies*

Mr. Stuij and Mr. Rispens were confident that existing regulations would be sufficient to regulate activities. Pipelines and gas storage are not regulated through specific legislation; instead permits are established through a system whereby developers apply for concessions direct from central Government. For example, there are currently three natural gas storage (stockpiling) facilities in the Netherlands which are regulated through concessions. CO_2 transfer and storage would be regulated in the same way. CO_2 capture and storage projects would be subject to the same environmental, planning etc regulations as other energy-related projects (e.g. EIAs, permitting, etc.), and so regulations would not specifically discriminate against these types of project.

Existing laws on groundwater protection may prevent CO_2 storage in aquifers. It is very difficult to obtain permission to discharge waste products (e.g. wastewater) into aquifers, and CO_2 would be regarded as a waste (albeit a non-hazardous waste). However, given the considerable storage capacity available in gas / oil reservoirs, it is highly unlikely that it would be necessary to store CO_2 in aquifers.

The Environment Ministry is currently looking at CO_2 should be regarded as a waste. CO_2 is likely to be classified as a non-hazardous waste, and could therefore be disposed underground with a permit, but without penalty (i.e. like process wastewater is at present).

Although clean fossil fuel technology / climate neutral electricity is seen by the Netherlands Government to be an important part of its energy and climate change

strategy, the Government has yet to establish a clear policy on the issue. The Ministry of Economic Affairs released a Government White Paper on Clean Fossil Fuels on 24th September 2003. The White Paper's Accompanying Letter to the Parliament states that it seems there is no imminent need to take further Government action promoting the use of CO_2 capture and geological storage. However, it also recognises that, as more stringent CO_2 emissions reductions are required, CO_2 capture and storage will be considered as an option supporting the transition from a fossil fuel economy to one based on renewables. The Letter concludes that work on CO_2 capture and storage should begin now. The technology is seen as important because:

- the Netherlands has a large oil / gas sector, and the Government intends keeping production levels high for the medium-term;
- there is a very large storage capacity in offshore gas fields; and
- the Netherlands has a strong knowledge base on the issue, and would like to develop and market CO_2 capture and storage technologies worldwide.

Within the context of CRUST, a Framework for the safety and monitoring of a facility for underground CO_2 sequestration was published by TNO-NITG and ECN, May 2003. The report contains tables listing requirements from current legislations.[12]

A1.5.5 *Implications of the lack of regulatory framework*

A regulatory framework for CO_2 capture and geological storage projects will emerge as projects are developed. The most relevant existing legislation for CO_2 capture and geological storage is the Mining Act (*Box A1.1*). As CO_2 capture and storage projects emerge, leading to uncertainties with reference to the Mining Act, the Dutch Government will add articles to the Addition to the Mining Act, which explains specific Articles of the Mining Act.

A1.5.6 *Use of stored C as C credits for compliance in a domestic GHG regime*

A Government and Industry Committee is currently looking at the possibilities for the Netherlands to participate in an EU- wide Emissions Trading Scheme. Mr. Stuij believed that CO_2 capture and geological storage would be eligible for trading under such a scheme. Indeed, the forthcoming Government White Paper on climate change and clean fuels will establish that carbon sequestered through CO_2 capture and storage should be eligible for carbon credits in the EU Emissions Trading Scheme, which is expected to come into force in 2005. It is not clear that the European Commission or other EU member states share this view. Mr. Stuij added, however, that it is too early to establish whether a lack of rules for monitoring and certification of CO_2 capture and storage will prevent project developers to gain carbon credits from the project.

It is too early to say whether CO_2 capture and storage projects will be accepted under the Dutch GHG regime. It is also to early to state whether the projects will qualify under CERU-Pt and ERU-Pt, although one government official's personal view was that they could.

In principle, CO_2 capture and geological storage projects would be eligible for CERU- PT and ERU- PT (the Dutch Government's international tenders for CO_2 reduction projects under CDM and JI), but it is highly unlikely that these schemes

would invest in the technology, as the priority for the funds is (1) renewables, (2) energy efficiency, and (3) clean fuels.

NGO/ public awareness

Public perception of CO_2 capture and storage and the lack of understanding may impede the development of technologies associated with it.

As CO_2 injection is relatively new, the opinion of Dutch politics and non-governmental organisations (NGOs) should be derived from their programmes and from reactions to comparable developments. An assessment has shown that no strong impediments can currently be expected, though some NGOs are in opposition to the application of CO_2 injection and storage in general.

The CRUST feasibility studies state that a demonstration project may enhance awareness and support for this technique. Such a project could show that the injection of CO_2 is not an underdeveloped technological process, adding that the execution of such a (small-scale) test phase should be accompanied by a suitable monitoring and control system. The involvement of Government, political parties, environmental groups and other organisations during the demonstration phase is likely to enhance support and raise the attractiveness of large-scale injection projects.[13]

A1.6 *NORWAY*

A1.6.1 *Overview*

The Norwegian Government places a lot of importance on the use of CO_2 capture and storage technologies, as a means to curb CO_2 emissions. In particular, CO_2 capture and geological storage is mainly an issue the Ministry of Petroleum and Energy are interested in. The Ministry of Environment and the Ministry of Trade also have an interest in the issue, to a lesser extent.

The following individuals were interviewed for this report:

- Benedikte Lilleås, Peer Stiansen, Norwegian Ministry of Environment;
- Trygve Riis, Norwegian Research Council; and
- Mrs. Tone Skogen, Ministry of Petroleum and Energy.

The government officials interviewed had a positive outlook on the development of the technology and doubted that the current lack of policies and regulatory framework would hinder the development.

The Norwegian government issued a Parliament White Paper on gas utilization in Norway (1st November 2002), in which it commits itself to develop natural gas-fired power plants with CO_2 capture and storage technology, while pressing for an international “mandatory certificate market for green electricity”.

Indeed, an entire chapter in this Norwegian White Paper is devoted to CO_2 capture and storage, and the paper announces that the support for R&D and large-scale investments will be increased. Additionally, CCP is mentioned as "one of the most important international initiatives" and is given a separate box in the paper.

A1.6.2 ***Fiscal incentives for R& D, pilot and demonstration projects***

Introduction

CO_2 stored in geological structures is exempt from the Norwegian CO_2 tax. Indeed, the Norwegian CO_2 tax gives industry an incentive for CO_2 capture and storage. The CO_2 tax offshore (natural gas and fuel oil) is equivalent to approximately €34.8/ tonne CO_2 (US$40); CO_2 tax in transport (gasoline) is similar to offshore (about €34/tonne CO_2); for mineral oils it is generally €22 (US $25) with exemptions and special rates for some.

According to the white papers, the CO_2 tax is to be replaced by an emission trading system from 2008. The legal proposal on the Norwegian trading scheme may further clarify a number of issues in Autumn 2003. It will also outline how the Norwegian system will be linked to the EU Emissions Trading Scheme, which differs from the Norwegian White Paper in several aspects. "This system is expected to give an incentive for reducing CO_2 emissions (e.g. by CO_2 capture and storage)"[14].

At present the thinking is that if installations capture and store CO_2 (e.g. Sleipner), they will not have to surrender allowances.

Fiscal incentives for R & D

Promoting research, development and demonstration of technologies for capture and geological storage of CO_2 is considered an important task by the Norwegian government.

In 1997, the Government, through the Research Council of Norway, established a program called KLIMATEK – technology for reducing GHG emissions. KLIMATEK is a five-year $70 million Norwegian National Technology Programme aimed at promoting technology development for reducing greenhouse gas emissions. Several Norwegian initiatives for developing technologies for capturing and storage of CO_2 have received financing from the KLIMATEK-program. Currently, projects ranging from CO_2-separation and storage to direct biological fixation of CO_2 have been initiated. The yearly budget has increased significantly in the last two years, and this increase is primarily aimed at supporting development in the field of CO_2 capture and storage. Indeed, "*The petroleum and process industries are the key sectors in KLIMATEK but projects in other sectors are also welcome.*"

The objective of KLIMATEK is to encourage increased use of technology that reduces emissions of greenhouse gases. The main focus of the programme will be on demonstration of technology, with roughly 80% of the funds allocated for this purpose. The remaining funds will cover long-term research with a view to introducing a technology shift in the mitigation of greenhouse gas emissions.

Examples of projects under the KLIMATEC programme include:

- The NorCap project, which consists in developing and testing promising technologies for reducing the costs of separating and capturing CO_2 from fossil fuel combustion sources, plus its transport and storage. The overall aim of the

project is to develop and test promising technologies for CO_2 capture and sequestration. The project cost €8.92 m overall and is due to be completed by the end of 2003.

- A project on the *Separation of CO_2 Using Membrane Gas/Liquid Contactors*

- Development of the HiOx Technology: a project developing a power generation technology whereby oxygen if firstly separated from the air, followed by the combustion of natural gas and concentrated oxygen in an atmosphere of recirculated exhaust gases. A concentrated CO_2 stream is produced. The overall project cost is €4.33m.

For several years Norwegian governments have attached great importance to stimulating the development of new technological solutions for the removal and disposal of CO_2 from major sources, like gas-fired power plants. Two White Papers on Norwegian climate policy (Report No. 54 (2000-2001) and Report No. 15 (2001-2002)) and one White Paper on domestic use of natural gas (Report No. 9 (2002-2003)) all show that a strategy for enhancing the development of gas-fired power plants with CO_2 capture and storage is a main element in the Government's climate and energy policy. For further information, contact the Ministry of Petroleum and Energy.

The recent White Paper on use of natural gas proposes substantial incentives for gas power with CO_2 separation and storage:

- R&D support (proposed for 2003) of approximately $6.5 million.

- Investment support, which is not fixed, but as an example mentioned in the White Paper: a 400 MW gas power plant could get a $200 million grant, over 5 years (i.e. $40 million per year), which is similar to what the current Government promised before the elections in 2001.

- The White Paper indicates a governmental initiative to establish a CO_2 infrastructure for transport of CO_2 to storage facilities for EOR or storage. No funding has been mentioned, but studies are being prepared.

- Support to demonstration plants: the exact size of the grant was not given, but substantial grants are expected. The government expects a demonstration plant in 2006.

Pilot and demonstration projects

Norway's draft budget for 2004 was presented on the 8th October 2003. In it, the government proposes allocating NOK 50 M to an "*increased commitment*" to research related to carbon sequestration for gas-fired power plants. The draft budget is still under negotiation and the final outcome of the negotiations will be included in this report when they are published.

Whereas the Government provided €4.9 M (40 M NOK) for CO_2 capture and storage in 2003, the initial budget proposition suffered major cutbacks during the period of negotiations. Indeed, in 2003, a proposed €6 M (50 M NOK) from the Ministry of

Petroleum and Energy was cut back to €2.4 M (20 M NOK): the total of €4.9 M was made up with the help of other Ministries. The amount of €6 M was recently agreed upon for CO_2 capture and storage R&D, pilot and demonstration projects in the 2004 National Budget.

The Government also handed out €1.9 M (16 M NOK) for early demonstration projects in summer 2003 (this had been agreed in 2002). The money went to Statoil, NorskHydro and several other smaller projects. These projects aim to study power production, CO_2 capture and CO_2 sequestration.

To date, the Sleipner project is still the only existing demonstration project in Norway.

Norwegian companies and research institutions have, for a long time, been working on ways to cut emissions below the levels achieved by today's best available technology for gas-fired power production. For example, Statoil, Norsk Hydro, Kværner and Aker Maritim have been developing technology for CO_2 separation from exhaust gases from turbines or CO_2-efficient gas-fired power production.

Norway has also been at the forefront of research into the storage of CO_2 in geological formations:

Existing projects

The Sleipner West injection: The first commercial-scale storage in a deep saline reservoir commenced operation in 1996, offshore Norway. This has been established by Statoil as part of their development of the Sleipner West gas field. In this plant, 1 million tonnes / year of CO_2 are being removed from a natural gas stream using a solvent absorption process and injected into the Utsira formation, 800 metres below the seabed. The project is part of the Saline Aquifer CO_2 storage-project (SACS). The project has received financing from KLIMATEK, as well as EU and the IEA Greenhouse Gas R&D Programme.

Expected projects

Underground storage of carbon dioxide at four locations on land: The experience from the Sleipner-project will be used to investigate possibilities for underground storage of carbon dioxide at four locations on land. One of the possible locations is at the coast of mid-Norway. The project, which starts this autumn, is part of Saline Aquifer CO_2 storage-project (SACS) under the IEA Greenhouse Gas R&D Programme.

The Snøhvit injection: Statoil and its licence partners have decided to develop Snøhvit natural gas field in the Barents Sea. CO_2 is to be captured from the natural gas during the processing to LNG and sent back to the Snøhvit field for storage.

A1.6.3 *Disincentives for CO_2 Sequestration*

There are no specific disincentives for the development of CO_2 capture and storage projects in Norway. It is unlikely that the Norwegian Government will establish such disincentives in the future.

A1.6.4 ***Regulations and Policies***

The NVE, the Norwegian Energy and Water Authority, gives concessions for power plants. It has already given concessions to three gas fired power plants (without CO_2 capture and storage). Mr. Riis speculated that it shouldn't be a problem to obtain permission for building power plants with CO_2 capture and storage, although the usual environmental regulations would apply to such project, as they do for other projects. Norway has gained a lot of experience on installing huge gas pipelines linked to the rest of the EU continent: pipeline regulations are unlikely to present a major challenge to CO_2 transport.

A1.6.5 ***Implications of the Lack of Regulations***

To date, the Ministry of Environment has not undertaken a discussion on the regulations applying to CO_2 storage in geological formations. There are no specific rules and regulations for CO_2 capture and storage projects in Norway.

To date, the regulatory framework for the Sleipner field project are an extrapolation of existing regulations. The framework for regulations on CO_2 capture and storage projects in Norway has not been formalised yet. The current framework is a result of informal deliberations between project developers (i.e. companies), the Ministry of petroleum, and the ministry of Environment. Up till now Statoil's discharge permit for the Statoil-run Sleipner West field, has not covered CO_2-emisissions at all – neither CO_2-emissions to the atmosphere nor CO_2 injected into the Utsira formation. This seems to be in line with the general practise under the Pollution Control Act. Greenhouse gas emissions are a form of pollution as this is defined in the Pollution Control Act. As a general rule, such emissions must therefore be regulated, i.e., companies that generate greenhouse gas emissions must be licensed to do so, either by obtaining a discharge permit or through regulations pursuant to the Pollution Control Act.

Until now, few requirements to reduce emissions of greenhouse gases have been included in discharge permits that have been issued pursuant to the Pollution Control Act. This is mainly due to the fact that the petroleum companies are levied a CO_2-tax on the emissions related to the activities on the shelf. However, discharge permits, including Statoil's, will be somewhat revised in near future. In the revising process Statoil will have to apply explicitly for permission to store CO_2 in the Utsira formation.

As a party to the OSPAR Convention, Norway will follow the discussions regarding geological storage of CO_2 under the Convention.

Mr. Riis believes that the lack of regulations presents a hindrance to the development of the technology: it is essential that the OSPAR Convention process reaches an agreement on the issues currently being discussed (see *Section 2.5*).

Mr. Stiansen agrees that it would have been nice to get an international consensus on the issues raised by OSPAR, but the development of the Sleipner project in Norway demonstrates that the lack of regulatory framework for CO_2 capture and geological storage is not affecting the development of the technology.

No decision has been taken on how to tackle the issues raised in OSPAR to date: Norway has postponed making such decisions until after the next meeting of the Group of Jurist Linguist, which is taking place in a few weeks

A1.6.6 ***Use of stored carbon as carbon credits, or for compliance in a domestic GHG regime***

The views of government officials interviewed for this study differed on this issue. Mr. Peer Stiansen argued that this is unlikely to happen in the context of the Norwegian emissions trading scheme, which is scheduled to be introduced in 2005.

Mrs. Benedikte Lilleås kept an open mind, adding that for projects regarding sinks as for other projects, it is important that the project owner is able to document the effects. One condition for recognising the use of sinks as a way of removing emissions would therefore be that the project owner provides documentation showing if/to what extent CO_2 stored in sinks returns to the atmosphere.

It is to early to tell how Norway will treat CO_2 capture and geological storage under the EU Emissions trading scheme. Whereas it is still not clear whether CO_2 capture and storage will be accepted under a domestic GHG regime, it is clear that the only current incentive for project developers to invest in such projects is the prospect of receiving C credits in compliance with a domestic or international regime.

Furthermore, the establishment of rules for monitoring and certification of CCS projects will be essential for the project developer to obtain valid carbon credits.

A1.6.7 ***NGO and public awareness***

The last minute veto from Norway's environment minister, Børge Brende, scuppering what would have been the world's first attempt to demonstrate sequestration of carbon in the oceans by injecting liquid CO_2 into the Norwegian Sea, was widely publicised. It is important to note that this veto involved **ocean** disposal of CO_2, **not** geological storage.

This has important implications on the attitude of Norwegian NGOs and public opinion towards CO_2 geological storage, as the issue of CO_2 storage has so far mainly been addressed in relation to ocean storage, rather than underground storage, and many NGOs and the public have not yet studied the issue in enough detail to understand the difference. Among the environmental NGOs, Greenpeace in Norway has a skeptical position on CO_2 storage, which has been reflected in Norwegian media. Although the technique of geological storage is completely different from ocean storage, some NGO attitudes in Norway do not yet appear to recognise the difference.

Again, the general public is not aware of the development of CO_2 capture and storage technologies. However, the media have made positive references to Statoil's Sleipner West-projects.

The fact that a major international NGO (Greenpeace) is strongly against the principal of CO_2 capture and storage could be a major concern for Norwegian project developers. To date, other NGOs have been silent on the subject in Norway.

Public awareness on the subject is currently not very high. Once more pilot and demonstration projects are in place; the general public is likely to take more of an

interest in the subject. Although government officials interviewed believed that the public perception would be positive, it is difficult to predict. An interesting illustration is that of windmills: the public view on wind power was positive in Norway until windmills were being built and the public displayed signs of protests. A NIMBY (Not In My Back Yard) attitude can be expected from the Norwegian public.

A1.7 *UNITED KINGDOM*

A1.7.1 *Overview*

In the UK, representatives of the DTI, DEFRA, and the British Geological Survey were interviewed.

There is a clear momentum towards giving the area of CO_2 capture and geological storage serious consideration in the UK as a longer term means of reaching the Government's target of 60% reduction in greenhouse gas emissions by 2050. The most significant event in the UK has been the publication of the recent UK Energy White Paper, which recognised the longer-term strategic importance of CO_2 capture and storage as a potentially valuable contribution to the achievement of its target.

However, several issues need to be resolved before pilot and demonstration projects can be considered. R & D is currently being carried out to assess whether such projects are feasible in the UK context.

The DTI *Performance and Innovation Unit Energy Review* have recently published a study on the feasibility of storing CO_2 emitted from power stations in depleted oil and gas wells in the North Sea. The final report is now publicly available on the DTI website, at http://www.dti.gov.uk/energy/coal/cfft/co2capture/review.pdf [see also *Box A1.2* below]. This review contains all aspects of the UK position on the issue of CO_2 capture and geological storage.

There are two main official groups influencing the decision making process and studying the issues surrounding CO_2 capture and geological storage in the UK:

- the UK CO_2 Capture and Storage Feasibility Study Advisory Group, a government-funded group, and
- the Power Sector Working Group, which is funded by industry and provides advice to the UK Department of Trade and Industry (DTI) .

The main issues to be resolved are (1) whether the OSPAR convention will constitute a legal barrier to these projects; (2) whether the negative public perception may be changed. Both these depend directly on being able to demonstrate that CO_2 can be reliably stored in geological strata beneath the North Sea. Another concern is the economics of CO_2 capture and storage and whether it may be rendered more profitable to project developers. It is expected that over time (possibly 10 to 20 years) the costs of the technology will be reduced.

Several developments relevant to CO_2 capture and storage occurred in the UK in 2003. The UK White Paper on Energy Policy published in February 2003 recognises that the amount of hydrocarbon that would be recovered from the North Sea using EOR would be significant; it recognises the need for an important deployment

around the technologies; it states that there is no future for coal fired power plants in the UK unless it is combined with CO_2 capture and geological storage; and recommends that the DTI compile a demonstration plan in cooperation with industry. The latter would be a 6-month plan, starting when the UK CO_2 Capture and Storage Feasibility Study Advisory Group completes its first study (published in September 2003). The DTI demonstration plan could be finished by February 2004, depending on the amount of government money and industrial help the DTI would receive.

The UK CO_2 Capture and Storage Feasibility Study Advisory Group has recently published its first study. This paper is a significant step for CO_2 capture and storage in the UK (*Box A1.2*). It contains a generic economic study; a statement about legalities; an overview of technologies and an implementation plan.

Box A1.2 Review of Feasibility of CO_2 Capture and Storage in the UK

The review sums up the UK position on CO_2 capture and geological storage at this stage. It is important to emphasise that the review is focussing on the long-term use of CO_2 capture and storage as a mitigation option. Indeed, the report concentrates on timeframes of 2020 and beyond. There have been no pilot or demonstration projects in the UK to date, and none are planned for the near future.

The Energy White paper sees a large-scale deployment of CCS being required from about 2020 onwards. However, the DTI review adds that two factors may lead to earlier deployment. Firstly, EOR is extensively discussed in the report. Secondly, the normal replacement of capital stock in electricity generation, which may permit the construction of plant suited to carbon capture presents a major opportunity for the UK to create a world-leading low carbon energy design, construction and skills capability.

To ensure the technology is available and cost effective when it is needed, several issues need to be resolved. The DTI review provides views on legal and regulatory issues; environmental impact; economic barriers and emissions trading; acceptance in the context of international emissions inventory methodologies; further development of the technologies; and better understanding by the public of what CCS means for them. Most of these are expressed in this analysis (see below)

The review also looks at the Technology Status; Environmental, Economic and Social Factors; Strategic Position of the technology (in UK GHG mitigation policy and at the international level).

Source: Review of Feasibility of CO_2 Capture and Storage in the UK, Cleaner Fossil Fuel Programme, DTI, September 2003.

In general, it is clear that *"There is a lot of political will for CO_2 capture and geological storage to happen. We are definitely going to see a UK operation with CO_2 capture and storage, and a power plant (IGCC) in this decade: there are a few very mature proposals around".*[15]

A1.7.2 *Fiscal incentives for R& D, pilot and demonstration projects*

There are several small grants available from the Tyndall Centre and the Carbon Trust. However, additional funding is being restrained until the EU has reached a decision as to funding would constitute State Aid.

The Climate Change Levy (CCL) is an energy tax which exempts renewable energy. It is based on energy values, rather than carbon contents.

The UK's energy minister, Brian Wilson, recently stated:

"The UK has often taken the technological lead in new sustainable technologies, but failed to capitalise on it. I am determined to convert that know- how into real projects which help reduce the effects of climate change".

The British Geological Survey is looking at refining at Grange mouth refinery. AEA, a consultancy, is looking at modelling BP's oil fields.

A1.7.3 *Disincentives for CO_2 Sequestration*

The New Electric Trading Arrangement (NETA) has led to a decline in the price received by generators by between 30 and 40 percent since its introduction in April 2002. This decline in prices means that it is very unlikely that new plants suitable for CO_2 capture will be commissioned in the coming years. Retrofitting existing plants, although feasible, is unlikely, as the payback period of CO_2 capture equipment is not attractive, and can even be greater than that of most of the existing large coal fired plants in the UK.

A1.7.4 *Regulations and Policies*

Along with the regulations set by the OSPAR and the London Conventions, there could be possibly some NIMBY (Not In My Back Yard) resistance to planning applications for CO_2 geological storage projects: if the public does not agree with the projects, the local planning authorities are less likely to authorise a planning permission for disposal of CO_2 in geological structures. This resistance has been clearly seen in association with renewable energy applications and tends to be influenced by people's rejection of the technology rather than just the local impacts.

The UK White Paper on Energy Policy published in March 2003 recognises the need for investing in CO2 capture and geological storage. Also, the UK CO2 Capture and Storage Feasibility Study Advisory Group has published its first study in September 2003. This paper is a significant step for CO2 capture and storage in the UK: it includes recommendations for the long- term implementation of the technology in the UK. A number of policy measures are underway and a strong momentum towards including CO2 capture and geological storage in the UK climate change mitigation options portfolio (in the long- term) is apparent.

A1.7.5 *Implications of the Lack of Regulations*

Although the UK has not yet developed policies specifically aimed at CO_2 capture and storage, it seems to encourage a move in that direction. It is clear that such a regime needs to be developed if the technology is to be adopted Research is currently concentrated on the basic issues of legal barriers, cost effectiveness, and public perception of the projects. The BGS does not foresee any legal barriers to the development of the technology.

The current lack of regulatory framework around these technologies may imply that only small demonstration projects would be possible during the continued period of regulatory uncertainty.

On the subject of clarifying and amending the London Convention and OSPAR, the UK DTI stated in its recent paper that the UK should take the lead to establish international collaboration on this subject. It is in this frame of mind that the UK DEFRA organised a conference (13th and 14th October 2003) on OSPAR aiming to push for Member States to reach a consensus on the issues still under discussion.

A1.7.6 ***Use of stored carbon as carbon credits, or for compliance in a domestic GHG regime***

There have not been any decisions made in the UK on the eligibility of such projects for compliance in the domestic GHG regime (UK ETS).

Based on a series of e-mails between the IEA and the European Commission, Dr. Riley, BGS, anticipates that geologically stored CO_2 will be recognised under the EU ETS, provided that it can be verified that the CO_2 will stay underground. BGS also suspect that the commission will follow the Norwegian precedent, which recognises reduced emissions through the Sleipner project. However, the EU position, presented in *Section A 1.1* above, does not provide as much encouragement as the comments received in the UK about the EU.

On the issue of Acceptance into the Emissions Inventory Estimates used in National Reporting and the Flexible Mechanisms, the DTI *Review of Feasibility of CO_2 Capture and Storage in UK* states:

"A key to CCS becoming commercially viable is obtaining credits for its abatement of CO_2 emissions, thus providing a financial return to investors in the technology. To qualify under schemes designed to reward emissions abatement (eg the EU's Emissions Trading Scheme) internationally acceptable methods or monitoring, reporting and verification will have to be developed"

(…)

"Ultimately the take-up and deployment of CCS technologies will depend on acceptance of their effectiveness and on how verifiable they are. This needs to be achieved firstly in the production and verification of national emissions inventories under the UN-FCCC and the Kyoto Protocol, and secondly at the entity level for emissions trading. The two requirements are of course linked and the following need to be addressed:

- *agreed inventory methods to cover the operating period of a CCS technology*
- *agreed inventory methods to cover the continued sequestration of the CO_2 after injection into the storage medium, including checking and verification*
- *establishment of a system for redress that could be applied within emissions trading schemes should any leakage of CO_2 occur."*

Concerning monitoring and certification of CO_2 reductions in a CO_2 capture and storage project, rules exist for EOR, but there are no existing rules for dedicated storage. However, it is very likely that such rules will be derived from the existing rules for underground gas storage (e.g. natural gas).

A1.7.7 ***NGO and public awareness***

Whereas Greenpeace UK sustains its negative outlook on the technology, several other NGOs have expressed their willingness to look into CO_2 capture and geological storage, as long as ocean sequestration is kept out of the question.

Greenpeace's skepticism is mainly based on the fact that they believe that the flow of investment being directed towards the development of CO_2 capture and storage technologies could be invested into renewable energies and efforts to reduce CO_2 emissions at source. Greenpeace also believes that this option does not result in a decrease in the rate of oil and gas exploration, leading to concerns over other environmental issues. Finally, they expressed their concerns on the uncertainties surrounding geological storage technologies, particularly concerning the issue of permanence of the storage.

Public awareness is rising on the subject. Public concern over CO_2 geological disposal infrastructures being developed around the UK is rising. NIMBY could also be an obstacle to planning consent.

The DTI *Review of Feasibility of CO_2 Capture and Storage in UK* states:

"There is a role for government in helping to raise public awareness of CCS technologies. This should be done once the environmental issues are better understood and should involve bringing together technology developers and users with external stakeholders including local government, the regulatory authorities, national and regional media and NGOs. Dialogue with stakeholders should include exchange of information on progress with the technologies, the increasing knowledge base on the benefits and impacts of CCS and views on the location and options for their deployment".

A1.8 *USA*

A1.8.1 *Overview*

Representatives from six states were interviewed in the US, including California, Utah, New Mexico, Texas, Ohio, and Oklahoma. State regulations relevant to geologic sequestration of CO_2 were reviewed for each of the six states. In addition, interviews were conducted with representatives from the from the EPA, researchers working with the U.S. Department of Energy on CO_2 sequestration projects, the US Department of Energy Office of Fossil Energy (OFE), and the Department of Energy National Energy Technology Laboratory (NETL). All funding for research and development of geologic sequestration programs in the United States is allocated and managed by these organizations. NETL receives its funding from OFE. Industry leaders have contributed to a number of NETL research and pilot programs in the recent past; however, no other independent sources of funding for sequestration R&D exist in the U.S outside of the DOE.

The use of deep geologic repositories for permanent sequestration of CO_2 is a relatively new concept for most state and federal regulators in the United States. While the injection of CO_2 for enhanced oil recovery (EOR) is a well-established practice in oil-producing states and CO_2 injection for enhanced gas recovery is being developed by the Department of Energy (DOE), the use of geologic repositories for reduction of atmospheric greenhouse gasses has not gained widespread acceptance as an economically viable alternative. Regulations are in place in all oil-producing states for CO_2 use in EOR projects under individual state and / or federal Underground Injection Control (UIC) programs.

There are no formal or codified financial incentives, such as tax benefits or subsidies, at the state and federal levels for industry to undertake carbon sequestration projects.

Potential disincentives are present, however, in the form of federal and state laws, regulations, and guidelines established to complete environmental reviews of major projects, regulate waste disposal, and regulate storage of petroleum products (including natural gas) through underground injection.

Still, pilot and demonstration projects in the US are continuing to develop and emerge.

At present, more than 70% of all electricity produced in the United States comes from fossil fuel burning, including coal, natural gas, and oil. Coal alone accounts for more than 50% of the electricity generated in the US, and more than 90% of all coal produced is consumed in power plants scattered around the country. By all accounts, the demand for electricity in the U.S. is anticipated to continue growing into the foreseeable future and the vast resources of domestic coal will likely play an important part in meeting this demand. By some estimates, the U.S. has enough coal in reserve for the next 250 years at the expected consumption rate.

Recognizing this high level of dependence on high-carbon fossil fuels, the Bush Administration recently announced a climate change goal to significantly reduce (18 percent reduction by 2012) the greenhouse gas intensity of the domestic economy over the next 9 to 10 years, while at the same time sustaining growth in the economy that will support investment in innovative "clean energy" technologies.

The U.S. Department of Energy has been tasked with developing and implementing a strategy to achieve the President's objectives. The DOE approach involves technology development and mitigation strategies to: 1) create more energy efficient systems, and 2) capture and sequester CO_2 and other greenhouse gases. The Carbon Sequestration Program, within the Office of Fossil Energy, has been in place since 1997 and has overall responsibility for geologic sequestration programs. With the recently proposed increases in the FY-04 budget for sequestration research and development, the Administration has sent a clear signal that it intends to fund and pursue this pathway:

(...) "our investment in advanced energy and sequestration technologies will provide the breakthroughs we need to dramatically reduce our [greenhouse gas] emissions in the longer term." President George W. Bush; Global Climate Change Policy Book; February 2002

Research and Development: U.S. Approach and Budget

The US budget for the FY 2004 has been agreed upon. It includes funding of $62 M (an increase of $18 M over FY 2003) to the capture and disposal of CO_2 emissions. This covers the funding of R&D and demonstration projects. President Bush's Committee of Advisors on Science and Technology (PCAST) stated "*A much larger science-based sequestration program should be developed. The aim should be to provide a science-based assessment of the prospects and costs of CO_2 sequestration. This is a very high risk, long term R&D that will not be undertaken by industry alone without strong incentives or regulations…*"

The Carbon Sequestration Program FY 2004 objectives focus on the following areas:

- Development of capture and separation technologies
- Development of infrastructure needed for large-scale deployment of GHG mitigation strategies
- Funding for open competitive grants for research into carbon capture, separation, and sequestration
- Pursue sequestration strategies that support "zero-emissions" energy facilities
- Pursue global public / private R&D partnerships
- Accelerate development of the Regional Sequestration Partnerships
- Accelerate Novel Sequestration Systems R&D

As part of the Congressional FY2004 budget proposal, the following specific performance targets for geologic sequestration were established:

- **FY 2003 Update**

  - Establish a database for mid-continent planning of geological storage projects
  - Evaluate integrated sequestration concepts, including enhanced coal bed methane recovery, mineral carbonation, and CO2 flooding during enhanced oil recovery
  - Establish initial recommendations for long-term monitoring of sequestered CO2 to assure public acceptability
  - Complete initial planning, field testing, and / or analysis of sequestration concepts involving saline aquifers

- **FY 2004 Targets**
  - Initiate start-up of at least five regional sequestration partnerships to identify best regional technology options and source / sink locations for capture and sequestration
  - Complete site design and development for slant-hole application for coal seam sequestration; complete deep well and geologic characterization in saline aquifer in West Virginia to quantify storage potential and validate sequestration options

The $62 million budget for FY 2004 was recently accepted in the final budget. Of the $62 million, the Focus Area for Carbon Sequestration Science will see a slight decrease from the FY2003 budget:

- FY 2002 : $5,000,000
- FY 2003 : $7,425,000
- FY 2004 : $6,930,000

The Bush Administration and Department of Energy have engaged the private sector in a significant new initiative through the regional partnerships designed to develop the necessary infrastructure and regional knowledge base for carbon sequestration. The OFE has described the Regional partnership program as follows:

> *The Regional Carbon Sequestration Partnership is a field activity that would (1) determine opportunities and benefits of carbon sequestration to a region, (2) "baseline" a region for emission sources and sequestration potential, and (3) establish monitoring and verification protocols for possible future credits and assurance of the permanence of sequestration. Regional Carbon Sequestration Partnerships consist of academia, national laboratories, energy producers and*

users, and state and local agencies. The partnerships would focus on land-based sequestration approaches and be geared towards providing data required for large-scale field experiments to ensure the long-term safety and environmental effectiveness of specific sequestration approaches.

DOE feels that the Regional Partnership Program has a number of benefits, including acceleration of development and implementation of carbon sequestration technologies through university, industrial, and national laboratory partnerships; enabling the application of appropriate monitoring to predict, verify, and validate the safety, permanence, and environmental performance of sequestration; and facilitating public acceptance by acquiring field data and showcasing sequestration technologies and program successes. Such a regional sequestration network will also represent a good opportunity for the United States to assist developing countries in their efforts to reduce GHG emissions according to OFE.

Geologic Sequestration Options

Geologic storage is a form of "direct sequestration" that relies on the condition and characteristics of natural geologic materials to function as a long-term, if not permanent repositories for CO_2 gas. In the US, research and development programs are focusing on three principal options for geologic sequestration:

- Oil and gas reservoirs
- Un-mineable coal seams, and
- Saline aquifers

A fourth option (shale-hosted sequestration) is gaining a modest level of interest at the University of Kentucky.

Oil and gas reservoirs have long been a repository for CO_2 as a means of enhancing oil recovery (EOC). The US injects over 32 million tons of CO_2 per year into oil and gas reservoirs (over 74 individual projects) in an effort to extract additional hydrocarbons. Most of this CO_2 is captured from natural reservoirs, but a small amount is derived from natural gas and ammonia plants. Oil and gas reservoirs represent an attractive option for CO_2 sequestration, given the infrastructure often in place, the proximity to some source areas, and the known geologic characteristics of oil and gas bearing strata. Hydrocarbon reservoirs tend to have excellent gas retention characteristics as well, minimizing the concern that future leakage of CO_2 will occur. The potential to capture additional marketable hydrocarbons in the process makes the economics of this form of sequestration particularly attractive.

Coal deposits typically contain significant quantities of methane adsorbed onto the surface of the coal. Injection of CO_2 into un-mineable coal seams represents a sequestration option that would have net-positive financial benefits, as CO_2 will displace methane, making it amenable to extraction. Some estimates place the amount of coal in the US at over 6 trillion tons, 90% of which is unmineable using today's technologies and current economics. In further support of coal-seam sequestration, many of the power plants producing the majority of CO_2 emissions in the US are located in close proximity to coal seams in the subsurface. Proximity of sinks to sources will be an important consideration in the evaluation of individual project feasibility.

CO_2 sequestration in deep saline aquifers is not a value-added approach to long-term storage, in that no marketable by-products are generated to offset the cost of sequestration. Saline formations do, however, have a number of favourable attributes that make them worth serious consideration. First, saline aquifers are very common in many parts of the United States; therefore, proximity to sources of CO_2 is not likely to be a major concern. Secondly, the capacity for sequestering CO_2 in deep saline aquifers is enormous. By some estimates, there is sufficient saline aquifer capacity in the United States to store up to 500 billion tons of CO_2. Finally, the oil and gas industry has, for many years, injected CO_2 from production operations into deep saline aquifers, building a significant knowledge base from which to draw important lessons and information. The U.S. EPA has viewed deep underground injection of waste materials into saline aquifers with a certain amount of favour over the past 20 years, providing there is sufficient data to demonstrate a limited potential for adverse impact to other aquifers. Prior studies have identified a number of issues as possible economic problems with CO_2 sequestration in saline aquifers, including the injection rate and pressure required to achieve the necessary throughput, and the potential for long-term containment. These and many other issues need to be resolved through R&D work to prove the economic viability of saline aquifer injection.

Research and Development Pilot Programs

EOR represents perhaps the best and most cost-effective opportunities for pilot testing sequestration concepts. An excellent example of enhanced oil recovery coupled with sequestration of anthropogenic CO_2 is the Weyburn Project in Saskatchewan, Canada. A large coal gasification plant in North Dakota generates CO_2 that is then transported over 200 miles north via pipeline to the Weyburn oil field. Initial plans are for delivery and sequestration of over 5000 tons of CO_2 per day. It is anticipated that the EOR will result in an additional 122 million barrels of oil extracted from the reservoir. This is one of four projects in the US, out of 74 EOR projects, where anthropogenic CO_2 (from gas processing and fertilizer plants) is sequestered. The others use naturally occurring CO_2 from hydrocarbon recovery. The Weyburn project is also the first international, cross border transfer of CO_2 for emission reduction purposes.

In July 2003, DOE announced that drilling had commenced on an evaluation borehole at the American Electric Power (AEP) Mountaineer Plant in West Virginia. AEP, together with NETL, Battelle, BP, Schlumberger, and others, are undertaking a program to evaluate geologic conditions in a deep saline aquifer below the plant for CO_2 sequestration. Data generated from this study will be used to perform risk assessments, computer simulations, and support design and permit applications for long term use.

Statoil is currently operating the only full-scale commercial geological sequestration project in the world at their North Sea Sleipner West gas field. Approximately 1 million tons of CO_2 are injected annually into the saline Utsira Sand. This amount is roughly equivalent to the annual output of a 150-megawatt coal fired power plant. Initiated in 1996, this project marked the first instance where CO_2 injection was conducted largely for climate change considerations. Additional saline formation injection and sequestration studies are under way at Battelle, University of Utah, Texas Tech University, and the University of Texas.

Coal bed methane capture and production using CO_2 was field tested starting in the late 1990s at the Allison Unit in New Mexico. Over 100,000 tons of CO_2 were injected into this coal field over a three year period. Results from this study indicate that methane recovery from the coal field could be boosted by 75%. Enhanced coal bed methane production (ECBM) using CO_2 and nitrogen mixtures has been examined by the Alberta Research Council working with the IEA Greenhouse Gas R&D program. The initial field activities consisted of a single test well, designed to measure reservoir properties and increase primary methane production by hydrofracturing. Other research programs for enhanced coal bed methane production and CO_2 sequestration are under way at Battelle, ORNL, BP, the Geologic Survey of Alabama, Penn State, and Oklahoma State University.

Recent efforts to react CO_2 with other naturally occurring minerals to produce stable carbonates has met with interesting results, but the time frame for mineral reaction appears to be prohibitively long. The advantage of this approach is that the CO_2 would be stored for geologic periods of time that could be considered "permanent".

The NETL is currently involved in two pilot-scale programs in the southern US that focus on monitoring of CO_2 plumes in the subsurface. The Texas Bureau of Economic Geology (with NETL) is about to conduct a pilot program at an abandoned oil field by injecting CO_2 into a deep saline aquifer. The program is relatively small in scale, but important in terms of developing an understanding of CO_2 plume behavior and migration in saline formations. Strata Oil Company has recently completed a pilot injection program in New Mexico (with NETL), injecting approximately 2100 tons of CO_2 to monitor behavior and migration in an abandoned oil field.

Future Steps

In DOE's view, there are a number of important drivers for the continued support of R&D projects in the US. Among them:

- Development of reliable and cost-effective systems for monitoring CO_2 migration in the subsurface
- Assessing and ensuring long term stability of CO2
- Reducing the cost and energy requirements of CO2 sequestration [Note: DOE's goal is to reduce the cost by nearly an order of magnitude, from $100 or more per ton sequestered to $10/ton]
- Gaining public acceptance for geologic sequestration

Among DOE's the most pressing needs for continued R&D work are the following:

1. Fundamental research to aid understanding of critical processes and parameters that will contribute to safe and effective CO_2 sequestration
2. Reliable assessment of geologic formations available for sequestration from major power generating regions of the US; screening criteria for selection must be developed in partnership with industry, the scientific community, the regulators, and the public
3. Pilot tests of geologic sequestration are needed to help develop cost and performance data and help prioritize future R&D efforts and spending
4. Geologic analogues should be studied to determine the factors leading to caprock integrity issues and mineral trapping mechanisms

5. Advances in technology needed to: increase the volume of the geologic formations filled by CO2; create stable long term sinks; increase solubility of CO2 to acceptable levels
6. Full-scale demonstration projects in partnership with industry that integrate CO2 separation, transportation and sequestration.

A1.8.2 *Fiscal incentives for R& D, pilot and demonstration projects*

At present, there are a limited number of state-funded and/or federal research grants specifically earmarked for CO_2 sequestration projects in the United States. Included among these are several small pilot programs funded largely by the U.S. DOE. For example, the University of Texas Bureau of Economic Geology, is in the planning and permitting stage to undertake the first U.S. based demonstration project for CO_2 injection specifically designed for GHG reduction. Lead investigators Sue Hovorka and Paul Knox are currently working through the National Environmental Policy Review (NEPA) process, and must complete all Texas Class V Underground Injection Control (UIC) well permit stipulations prior to beginning the pilot program. The pilot program team involves researchers from several DOE facilities, including Lawrence Berkeley Lab, Lawrence Livermore Lab, Oak Ridge National Lab, and Sandia. The proposed site is located in the high permeability sandstones (non-oil bearing) of the Frio Formation in gulf coastal Texas. DOE is currently looking for other pilot program opportunities in California.

The economics of injecting CO_2 at the "well-head" for enhanced oil recovery favour this practice. In 2001 alone, the state of New Mexico EOR programs (using CO_2 and water) recovered over 13 million barrels of oil that would otherwise remain in the reservoirs. The U.S. is the world leader in EOR technology, using over 32 million tons of CO_2 per year for this purpose. Similarly, coal-bed methane recovery through CO_2 injection may be financially viable in the future. Researchers have shown that CO_2 adsorbs to the surface of coal nearly twice as effectively as methane, thereby promoting the displacement of methane in coal seams. With over 6 trillion tons of coal reserves in the U.S., 90% of which is unmineable due to seam thickness and structural issues, the potential for economically beneficial coal bed sequestration of CO_2 and recovery of methane is clear.

A1.8.3 *Disincentives for CO_2 Sequestration*

Disincentives for underground injection of CO_2 are present in the U.S. through state and federal programs designed to regulate and monitor possible environmental impacts from industrial operations (see Regulations and Policies below). The most significant disincentives in the U.S., as in other countries, are the simple economics of sequestration. Importing CO_2 from industrial sources, such as power plants and cement kilns, to inject in oil and gas reservoirs becomes financially unfavourable as the distance from the source to sink increases. Unfortunately, in the United States most large sources of CO_2 are located a significant distance from oil and gas reservoirs. Given the unfavourable economics of EOR programs where the CO_2 must be transported some distance, it follows that sequestration projects located where there is no additional net benefit in the form of saleable product (methane or oil) would likely be even less favourable.

A1.8.4 ***Regulations and Policies***

The Safe Drinking Water Act (SDWA, 1974) was promulgated by the United States Environmental Protection Agency (EPA) in response to widespread and uncontrolled pollution of surface and subsurface waters. Under the SDWA, the Underground Injection Control (UIC) Program was established to provide assurance that injection of fluids below the ground surface would be accomplished in an environmentally safe and responsible manner. The federal program was designed to enable state programs, which meet federal standards to receive authority to regulate UIC activities within their state boundaries. In 1980, EPA promulgated regulations that established minimum standards of performance for injection wells, including sitting/construction standards, operational permit stipulations, testing, monitoring, and reporting. Most U.S. states adopted the EPA standards into state-specific UIC programs after 1980. For those states that did not develop state-specific UIC programs, EPA retains enforcement authority.

All underground injection wells must be classified and permitted according to state or federal classification schemes. The EPA UIC program defines five well classifications:

Class I: wells used to inject liquid hazardous and non-hazardous wastes beneath the lowermost sources of potable ground water;

Class II: wells used to dispose of fluids associated with the production of oil and natural gas, enhanced oil recovery (using water or CO_2), and storage of liquid hydrocarbons;

Class III: wells used to inject fluids for the extraction of mineral resources, exclusive of oil and natural gas; injection well technology is commonly used for the production of uranium, potash, and sulphur;

Class IV: wells used by generators of hazardous and/or non hazardous wastes and radioactive wastes to inject fluids into or above a formation that contains potable water within one-quarter mile of the wellhead; (Class IV wells are prohibited in many states);

Class V: miscellaneous injection wells that do not fall under Class I through IV; examples include geothermal wells, subsidence control wells, drainage wells, aquifer recharge wells, etc.

Many state regulators and researchers feel that CO_2 injection wells for carbon sequestration should be governed under Class II injection well requirements:

- Class II wells are currently used for EOR purposes
- CO_2 leakage is not an environmental concern if it does occur
- Class II approach can take advantage of existing tools and experience among industry and regulators

Industry and government regulators have yet to focus on the legal and regulatory issues needed to develop a governing framework for carbon sequestration under a UIC program at the state or federal level. Once a predictable regulatory framework is established, technology advances and development will follow.

The U.S. Department of Energy anticipates having a monitoring and verification program in place for carbon sequestration within the next 3 to 5 years.

With increasing U.S. and international interest in low-cost carbon sequestration approaches, state-level underground injection programs in the US may be most important for the administration and regulation of injection of CO_2 specifically for greenhouse gas reduction.

A number of states in the U.S. have enacted legislation that is designed to slow the rapid assimilation of undeveloped lands into the industrial landscape and ensure a thoughtful review process before permits are granted. For example, the California Environmental Quality Act (CEQA) may be an impediment to future development of CO_2 sequestration projects. Any proposed projects must be permitted through CEQA; this permitting process has a long history of delaying a number of large projects, such as a pipelines and cogeneration power plants in California. In some cases, the CEQA review process has resulted in delays of as much as several years.

Future CO_2 sequestration projects done in conjunction with a U.S. federal agency are required to complete a National Environmental Policy Act (NEPA) review. NEPA was designed to ensure that government agencies complete a thorough review of all environmental considerations prior to any significant undertaking. Under NEPA, the Council of Environmental Quality (CEQ) was established in 1969. CEQ regulations state that "government agencies shall make diligent efforts to involve the public in preparing and implementing their NEPA procedures." NEPA compliance documents include:

- Environmental assessments (EA) to determine if there are any significant impacts
- Finding of no significant impacts (FONSI)
- Environmental impact statements (EIS) to analyse significant impacts, and
- Record of decision

NEPA also requires consultation with agencies or technical experts that have participated in the project planning process and provided significant information and recommendations. For the Department of Energy, DOE Order No. 0451.1B (National Environmental Policy Act Compliance Program) provides guidance for NEPA reviews of DOE projects. The University of Texas sequestration pilot program is currently under NEPA review since the funding is through the DOE.

Other regulations may inhibit the development of CO_2 sequestration programs on a state-by-state basis. Most state regulators interviewed for this report, however, expressed strong support for such programs and suggested that their states would welcome industry participation in sequestration projects.

A1.9 *CANADA*

A1.9.1 *Overview*

In 1998, the Canadian federal, provincial, and territorial ministers of energy and environment initiated work on a National Climate Change Strategy. This prompted the formation of a National Initiative on CO_2 Capture and Storage.

There is a lot of interest in the issue of CO_2 capture and geological storage at the Canadian federal and provincial level (particularly in Alberta and Saskatchewan). CO_2 capture and storage is expected to become an important part of Canada's Climate Change mitigation options. With respect to specific technologies, the development of CO_2 storage is likely to commence with the use of enhanced oil recovery, and progress to enhanced coal bed methane recovery, as the technology develops, and CO_2 capture costs are reduced.

This review includes interviews of John Drexhage, former chief negotiator for Canada's Department of Environment; Janet Power, senior economist at Natural Resources Canada; Rob James, head of the PERRL initiative at Environment Canada; Bob Mitchell, head of Alberta Environment's CO_2 capture and geological storage task group; Michelle Heath, a private energy / environmental consultant (following a recommendation from Alison Taylor). At the Federal level, Kevin Cliffe, Natural Resources Canada, was contacted.

A1.9.2 *Fiscal incentives for R& D, pilot and demonstration projects*

A number of programs aimed at supporting the development of CO_2 capture and geological storage R & D, pilot, and demonstration projects are available at the federal level in Canada:

Sustainable Development Technology Canada, headed by Vicky Sharp, has $ 100 million targeted towards developing CO_2 emissions reductions technologies.

As part of Canada's Climate Change Action Plan 2000, $15 million was invested in a Pilot Emissions Removals, Reductions and Learning Initiative (PERRL)[16], headed by Rob James, Environment Canada. PERRL provides a financial incentive to encourage action to achieve incremental GHG emissions reductions in strategic areas: the initiative intends to purchase reductions through an auction process in four project areas, one of which is CO_2 capture and geological storage. PERRL aims to sign its first Purchase Agreement by the end of 2002, and take Delivery of Reductions by 2004.

Natural Resources Canada, a Federal Government Department, has developed the NRCan initiative, headed by Bob Lyman, has $ 25 million available for the development of commercially established CO_2 initiatives, essentially, CO_2 capture and geological storage. It has also developed an Incentive Programme aiming to fund new capture and storage demonstration projects, which will run in parallel to the CO_2 Project Royalty Credit Program. The initiative will be going to the Treasury Board next month. It will provide CAN $15 million to CO_2 capture and storage demonstration projects. Proposals will be reviewed throughout the winter and the funding will be available from the 1st April 2004.

Activity Coordination
There is also a lot of work going on in Canada, in terms of activity coordination. The Canadian Government is involved in the Carbon Sequestration Leadership Forum with the US and several other CO_2 capture and storage networks are regularly emerging (see CO_2 hub). In particular, the Petroleum Technology Advisory Committee is heavily involved in coordinating these initiatives.

CO_2 hub[17]

Dr. Malcolm Wilson is the lead organizer at the University of Regina for a proposed CO_2 Seminar to be held in Regina on October 9-10, 2003. Dr. Wilson provided a presentation on his vision for the Seminar, which included a Norwegian supported proposal for a bilateral S&T Agreement between Environment Canada (EC) and the Norwegian Ministry of Environment. It was proposed that the Agreement be in effect for 5 years and that Canada and Norway each commit $500,000 / year for the funding of bilateral research projects.

The CO_2 hub is a unique, multi-level online auction website designed to foster the development of a sustainable CO_2 market.

The CO_2 hub provides the logistics necessary to bring together buyers and sellers of CO_2, as well as providers of auxiliary services such as purification and transportation. The motivation behind this was to encourage an energy sector market activity that establishes the availability of long-term supplies of CO_2 at economically viable price levels for the purpose of enhancing petroleum production and sequestering CO_2 emissions.

For companies who produce CO_2 and are looking for market opportunities and for companies who are in search of CO_2 for enhanced recovery projects or other industrial uses, the CO_2 hub Market Floor introduces new and significant benefits, including:

- Suppliers can anonymously post CO_2 for sale, set their own reference price and receive bids from potential buyers;
- Buyers can anonymously post requests for CO_2, set their own (delivered) reference price and receive bids from potential suppliers;
- If the product specifications differ between those requested and offered, auxiliary purification (as well as transportation) auctions will automatically be spawned;
- This auction platform encourages the inherent benefits of timeliness, choice and overall 'best economics'; and
- Volumes of CO_2 bought and sold are monitored, for the purpose of supporting future emissions credits.

Buyers and sellers of CO_2 also have the opportunity to post direct requests for services such as purification, compression, storage and transportation. For these auxiliary service providers, the CO_2 hub provides new business development opportunities. Indeed, the anonymous monitoring and responding to auction events where auxiliary services are critical in delivering the supplier's CO_2 to the buyer.

All registered Users, as well as visitors to the CO_2 hub, may also use the Analysts' Hub, a section of links to articles and websites featuring information on CO_2, its utilization in enhanced petroleum recovery and related energy and environmental issues.

Technology Roadmap Process

The Federal Government has also organized a series of workshops, the Technology Roadmap Process, for developing a strategy for further definition of technology needs for implementation of CO_2 Capture & Storage as a Climate Change Mitigation

Option. The first workshop took place in September 2003. The objective of the CO_2 Capture & Storage Technology Roadmap is to identify future technology pathways, process integration needs and technology development needs to capture CO_2 from large industrial emitters. The Roadmap will also identify CO_2 storage and sequestration opportunities in some of Canada 's depleted oil and gas reservoirs, saline formations and deep coal seams and will identify the respective technology development needs associated with each of these opportunities. It will also identify synergistic opportunities to sequester CO_2 while used for EOR, coal bed methane production and the large-scale production of hydrogen from the decarbonisation of fossil fuels.

Petroleum Technology Alliance Canada (PTAC) Workshop

PTAC is carrying out a CO_2 from Industrial Sources to Commercial Enhanced Oil & Gas Recovery Forum and Workshop on the 1st-2nd October. This event will focus on CO_2 enhanced oil & gas recovery technology solutions, government policy and initiation of new joint industry technology projects to address current barriers to CO_2 enhanced oil & gas recovery implementation.

GHGT 7 conference

Canada will be hosting the host the next GHGT 7 conference, which will be held at the Vancouver Convention and Exhibition Centre during the week of September 5th, 2004.

A complete list of R & D, pilot, and demonstration projects is provided in *Table A.1*. 2

Table A1.2 Summary of R & D, pilot and demonstration projects underway in Canada

Project name	Funding level and funders
Suitability of Canada's Sedimentary Basins for CO_2 Sequestration	$270,000 from federal government, and matching funds for manpower from the Alberta Energy and Utilities Board of Alberta government.
Sequestration of Carbon Dioxide in Alberta's Oil and Gas Reservoirs	$240,000 from the Alberta Energy Research Institute. More than $300,000of manpower-equivalent from the Alberta Energy and Utilities Board.
Assessment of CO_2 storage capacity of deep coal seams in the vicinity of large CO_2 point sources in central Alberta	$275,000 for fiscal year 2002-2003. A separate project is underway to assess the CO_2 storage capacity in Nova Scotia with the Canadian Clean Power Coalition.
International Test Center for CO_2 Capture	Government funds from a variety of sources including federal and provincial: $550,000 Canadian annually, with more than 50% coming from industry sources.
CANMET CO_2 Consortium: Pre-competitive research consortium led by the CANMET Energy Technology Center to investigate oxy-fuel combustion based CO_2 capture methods.	Canadian federal government (Program of Energy Research and Development), Alberta government, US Department of Energy, TransAlta Utilities, Sask Power, Ontario Power Generation, McDermott Technology Inc and in the past by EPCOR, Nova Scotia Power and Air Liquide.
Oxy-Fuel Field	$1.5 million over 5 years from Climate Change Action Plan (CCAP).

Project name	Funding level and funders
Demonstration Project	
Closed Gas Turbine Cycle Project	$250,000 Canadian over 5 years from CCAP Program
Canadian Clean Power Coalition	$2.54 million are currently available from Industrial Participants; Province of Alberta; Nova Scotia Department of Natural Resources.
IEA Weyburn CO_2 Monitoring and Storage Project: The primary objective of the project is to understand geo-sequestration of greenhouse gases.	Total cash funding is $20.5 million, as well as in-kind contributions valued at approximately an equal amount. Funding participants include the following organizations: Natural Resources Canada, Saskatchewan Energy and Mines, Government of Alberta, US Department of Energy, European Community, EnCana Corporation, Saskpower, Nexen Canada Limited, BP, Dakota Gasification Co, TransAlta Utilities, ENAA – Japan, Totalfinaelf.
Enhanced Coalbed Methane Recovery for Zero Greenhouse Gas Emissions	Current partners include IEA Greenhouse Programme, Environment Canada, Canadian Climate Change Action Plan, Geological Survey of Canada, Alberta Innovation and Science, Alberta Geological Survey, Saskatchewan Energy and Mines, US Department of Energy, UK Department of Trade and Industry, Netherlands TNO, Japan Coal, Australian CSIRO, Gas Technology Institute, Suncor Energy, BP, Burlington Resources, Conoco Canada, EnCana Corporation, MGV Energy Inc., ExxonMobil Canada, Husky Energy, PetroCanada, TransCanada Pipelines, EPCOR Utilities, TransAlta Utilities, Air Liquide, Sproule International, Tesseract, University of Alberta, University of British Columbia, and BJ Services Canada. To date more than $4 million has been expended.
Acid Gas Re-injection in Alberta, Canada	$ 205,000 from Canadian federal and provincial governments and government agencies and the IEA Greenhouse Gas Programme.
Sequestration of Carbon Dioxide in Oil Sands Tailings Streams	$ 1 million from the Climate Change Action Plan. Suncor has contributed some funds in the past and has agreed to provide up to $50,000 (potentially more) in kind, for 2002.
Geologic sequestration of CO_2 and simultaneous CO_2 sequestration / CH_4 production from natural gas hydrate reservoirs	Climate Change Action Plan, $307,000 for 4 years.

Source: personal communication, Janet Power, senior economist at Natural Resources Canada, 2001.

State-level initiative: CO_2 Project Royalty Credit Program in Alberta

This is a new royalty program to promote the development of a CO_2 enhanced oil / gas recovery industry in Alberta. On May 16, 2003, the Minister of Alberta Energy announced that a maximum of $15 m would be provided over five years in the form of royalty credits to offset up to 30 per cent of companies' approved costs in approved CO_2 projects. A maximum of $5 m in royalty credits may be approved for a single project. Alberta Energy is also revising royalty deductions under the Enhanced Recovery of Oil Royalty Reduction Regulation. It is expected that the additional oil recovered will result, over time, in over $30 m in additional royalty payments.

> *"Enhanced recovery methods like CO_2 injection have the potential to provide significant long-term benefits to Alberta through increased production and economic activity in addition to managing Alberta's greenhouse gas emissions as part of Alberta's Albertans & Climate Change - Taking Action".*[18]

Companies interested in the CO_2 Project Royalty Credit Program will need to complete an application package and submit it to the Department of Alberta Energy.

A1.9.3 *Disincentives for CO_2 sequestration projects*

There are no specific disincentives for CO_2 sequestration projects in Canada, other than the fact that project developers will need to get approval to use geological formations as space for CO_2 storage. Any experimental project would require specific planning permissions.

The most significant disincentives in Canada, as in other countries, are the simple economics of sequestration (*Section A5.8.3*). Currently, there is no mechanism set in place to set the price of carbon. The fact that this price is not determined has an implication on the viability of carrying out CO_2 capture and geological storage. One option to overcome this barrier would be to make the technologies more cost effective: this option is currently being investigated at the provincial level, in Alberta, and Saskatchewan.

A1.9.4 *Regulations and Policies*

There are no existing regulations or policies *specific* to CO_2 capture and storage in Canada at present. The Energy Utilities Board, the regulators of the oil and gas industry in Alberta have designed regulations to ensure the safety of gas transportation through pipelines: the same pipeline regulations are likely to relate to CO_2 pipelines.

A fiscal framework study for CO_2 capture and storage is currently underway in Canada: results will be available in late fall 2002.

In the Orion enhanced oil recovery project's Environmental Impact Assessment, a regulatory review listed the major regulations the project should consider as: the Water Act, the Public Lands Act, the Canadian Fisheries Act, and the Navigable Waters Protection Act.[19]

A1.9.5 *Implications of the Lack of Regulations*

The lack of a regulatory framework for CO_2 capture and geological storage presents a barrier to the development and use of the technologies available. It is not clear, for example, who would be liable for the CO_2 injected into the ground (is the project developer ultimately liable for the CO_2, once it is contained in a geological structure?).

There is a clear need for a streamlining of regulations that currently exist. Regulations which have been developed for other technologies (e.g. regulations specific to pipelines, gas storage, waste disposal regulation, and groundwater disposal) are currently under review to determine their applicability to CO_2 capture and storage initiatives. Michelle Heath noted that the development of any regulations specific to CO_2 capture and storage should involve representatives from all potential stakeholders and could perhaps be done initially on an MOU basis until the science is sufficiently understood.

There is a clear need for consensus on regulations applying to CO_2 capture and storage on a federal level, and ultimately at the international level. There are currently no international criteria for establishing the price of carbon in a geological structure. This is one of the issues to be discussed at the IPCC meeting on CO_2 capture and storage, on the 19th- 21st of November.

A1.9.6 *Use of stored carbon as carbon credits, or for compliance in a domestic GHG regime*

The issue of the use of stored carbon as carbon credits, or for compliance in a domestic GHG regime has not been decided upon yet: there are a lot of uncertainties as how individual governments are going to tackle the issue. The debate is being carried out in the context of Canada's pilot emissions reductions trading scheme, PERT. This report reflects the opinions of government officials interviewed.

Several interviewees believe that carbon stored in geological structures will be eligible for compliance in a domestic GHG regime. In fact, Mr. Drexhage added that CO_2 geological storage projects are sequestration projects, and should not be treated differently from LULUCF sequestration projects. In this respect, they could also be eligible under the CDM and JI.

However, others put forward that the absence of a common accounting system, and of monitoring and certification rules could present a problem for using the CO_2 stored as carbon credits, or for compliance in a domestic GHG regime.

A1.9.7 *NGO and public awareness*

NGO action towards this process is minimal in Canada. There is growing NGO awareness of the subject. The main concern is that this process will be used as a way to go ahead with business as usual. The main question they raise is whether the option is sustainable.

The public awareness towards the issue is very limited.

A1.10 *AUSTRALIA*

A1.10.1 *Overview*

The level of interest in CO_2 storage in Australia will depend to quite an extent on how strict is regulation of carbon. The Australian Government has made clear that it does not intend to ratify the Kyoto Protocol, although it does say it is committed to achieving the target reductions that would apply under the Kyoto Protocol.

Currently only NSW has binding emissions targets, and these are only for electricity. Stricter targets will require more ways of achieving reductions.

To date, there has been more effort put into carbon storage in forests rather than geological storage, because forestry sequestration is much more easily implemented. There are large areas of land in Australia for forestry, although low rainfall in many areas will limit growth rates.

However the collaboration between government and industry in the GEODISC research program (*Box A1.5*) indicates that capture and geological storage is regarded as a significant opportunity in Australia.

Preference will be given to methods that can improve yield from gas fields, (e.g. re-injection). However major CO_2 emissions sources such as coal-fired power stations are generally not located near gas fields, so methods suitable to coal fields will also be favoured.

Still, interest in geosequestration in Australia is growing. The Prime Minister's Science Engineering and Innovation Council (PMSEIC) in its report, *Beyond Kyoto - Innovation And Adaptation,* said[20] *"the production of electricity using coal gasification and sequestration of CO_2 in geological structures appears to offer the best chance of large scale GHG mitigation"*. More detail is in *Box A1.3* and in a media release from Geoscience Australia[21].

Box A1.3 Potential for geosequestration

"In Australia, the potential for geological sequestration has been examined by the Australian Petroleum Cooperative Research Centre's GEODISC project. This program has identified 65 sites that are thought to be environmentally sustainable for CO_2 injection and have the capacity to meet the volume requirements of neighboring CO_2 sources[22]. Depending on the method of carbon capture and transport geosequestration costs have been estimated at from $10[23] to $50[24] per tonne of carbon abated. Such figures compare favorably with other options offering large reductions in emissions[25].

The principal challenge for geosequestration is to develop cost-effective methods of capturing carbon emissions and testing the geosequestration process on a large scale. All indications and trials to date in other countries indicate that sequestration will be technically feasible. The community will need to be satisfied of this feasibility. "

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Source: http://www.dest.gov.au/science/pmseic/meetings/9thmeeting.htm, Beyond Kyoto: Innovation and Adaptation, p.26, December 2002

The above arguments haves been criticised in a recent article, *Backing a Loser*[26], as being unsustainable. However, the Australian Government has allocated funds to geosequestration research, as discussed in the next section.

A1.10.2 *Fiscal incentives for R& D, pilot and demonstration projects*

There are a number of general incentives for CO_2 emissions reductions, at the Commonwealth as well as State Government levels.

Commonwealth incentives that could apply to geological storage include the Greenhouse Gas Abatement Program (GGAP), administered by the Australian Greenhouse Office, which funds selected projects. However, no capture or geological storage projects have been funded under GGAP.

There are currently no demonstration or commercial carbon capture and geological storage project in Australia, but the Australian Budget brought down on 13 May 2003 allocated $11.6 M new funding over four years to identify specific sites and implement demonstration projects for geosequestration, through a special Cooperative Research Centre (CRC) for Carbon Dioxide (CO_2CRC) under the Department of Industry, Science and Resources.

There are currently no State incentives that could apply to geological storage.

There are a number of general incentives for CO_2 emissions reductions, at the Commonwealth as well as State Government levels.

The Gorgon LNG joint venture has proposed re-injection of CO_2 into the Gorgon gas field in Western Australia in its application for environmental approval, to address concerns about potential emissions from the development. However, the Western Australian Government is yet to decide on this application.

Other Australian gas fields also have high levels of CO_2. In operating fields the CO_2 is currently being scrubbed and vented. Future developments may involve re-injection.

In 2002, the Victorian Government tendered leases over lignite in Victoria that required successful tenderers to undertake research into geological storage. Australian Power and Energy Limited (APEL) was awarded a brown coal resource of an estimated 25 billion tonnes, located in the Latrobe Valley in south-east Victoria, Australia. APEL proposes to develop Australia's first commercial coal gasification and gas to liquids project with standard technologies used elsewhere in the world. The project is designed to produce 52,600 barrels per day (bpd) of sulphur free diesel and 1060 MW of base load power. The project claims[27] to have zero CO_2 emissions for its liquid production and lower than natural gas emissions for its power production.

A1.10.3 *Existing R & D and expected demonstration programme for CO_2 capture and storage in Australia: Geological Disposal of Carbon Dioxide*

GEODISC

Box A1.4 GEODISC

A research program on Geological Storage of Carbon Dioxide (GEODISC) has existed in Australia since 1999. It is a collaborative research program designed to investigate the technological, environmental and commercial feasibility of the geological sequestration of carbon dioxide in Australia.

Initial direct funding for GEODISC ($10 M) was provided by the Australian Greenhouse Office (AGO), the Australian Petroleum Co-operative Research Centre (APCRC), and industry, including BHP Petroleum, BP Amoco, Chevron, Gorgon[28] Shell and Woodside. The APCRC provides funding from its Future Investment Fund. In addition, each of the constituent organisations (Geosciences Australia, NCPGG, University of New South Wales School of Petroleum Engineering) provides substantial in-kind support, such as facilities.

The GEODISC group applied to the Australian Commonwealth Government for funding to evolve into a Carbon Dioxide Co-operative Research Centre, encompassing carbon capture, separation and storage.

Source: *http://www.apcrc.com.au/Programs/geodisc_res.html*

Research projects within GEODISC include:

- PROJECT 1 - REGIONAL ANALYSIS
  One task is to delineate the most favourable parameters for geological formations likely to be suitable for large-scale CO_2 injection. Another is to compile regional data to determine specific formations and potential locations

for injection. Outputs will include both parameter lists to be used in regional model development and also maps showing regional CO_2 injection potential.

- PROJECT 2 - SPECIFIC STUDIES (2-4 LOCATIONS)
  The tasks are to describe in detail the geology of both the potential injection horizon (reservoir) as well as the sealing formation, and to comprehensively evaluate and model the reservoir formation parameters such as hydrogeology, hydraulic connectivity and formation water chemistry. Outputs include detailed geological models for areas with potential for large-scale CO_2 injection and the development of fluid-flow models for these locations.

- PROJECT 3 - EXPERIMENTAL STUDIES
  The tasks here are to develop a better understanding of the CO_2 water / brine system, and to understand how the various fluids will interact with the rocks of the reservoir and seal formations. Outputs will be models for CO_2-water systems, documentation of solution chemistry of rock-water-CO_2reactions and geochemical models for the water-CO_2 -rock system for specific sites.

- PROJECT 4 – PETROPHYSICS
  In this project the tasks will be to document all petrophysical parameters at specific sites and to develop simulation models for optimum CO_2 injectivity. Outputs will include simulation models for both reservoir and seal systems based on documented micro and macro-scale petrophysical parameters for specific sites.

- PROJECT 5- DEVELOPMENT OF A COUPLED CHEMICAL-DYNAMIC-KINETIC-MODEL
  The task here is to develop a coupled model for chemical-dynamic-kinetic model using material derived from Projects 3 and 4, as applied to areas identified in Project 2.Output will be a generalised coupled model for CO_2 injection.

- PROJECT 6 - MONITORING CO_2 INJECTION
  The tasks in Project 6 relate to the modelling of seismic characteristics at each of the specific sites to provide a theoretical basis for seismic monitoring of CO_2 injection, leading to the development of seismic monitoring technology. Other monitoring techniques will also be addressed including well monitoring. Outputs will include a mathematical model and theoretical base for a monitoring program, leading to enhanced capability to accurately monitor the migration of CO_2 in the subsurface.

- PROJECT 7 - RISK ASSESSMENT
  The major task in this project will be to assess and quantify the technical and environmental risks that may arise from CO_2 injection. The main output will be quantified assessment of the risks and uncertainties of CO_2 injection as a storage and sequestration option.

- PROJECT 8 - ECONOMIC MODEL
  The major task in this project will be to develop an economic model for transportation and injection of CO_2 at various sites identified in project 2. Initially a generic economic model will be developed. The main output will be a fully quantified economic assessment of transportation, injection and monitoring of CO_2 storage.

- PROJECT 9 - INTERNATIONAL COOPERATION
  The task here is to develop a network of international cooperation and collaboration in the area of research into CO_2 sequestration in order to eliminate duplication of research effort, and to allow greater leverage of both GEODISC research and other international research efforts.

- PROJECT 10 - NATURAL ANALOGS
  The task is to develop a better understanding of CO_2 entrapment and the effects it has on the reservoir and seal geology by studying naturally occurring CO_2 accumulations both in Australia and internationally. The main output will be an improved understanding of natural CO_2 entrapment, mobilisation and formation geochemistry leading to improved risk assessment.

CO_2CRC

BoxA1.5 Carbon Dioxide CRC (CO_2CRC)

Commencing operation on 1 July 2003, the CO_2CRC will research the logistic, technical, financial and environmental issues of storing industrial carbon dioxide emissions in deep geological formations. The CRC will research the capture and separation of carbon dioxide from industrial systems as well as geological storage.

Major support from industry, research parties and government organisations along with eminent international collaborators are ensuring that CO_2CRC has a strong role to play in the mitigation of carbon dioxide emissions to the atmosphere.

The GEODISC program of the Australian Petroleum CRC has already established that the geological features of the continent ensure that Australia is well placed to make use of geological storage of carbon dioxide. The CO_2CRC will build on the findings of the GEODISC program and plans to achieve a demonstration project within the term of the CRC.

As part of the planning process an overview of the CO_2CRC proposal was produced with additional documents concerning the business plan and the research plan.

Industry partners in the new CO_2CRC:
The Australian Coal Association Research Program, BHP Billiton, BP, Cansyd Australia, Chevron Texaco, the Process Group, Rio Tinto, Stanwell Corporation Ltd, Shell, URS, and Woodside Australian Energy.

Research parties:
CSIRO, Curtin University, Geoscience Australia, Monash University, the University of Adelaide, the University of Melbourne and the University of NSW.

Government parties in the CRC:
The Australian Greenhouse Office, the Western Australia Department of Mineral and Petroleum Resources, and the South Australia Department of Primary Industries and Resources (PIRSA)

International collaborators:
Alberta RC and the University of Regina (Canada); the British Geological Survey, CO2Net, IEA (UK); NASCENT (Denmark); SACS (Norway); TNO (Netherlands); RITE and Meji University (Japan); Institute of Geological and Nuclear Sciences (New Zealand); Advanced Resources International (ARI), Carbon Capture Program (CCP), Lawrence Livermore, Massachusetts Institute of Technology (MIT) and NETL / US DOE (USA).

Members of the CO_2CRC Interim Board:
Mr Tim Besley (Chair), Mr Roger Bartlett (Chevron Texaco), Mr Paul Crabtree (Shell), Mr Mitch Ellis (BHPBilliton), Mr Mal Lees (Pacific Coal), Mr Ross McKinnon (Australian Coal Research), Professor Brendon Parker (UNSW), Dr Trevor Powell (Geoscience Australia), Mr Ross Rolfe (Stanwell Corporation), Mr Alec Svendsen (BP), Mr Greg Thill (CSIRO), Mr David Watkins (Woodside Energy) and Dr Peter Cook (CEO).

Source: *http://www.co2crc.com.au/about_f.htm*

The CO_2CRC represents an expansion of the Geological Storage of Carbon Dioxide (GEODISC) research program.

A1.10.4 *Disincentives for CO_2 sequestration projects*

There do not appear to be any financial disincentives for CO_2 capture and geological storage in Australia at present, other than cost. However some care would be needed in structuring transactions in order to get tax deductibility, as deductions are generally limited to expenditure necessarily incurred in earning income. Care would also be needed to get R&D incentives.

A1.10.5 *Regulations and Policies favouring CO_2 capture and storage*

There are general policies and regulations encouraging emission reductions at the Commonwealth as well as State Government levels. However there are not currently any specific policies or regulations favouring CO_2 capture and storage.

Commonwealth policies and regulations that could apply to geological storage include the Greenhouse Challenge, administered by the Australian Greenhouse office (AGO). Chevron has signed the Greenhouse Challenge for the Gorgon Joint Venture.

State policies and regulations that could apply to geological storage include the NSW emissions reductions benchmarks scheme.

A1.10.6 *Regulations and Policies restricting CO_2 capture and storage*

There are no specific regulatory restrictions, but standard environmental and planning policies have to be satisfied. For example, approval is needed for any construction work, and requests for approval for major construction work will need an Environmental Impact Statement to be prepared. These requirements differ from state to state, but ERM is well qualified to advise on state requirements.

Natural gas tends to be regulated under petroleum acts. State Governments have jurisdiction over onshore gas fields, while the Commonwealth Government has jurisdiction over offshore gas fields. The South Australian Petroleum Act, for example, has recently been rewritten to clarify the position in respect of re-injection of gases, such methane for subsequent recovery and CO_2 for disposal. Other states have not yet clarified the situation for re-injection.

Underground storage of waste that could leach and potentially cause damage to the environment is prohibited in all states under state environmental regulations. However, CO_2 is currently not regarded as a waste in Australia.

Any activities that may affect surface water or groundwater are subject to strict impact assessments. However geological storage of CO_2 as a super-critical fluid

would seem to require depths greater than 800 metres, which is probably below the most significant fresh water levels.

A1.10.7 ***Implications of the Lack of Regulations***

The limited specific regulations in Australia are not currently regarded as a major impediment to CO_2 capture or geological storage. The science and technology is still rapidly developing. Regulations are expected to develop along with technology over the next few years.

A1.10.8 ***Use of stored carbon as carbon credits, or for compliance in a domestic GHG regime***

Currently, the only carbon-trading scheme in Australia is the NSW emissions benchmarks scheme, announced on 8 May 2002 to apply to electricity consumers in NSW effective from 1 January 2003. One of the means of satisfying such targets will be carbon sequestration. The announcement says that "the use of sequestration from sinks anywhere in Australia that comply with a methodology to be approved by the Minister for Energy and Utilities will be allowed as an abatement option." Methodologies for geological sequestration have yet to be submitted to the Minister, but should be accepted if sufficiently robust.

Credits will only be recognised domestically once methodologies have been approved. The NSW Government may wait for the UNFCC to report on geological storage before approving any methodologies.

Australia is an Annex I country, but has indicated that it will not ratify the Kyoto Protocol. Hence there will not be strong demand for credits at the national level. However, Australian companies exporting to Annex I countries, especially coal exports, may be interested in buying credits including those from capture and geological storage, once recognised under the Kyoto Protocol. Until Australia ratifies the Kyoto Protocol, CO_2 storage in Australia will not be Kyoto compliant and hence not recognised in countries that have ratified.

A1.10.9 ***NGO and public awareness***

NGOs in Australia are generally not supportive of arrangements to offset emissions with sequestration or other credits. They would prefer actual reductions in emissions.

Public attitudes are likely to be dominated by whether or not Australia ratifies the Kyoto Protocol. If Australia ratifies, then any Kyoto compliant methodology will be supported. There have been adverse reactions in the past to suggestions that nuclear waste might be stored in geological formations in the Australian desert.

A1.11 ***CHINA***

Dr. Guoqiang Lu of the China State Environmental Protection Administration (SEPA) was interviewed.

A1.11.1 ***Chinese government's general view on climate change issues***

China's climate change policy is embedded in its economic and sustainable development strategies, which clearly claim that China is a low-income developing country with a large population; economic development and poverty elimination are its top priorities. Although a lot of Chinese officials and scientists agree on the need to reduce greenhouse gas emissions, it is unlikely that the Chinese government will approve any policies that could curb economic growth in the foreseeable future, according to Dr. Lu.

Until now, China has not committed to reducing CO_2 emissions as some developed countries have. CO_2 is not yet treated as a waste in China. However, Dr. Lu does believe that China will do as much as it can within the framework of its economic development strategy, such as promoting energy efficiency and developing renewable energy. A good example is that the Chinese Government now has a very positive attitude towards CDM projects in China and related regulations and policies are under discussion.

A1.11.2 ***Incentives and disincentives for R& D, pilot and demonstration projects***

There is neither financial incentive nor pilot or demonstration project for CO_2 capture and storage in China for the time being, nor are there any specific disincentives relating to CO_2 capture and storage projects China.

A1.11.3 ***Regulations and Policies***

There are no existing policies or regulations favouring the development of CO_2 capture and storage at the moment. General understanding is that none of the environmental regulations specific to pipelines / gas storage / waste storage / ground water have specific relationships with CO_2 emission or its capture and storage. However, the lack of regulatory framework may imply that there will be little development of CO_2 storage and capture in foreseeable future.

A1.11.4 ***CDM in China***

At moment, CDM is perhaps the only opportunity in China for project developers to get carbon credits. The two key areas for CDM projects are renewable energy and energy efficiency. It is unlikely for CO_2 capture and storage project developers to claim carbon credits under CDM scheme in China.

Dr. Lu also mentioned that in general, CDM project implementation agencies should be Chinese owned or Joint Ventures with over 50% shares owned by the Chinese Partners (this rule may change as there are a lot of arguments on this issue within the Chinese government at the moment). Dr. Lu also suggested that there should be significant opportunities for industries if the CO_2 capture and storage projects were to be eligible for CDM projects.

A1.11.5 ***NGO and public awareness***

Compared to NGOs in developed countries, most NGOs in China have governmental backgrounds. Their attitudes in general are quite similar to those of the Chinese government. According to Dr. Lu, some surveys conducted by Chinese universities show that the public awareness of CO_2 and climate change related

issues is very limited. Therefore, it is difficult to understand whether the public awareness is positive or negative on CO_2 capture and storage projects.

[1]The water framework directive does not currently mention CO_2 capture and storage specifically, but this will need to be followed closely.

[2] Legal Aspects of Underground CO_2 Storage: Summary of developments under the London Convention and North Sea Conference, The Fridtjof Nansen Institute, 2001.

[3]*Proposal for a Climate Strategy for Denmark, p.20*

[4]*Proposal for a Climate Strategy for Denmark, p.16*

[5]www.cooretec.de

[6]http://www.nachhaltigkeitsrat.de/service/download/stellungnahmen/RNE_Position_AG_Kohle_01-10-03.pdf

[7]Sotacarbo Spa, Ansaldo Ricerche, ENEA, Dipartimento di Ingegneria Meccanica, Test plant for R&D activities on hydrogen and clean fuels from Sulcis coal, DRAFT.

[8]http://www.co2-reductie.nl/default.aspx?strurl=http%3A//www.co2-reductie.nl/content/content.aspx%3Ftxt%3D59
[9]*Legal Aspects of Underground CO2 Buffer Storage*, CRUST legal task force, 2003
[10]CRUST, Offshore re-injection of CO_2 into a depleted gas field in the North Sea, a feasibility study conducted by Gaz de France, D. d'Hoore, (teamleader) gaz de France B.V.
[11]CO_2 reduction by subsurface storage in a depleted gas field; a feasibility study conducted by Shell and NAM J.A. van Luijk (teamleader), Nederlandse Aardolie Maatschappij B.V.
[12]Framework for the safety and monitoring of a facility for underground CO2 sequestration TNO-NITG and ECN.
[13] CRUST, Offshore re-injection of CO_2into a depleted gas field in the North Sea, a feasibility study conducted by Gaz de France, D. d'Hoore, (teamleader) gaz de France B.V.

[14]Norwegian Ministry of Environment, 01/ 03.

[15] Personal communication, Dr. Nick Riley, British Geological Survey, June 2003.

[16]Pilot Emission Removals, Reductions and Learnings Initiative (PERRL), Using PERRL to Assist New Climate Change Projects, Presentation by Rob James, Environment Canada.

[17]www.theco2hub.com

[18] Environmental Impact Assessment Report for the Blackrock Ventures Inc., Orion Enhanced Oil Recovery Project, Approximately 12 km Northwest of Cold Lake, Alberta, Alberta Environment, 2001.

[19] see http://www.dest.gov.au/science/pmseic/meetings/9thmeeting.htm, Beyond Kyoto: Innovation and Adaptation, Executive Summary
[20] Geoscience Australia was previously known as Australian Geological Survey Office, or AGSO.
[21] J Bradshaw, B.E. Bradshaw, G Allinsson, A.J.Rigg, V. Nguyen & L. Spenser.(2002) *The Potential for Geological Sequestration in Australia: Preliminary findings and implications for new Gas Field Development*. APPEA Journal.
[22] Roam Consulting 2002. Unpublished data [Roan changed to Roam – 22 April 2003]
[23] IEA Greenhouse Gas R&D Programme (2001) *Putting Carbon Back in the Ground*
[24] Ibid
[25] Dr Mark Diesendorf, http://www.sustainabilitycentre.com.au/BackingLoser.pdf
[26] www.apel.com.au
[1]Gorgon is a joint venture between Chevron, Texaco, Mobil and Shell, to develop the Gorgon gas field in Western Australia, and produce liquefied natural gas (LNG). The Gorgon field has high levels of CO_2. [Note: ERM will work with the companies behind CCP (ChevronTexaco, ExxonMobil, and Shell) to update this information].

Annex B

Non-Governmental Organisations' Actions

B1 CLIMATE ACTION NETWORK

At the recent IPIECA conference on CO_2 capture and storage, Jason Anderson, spokesman for Climate Action Network[1], stated that no NGOs were *a priori* against CO_2 capture and storage. A few NGOs rule the technology out totally: the main arguments against the technology are non-climate aspects of fossil fuel damage (extraction, transport, supply security, geopolitical risks) or the fact that it represents a distraction from other GHG mitigation measures such as renewable energy development. On the other hand, many NGOs see the opportunities to engage the US, growing fossil fuel intensive economies like China and India and global corporations with vested interests.

Mr. Anderson identified the main concerns from the NGO world as:

- The diversion of resources from known solutions, such as renewable energy development.
- The energy penalty and uncertainties surrounding the efficiency of capture.
- Full chain impacts of fossil fuels, beyond GHG impacts on the climate.
- The climate change impact of leakage over long-term spans: NGOs voice a strong concern over the uncertainties surrounding leakage rates and industry's mentions of setting guidelines for 'acceptable' levels of leakage.
- Local environmental impacts (particularly concerning ocean disposal).

Mr. Anderson concluded by stating:

"The jury is definitely still out on C&S: credibility, cooperation, internalisation of important environmental values are key to success from our perspective." [2]

[1]The Climate Action Network (CAN) is a global network of over 287 Non-Governmental Organizations (NGOs) working to promote government and individual action on climate change mitigation. http://www.climatenetwork.org/

[2] The presentations from the IPIECA Workshop on Carbon Dioxide Capture and Geological Storage, 21-22 October 2003, Brussels can be found on www.ipieca.org

The WBCSD have not worked on this issue specifically, but it is in the portfolio of CO_2 mitigation options. It is an important issue that deserves more attention and research. It is indeed an important option to consider carefully.

The lack of regulations currently surrounding the technologies is indeed restricting the development of the technologies. WBCSD see a close link between the regulatory framework development, technology development, and the business case.

WBCSD are in no doubt about the fact that geologically stored CO_2 will be eligible as carbon credits under domestic GHG regimes.

B3 THE BELLONA FOUNDATION

Mr. Paar Frisvold, Policy Advisor to the Bellona Foundation, was interviewed for this review. Mr. Frisvold stated that the Bellona Foundation has extensively considered the issue of CO_2 capture and geological storage and it sees the use of the technology as an essential element of energy policy.

During a presentation at the recent IPIECA conference on CO_2 capture and storage, Mr. Frisvold stated *"renewable energy sources will accomplish what fossil fuels are incapable of in the long term, while fossil fuels can accomplish what renewables are incapable of in the short term."*

The use of CCS will allow countries to produce enough energy to carry out the transition to a hydrogen economy. Indeed, the use of renewable energy will not be sufficient to enable a transition from the current fossil fuel based economy to a hydrogen economy. Additionally, countries will need to produce more energy in order to produce the installations which will yield renewable energy.

The situation in the North Sea is ideal, as CO_2 is needed in order to enhance oil recovery in the North Sea fields: the use of CO_2 will prolong the life span of existing oil fields.

At IPIECA, Mr. Frisvold also stated "*Europe is in a position to realise a clean hydrogen economy by taking advantage of the availability of fossil resources combined with the large EOR and storage potential of CO_2 in the North Sea basin."*

B4 WORLD WILDLIFE FUND

WWF haven't considered the issue in detail. As a general rule, they are very sceptical.

However, WWF is not opposed to R & D, pilot studies, and demonstration projects: they are keeping an open mind on the issue.

Still, WWF believes there are plenty of opportunities for reductions of emissions at source, and are concerned that CO_2 capture and Geological storage is just a technical fix, requiring large investments. WWF believes that the flow of investment being directed towards the development of these technologies could be invested into renewable energies instead.

Another issue of concern to WWF is the fact that this option does not result in a decrease in the rate of oil and gas exploration; which leads to concern over other environmental (essentially marine conservation) issues.

WWF also expressed their concern about the uncertainties surrounding the technologies involved in CO_2 geological storage, and the permanence of the solution.

Concerning the eligibility of geologically stored CO_2 as carbon credits under domestic GHG regimes, WWF expect that the outcome of the debate will depend on the amount of lobbying carried out by each side of the argument. Whereas major oil and gas companies lobby in favour of CO_2 sequestered being eligible as carbon credits, environmental groups and the renewable energy industry lobby against it.

B5 FRIENDS OF THE EARTH INTERNATIONAL

Kate Hampton, Global Co-ordinator on Climate Change, stated FoE International's unequivocal opposition to CO_2 capture / storage. Miss Hampton raised a wide range of objections to the technology, which are here summarised as two issues.

- *Sustainable Development*: fossil fuel use is inherently unsustainable, environmentally, socially and economically. Even if the technology was reliable (and there is no guarantee that it can be made reliable – see below), the environmental and social impacts of extraction and transport activities are still immense, particularly for the local communities who host extraction / transport (Kate listed a wide range of negative impacts that the oil sector has around the world, particularly in developing countries, e.g. geopolitical instability, corruption, human rights issues, access to resources, economic underdevelopment, pollution etc). For social, environmental and political reasons, FoE supports the change from fossil fuels to renewables, and opposes the use of any technology that diverts resources away from the development of renewable energy technology.

- *Technical:* the technology is unproven, and increasing the active carbon pool is inherently dangerous as there is no guarantee that CO_2 could be permanently stored as would be required. FoE International is sceptical about the value of carbon sequestration in any form, given that it is never possible to guarantee the long-term security of any sequestered carbon, for political, economic, social and technical reasons.

B6 REFERENCES

Table B6.1 lists the contact details of NGO members contacted during this review.

Table B6.1 Non Governmental Organisations Interviewed

Name	Organisation	Position	Contact detail
Jason Anderson	Climate Action Network		Jason@climnet.org
Kjell Oren	World Business Council for Sustainable Development (WBCSD)	Member of the CC department	00 41 22 839 31 00
Paal Frisvold	Bellona Foundation	Policy Advisor	+32 473 97 87 60
Kate Hampton	Friends of the Earth (FoE)	Foe Climate Change, global coordinator	0207 490 15 55. Mob: 07748967323
Ute Collier	WWF	Head of climate change and energy	01483 42 64 44 (WWF), direct line: 01483 412 549

Annex C

Questionnaire for Government Officials

Note:
For the purpose of this update report, the interviews with government officials were based on the same questionnaire as for the report ERM delivered to the CCP in January 2003[1]. However, this questionnaire was tailored to each country review, in order to further investigate the issues of importance to CO_2 Capture and Storage technology development identified in the first report.

C1. *REVIEW OF THE INCENTIVES FOR R & D, PILOT AND DEMONSTRATION PROJECTS*

- Are there any existing, or expected financial incentives (e.g. tax benefits, subsidies, research grants) for CO_2 capture and storage R & D, pilot, and demonstration projects?

- Are there any existing, or expected disincentives? (e.g. targeted tax cost, need for special planning permissions)

- To your knowledge, is there any existing, or expected program or funding in your country, for CO_2 capture and storage R & D, pilot and demonstration projects?

- Have their been, or is there expected to be any CCP pilot, or demonstration projects in your country?

C2 REVIEW OF POLICIES AND REGULATIONS AFFECTING CO_2 CAPTURE AND STORAGE

C2.1 REGULATIONS AND POLICIES

- Do you know of any policies or regulations favouring CO_2 capture and storage (financial measures, Voluntary Agreements)?
- Regulations restricting CO_2 capture and storage?
- IF NO: How about regulations specific to pipelines / gas storage / waste disposal regulations / groundwater regulations?

C2.2 LACK OF REGULATIONS

- IF NO / OR LIMITED REGULATIONS: In your opinion, how might the lack of regulatory framework affect the development of CO_2 capture and storage projects?
- How can the developer of such projects be expected to be treated, with respect to carbon crediting, or for compliance in a domestic GHG regime (with respect to tradable carbon credits, would they be recognised as being compliant?).
- With respect to monitoring and certification of projects: does the lack of rules mean that user won't get credits for it?

C2.3 NGO AND PUBLIC AWARENESS

- Positive or negative NGO actions?
- Positive or negative public awareness?

C3 OTHER QUESTIONS OF INTEREST

- Policies on underground injection of waste?
- Safety regulations about storage of other gases (e.g. regulations on natural gas storage)?
- For Annex I countries: As a country buying credits, would you be able to recognise CO2 Capture and Storage Projects as CDM / JI projects from outside the country?
- The Netherlands: do Capture and Storage Projects qualify for CERU- PT, ERU-Pt?
- Denmark: would the projects be eligible under your new JI fund?

C4 FINALLY… GENERAL PERSPECTIVE

From the perspective of your government, looking at CO_2 capture and storage, do you believe that this can be a significant opportunity for industry to utilise, in your country?

IF YES, would you say that this applies for any potential methods, or one specific one?

IF NO, what sort of work needs to be done to overcome the barriers?

Annex D

Documents Relevant to the CCP Team

Table D1 lists all the documents referred to in the main body and in *Annex A* (Country Reviews) of this report. The comments column of the table describes which reports are included in this annex and why some of these reports have not been included in this Annex. ERM requires guidance from the CCP team members to find these documents.

Table D1 Documents provided in Annex D

Country	Document	Comment
EU	EU Directive 85/337 relating to environmental impact assessments (as amended by directive 97/11)	Attached
	EU Water Framework Directive	Attached
UK	UK Energy White Paper	Attached
	DTI Performance and Innovation Unit Energy Review	Attached
	Draft report from DEFRA/DTI OSPAR Workshop- October 2003	Attached
Denmark	Danish Subsoil Act	Attached
	Proposal for a Climate Strategy for Denmark, Feb 2003	Attached
	Danish Offshore Installations Act	Attached
Netherlands	New Mining Act	Attached
	Environmental Management Act	http://www.eel.nl/Countries/NL/indxema.htm
	Soil Protection Act	Attached- only available in Dutch.
	Electricity Act, July 2003	Forthcoming
	Government White Paper on Climate Change and Clean Fuels, 2003, Ministry of Economic Affairs	[Only available in Dutch? ERM has not been able to locate it]
Norway	Parliament White Paper on Gas Utilisation (Report No 9 2002-2003)	http://odin.dep.no/archive/oedvedlegg/01/02/Stmnr069.pdf
	2 White Papers on Norwegian Climate Policy (Report No 54 2000-2001 and Report No 15 2001-2002)	http://odin.dep.no/md/engelsk/publ/stmeld/022001-040012/index-dok000-b-n-a.html http://odin.dep.no/md/engelsk/publ/stmeld/022051-040013/index-dok000-b-n-a.html
Canada	National Climate Change Strategy Oct. 2000	Attached
	Climate Change Action Plan 2000	Attached
	Alberta Climate Change Action Plan	Attached
	Energy Utilities Board's Northern Pipeline Regulations	Attached
International Organisations	IEA GHG R&D Programme Review of International Conventions Having Implications for CO_2 Storage in the Ocean and Under the Sea Bed	Attached