FINAL REPORT

CO_2 Capture Project

Inventory and review of government and institutional policies and incentives contributing to CO_2 capture and geological storage

January 2003

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INTRODUCTION

This report identifies, reviews and summarises existing incentives and public policies or regulations that allow, inhibit or stimulate the geological storage of carbon dioxide (CO_2) as a GreenHouse Gas (GHG) mitigation option.

The report highlights how regulations, incentives and public policies treat CO_2 capture and geological storage (compared to other GHG mitigation options) and how this might develop in future.

Given the lack of experience in most countries with developing either commercial or demonstration projects for CO_2 capture and geological storage, the lack of specific regulations and tools has also been considered to determine whether it is a constraint to future development of the technology.

Highlights of the report

On balance, the government officials interviewed generally displayed a positive (Denmark, Norway, the UK, the US, Canada, Australia) or neutral (the Netherlands) attitude to the issue. Germany was the only country to display a negative attitude to the development of CO_2 capture and storage technologies: the German Federal Ministry of Environment recently announced its opposition to any CO_2 storage strategy, however, other German ministries may not be opposed to the use of the technology. It is important to note that the German Ministry of Environment would be setting the rules and regulations applying to CO_2 capture and storage.

There are not yet any specific subsidies for commercial scale CO_2 capture and storage projects, although the lack of commercial viability is widely recognised. Some support for Research and Development (R&D) and pilot projects is available, mainly through the EC and clean energy programmes in the Netherlands, Denmark, the UK, Norway, the US, Canada, and Australia, with the possibility of growing support in future

The key international regulations likely to apply to CO_2 capture and storage are the London Dumping and OSPAR Conventions.

In general, regulations developed for protection of aquifers and development of oil and gas facilities generally apply, but have typically not 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 may trigger various waste regulations and make storage in aquifer zones difficult.

Whereas green NGOs generally keep an open mind, some express their scepticism (or even opposition), largely because capture and storage is seen as a threat to the transition towards a renewables based energy sector, and a way (in their view) for the oil and gas industry to adopt a "business as usual" attitude towards CO_2 emissions mitigation.

Public awareness of the technology is low and it is as yet unclear whether CO_2 storage will be perceived as risky. In some places (e.g. UK and California) CO_2 storage is likely to face the same difficulties in obtaining planning permission that cogeneration plant, waste incinerators and renewables have faced. Given the low level of public awareness regarding carbon capture and storage, the jury is still out on whether public reaction might be a barrier to this option making a significant contribution to greenhouse gas control.

1 INTRODUCTION

Background

The CO_2 Capture Project and its members have embarked on a major research and development programme intended to:

- Achieve major cost reductions for CO_2 capture and geologic storage by 50% in retrofit applications, and 75% in new-build plants;
- Demonstrate that CO_2 storage is a safe, measurable and verifiable;
- Develop new and existing technologies; and
- Share learning with others.

However, the programme will involve the partners in major research and development costs and is likely to encounter some concerns amongst government and non-governmental organizations committed to Kyoto about:

- Possible health, safety and environmental impacts of specific technologies;
- Potential leakage and long-term reliability of geological storage for carbon fixation;
- Monitoring and certification issues related to verification of the amounts and migration of CO_2 injected, plus continued certification over time; and
- Whether this is distracting from other GHG mitigation measures.

Objective and Scope

The Objectives of this paper 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.

This paper is intended to provide a basis from which, 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.

Approach

In preparing this report, Environmental Resources Management (ERM) has carried out interviews with representatives of environmental protection agencies and those involved in R&D and demonstration projects for CO_2 capture and storage. While the focus has been on understanding the current

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

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 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 CO_b Capture Project (CCP).

Structure of the report

Section 3 is an overview of the main findings on policies and regulations which may influence CO_2 capture and geological storage technologies. *Section 4* is an overview of the main findings on fiscal incentives for R& D, pilot and demonstration projects. *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*. Finally, a copy of the questionnaire used to interview government officials in this review is provided in *Annex C*.

Introduction

CO_2 capture and geological storage 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 (*Section 1*). The technology is developing steadily but, given the lack of commercial scale demonstration projects, international and national policy and regulatory frameworks for carbon capture and storage are still under-developed. In some cases, the *absence* of specific regulations may create barriers to the further development of the technology.

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 (*Section 4*)) 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 CO_2 capture and storage;
- Regulatory frameworks for pilot programmes and commercialisation of the technology;
- Public attitudes and stated positions of NGOs.

Box 2.1 Risks and Uncertainties Associated with CO_2 Capture and Storage

The main perceived risks are associated with:

- CO_2 leakage due to the failure of pipeline and surface injection facilities resulting from materials and/ or design problems.
- CO_2 leakage via various kinds of unidentified migration pathways from the reservoir.
- Remaining contaminants in CO_2, such as SO_2, NOx, heavy metals, and toxic hydrocarbons.
- Monitoring requirements to confirm CO_2 volumes stored and any subsequent leakage: what will these requirements be, and how much might they cost?
- CO_2 leakage during ship and/or pipeline transport/transfer of CO_2.

These risks are related to many factors (e.g. CO_2 injection amount and intensity, fluid properties of CO_2, sedimentary origin of reservoir, permeability of aquifer and cap rock, injection facilities,

and site geological features). These factors have complex interrelationships; many of them are uncertain, and vary with time.[1] (See Lui, et al. 1998)

Box 2.2 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 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.

International Policy Context

International Conventions and Agreements

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

London Dumping and OSPAR Conventions

There is 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.

Other International Activities

The IPCC is currently preparing a Special Report on Geological Carbon Storage. The start up meeting for this project took place in Canada, between the 19th -21st of November. 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

[1]

for establishing a tonne of carbon dioxide in a geological structure has been flagged as a major issue for this meeting.

The IEA GHG R & D program is also preparing a special report on Implications of International Conventions for CO_2 Storage.

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, and 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)	No or Limited awareness (No) Negative (-ve) or Positive (+ve) NGO actions?	No or Limited awareness (No) Negative (-ve) or Positive (+ve) public opinion?
EU	×	×	✓	✓	Yes	-ve	No
Denmark	×	×	×	×	No	-ve	No
Germany	×	×	×	×	Yes	-ve	-ve
Italy	×	×	×	✓	No	No	No
Netherlands	×	×	✓	✓	No	-ve	No
Norway	×	×	✓	✓	No	-ve[1]	No
The UK	×	×	×	✓	Yes	-ve	-ve
USA	×	×	✓	✓	Yes	No	No
Canada	×	×	✓	✓	Yes	No	No
Australia	×	×	✓	✓	No	-ve	-ve

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

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) with investigating CO_2 capture and storage or reutilisation [3], and specifies as a

[1] However, it is unclear whether the current negative attitude in Norway is related to ocean disposal, rather than geological storage.

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

medium term R&D priority the *"development of small and large scale CO_2 capture, transport and sequestration technologies"*[1].

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 and 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 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), 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. In both oil and gas producers and non-producers however, different views are evident amongst Energy/Finance Ministries who often see the technology as a potentially cost effective part of meeting Kyoto Commitments, and Environmental regulatory authorities who may have technical concerns.

For instance, in both the Netherlands and Denmark, attitudes are broadly positive since both 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 both national climate change strategies. In both countries, significant storage capacity exists in gas and oil reservoirs; and in the Netherlands 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, only Germany appears unsupportive of the technology, with the Federal Ministry of the Environment expressing opposition to any CO_2 storage strategy, a position which may in due course be reflected in the regulatory framework. 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.

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

[1]European Climate Change Programme, p. 139

Box 2.3 A Positive Policy Framework Developing in the Netherlands

At present, there is no policy framework either favouring or hindering the development/application of CO_2 capture and storage in the Netherlands but two new laws are expected to establish the basic legal and fiscal framework:
The Mining Act (also expected to enter into force 1 Jan 2003), which will establish provisions on storage of CO_2 and other gases, enabling developers to obtain licenses for underground storage. Licenses can currently be granted under the existing act but are more complex.
The Electricity Law (expected to enter into force 1 Jan 2003), which will establish a new subsidy worth €140m/yr for the production of electricity from renewables and for energy efficiency and climate neutral electricity (including CO_2 capture and storage).

The Ministry of Economic Affairs is also in the process of developing a policy on clean fuels for publication in early 2003 which is likely to suggest:
More support for R+D into CO_2 capture and storage;
Developing international consensus to support development of CO_2 capture and storage; developing CO_2 capture/storage to assist the transition phase from fossil fuel dependency to a renewable energy economy over the next 30 years, but not as a long-term alternative to renewables.

Source: personal communication, B. Stuji, F. Rispens, 2002

Box 2.4 Denmark

In Denmark DEPA is currently preparing a White Paper which is due for release on 1 December 2002, entitled 'Cost Effective Climate Change Strategy for Danish Commitments under Kyoto', which will look at the full range of methods for reducing greenhouse gas emissions in line with Kyoto protocol commitments, including (but focusing on) CO_2 capture/storage. This is expected to provide the first indication of Danish Government policy on CO_2 capture and storage. It is likely that the paper will explain how the Government will use flexible mechanisms to achieve its Kyoto commitments, and some fiscal measures may emerge from the paper. However, it will not result in the establishment of a legal/policy framework designed to promote the development of CO_2 capture/storage in Denmark.

Source, personal communication, U. Benson N. Christensen, 2002

Regulatory Frameworks

As mentioned in *Section 2.3.2*, 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. 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 through concessions let by the Ministry of Economic Affairs which establishes operating conditions; associated pipelines are also covered by EIA legislation. However, Dutch regulators report that there is currently a lack of clarity in relation to CO_2 capture and storage, and that it would be difficult for a developer to use the technology at present. This position will be clarified by two new laws due in January 2003 (*Box 2.3*).

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.

Box 2.5 Classification of CO_2 for Storage: The case of the Netherlands

In the Netherlands the Environment Ministry is currently considering whether CO_2 should be regarded as a waste. It seems likely that it will be classified as a non hazardous waste which would be disposed of underground with a permit but without penalty (in the same way as process wastewater is currently dealt with). There are three underground storage facilities for stockpiling of natural gas in the Netherlands, which are currently regulated through concessions rather than specific legislation. Were a CO_2 storage project in operation, it would currently be regulated in the same way.

Source: personal communication, B. Stuji, F. Rispens, 2002

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). There is so far no practical experience with CO_2 capture and geological storage, but it is highly likely it would be treated under the same framework.

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 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 aquifers while geological storage in oil and gas reservoirs is likely to be considered more favourably.

Public Attitudes to CO_2 Capture and Storage

This section summarises 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

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

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.

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.

Summary and conclusions

On an international scale, the London Dumping and OSPAR conventions (*Section 2.2.1*) are likely to be the key legislation applying to CO_2 geological storage. At a domestic level, regulations developed for protection of aquifers 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 aquifers zones difficult due to stricter disposal restrictions.

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

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 recognise 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. Whether this poses a barrier to the development of the technologies involved, or is a simple matter of sharing information with senior officials remains to be determined.

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. The next section therefore summarises existing and planned fiscal support measures and how CO_2 capture and storage is likely to fare in relation to the Kyoto mechanisms.

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

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 summarise 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 summarises 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.

Box 3.1 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 recent White Paper on gas utilization in Norway (1st November 2002) announces that the support for R&D and large-scale investments will be increased.

- **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. The Danish Environmental Protection Agency (DEPA) produced a review of socio-economic costs associated with the proposed projects. The results of the socio-economic analysis, or detailed information on the proposed projects, have not been released to the general public.

- **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).

- **Canada**: Research is underway on EOR, enhanced coal bed methane recovery, and storage of commercial acid gases.

- **USA**: Research studies are being carried out at Lawrence Berkley Laboratory and Cal **T**ech on escape paths of CO_2 from injection points and to the near surface and at atmospheric monitoring techniques, respectively.

Note: See *Annex A* for further detail.

Table 3.2 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?
EU	✓	×	✓	✓
Denmark	×	×	✓	✓
Germany	×	×	×	×
Italy	×	×	✓*	✓*
The Netherlands	✓	✓	✓	✓
Norway	×	×	✓	✓
The UK	✓	×	✓*	✓
USA	✓	✓	✓	✓
Canada	✓	×	✓	✓
Australia	✓	×	✓*	✓*

×: non existant; ✓: existant; * expected ;

Financial incentives/ disincentives for carbon management

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. Tax breaks are expected: for instance, in the Netherlands, the new Electricity Act (expected to enter into force by January 2003) is likely to provide tax relief for renewables, energy efficiency and climate neutral electricity up to €50 million a year, and CO_2 capture and storage is expected to be eligible.

In Canada, the Environment department of Alberta is aiming to obtain approval of a pilot project through which companies developing CO_2 enhanced oil recovery (EOR) projects would be exempt from 30 % of the Royalty Credits which are usually applied to minerals extraction.

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.

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). 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 an EC 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. A pilot project is currently being developed by the University Of Texas Bureau Of Economic Geology and four 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% by 2012).

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.

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

[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.

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 has other issues that would make the economics of CO_2 capture projects even less attractive[1].

Summary and Conclusions

There are not yet any specific subsidies for commercial scale CO_2 capture and storage projects, although the lack 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.

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 seen as economic. Without imputing a value to the carbon stored, it appears unlikely that the technology will be economic in the medium term.

In the absence of direct subsidies, the critical issue will be whether or not the technology is eligible for credits under the Kyoto mechanisms. This is dealt with in the final section.

[1] 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.

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.

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 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.

Potential linkages with Kyoto mechanisms

CO_2 capture and storage is not currently covered by the Kyoto mechanisms. 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, 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"

Many interviewees abstained from giving an opinion on the issue, and only one of the interviewees (in Canada) could comment on whether CO_2 stored in this way would be eligible as credits under the CDM and JI: he considered that, as a sequestration technique, it could be treated as LULUCF (Land Use, Land Use Change and Forestry), and consequently eligible for CDM and JI, but also within the limits set in the Marrakech Accords for total credits from LULUCF.

In the Netherlands, the Ministry believes that CO_2 capture/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 flexible 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.

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

It is interesting to note that EU interviewees 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.

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