



INTERNATIONAL ENERGY AGENCY

NEAR-TERM OPPORTUNITIES FOR CARBON DIOXIDE CAPTURE AND STORAGE

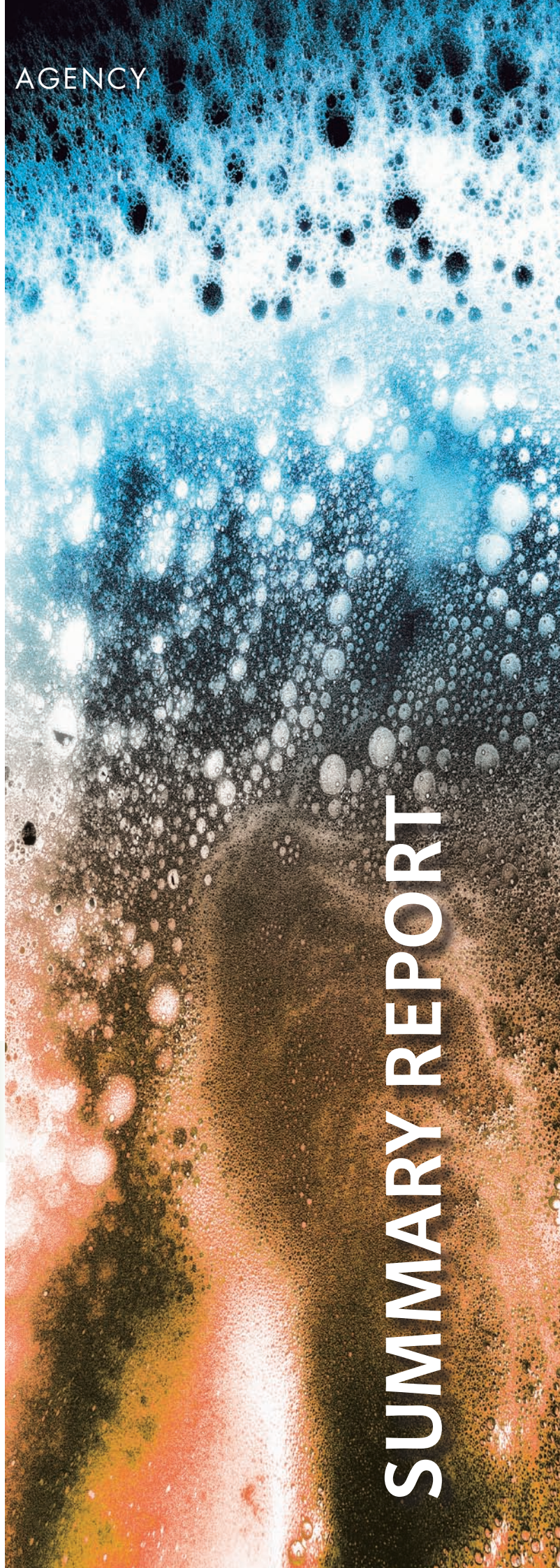
Global Assessments
WORKSHOP

In support of the G8 Plan of Action



CARBON SEQUESTRATION
LEADERSHIP FORUM

SUMMARY REPORT



INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six of the OECD thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The Slovak Republic and Poland are likely to become member countries in 2007/2008. The European Commission also participates in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

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

The European Commission takes part in the work of the OECD.

© OECD/IEA, 2007

International Energy Agency (IEA),
Head of Communication and Information Office,
9 rue de la Fédération, 75739 Paris Cedex 15, France.

Please note that this publication is subject to specific restrictions that limit its use and distribution. The terms and conditions are available online at <http://www.iea.org/Textbase/about/copyright.asp>



In support of the G8 Plan of Action

NEAR-TERM OPPORTUNITIES FOR CARBON DIOXIDE CAPTURE AND STORAGE

Summary Report of the Global Assessments Workshop

This document contains the summary report of the workshop on global assessments for near-term opportunities for carbon dioxide capture and storage (CCS), which took place on 21-22 June 2007 in Oslo, Norway. It provided an opportunity for direct dialogue between concerned stakeholders in the global effort to accelerate the development and commercialisation of CCS technology. This is part of a series of three workshops on near-term opportunities for this important mitigation option that will feed into the G8 Plan of Action on Climate Change, Clean Energy and Sustainable Development. The ultimate goal of this effort is to present a report and policy recommendations to the G8 leaders at their 2008 summit meeting in Japan.

The workshop was organised under the auspices of the International Energy Agency and the Carbon Sequestration Leadership Forum and was hosted by Norway's Royal Ministry of Petroleum and Energy. Participants were invited experts from industry, government, academia and civil society from around the world. Sponsors included Det Norske Veritas, Hydro, Statoil and Shell.

Disclaimer

"The contents of this document represent the various views presented by the participants at the workshop, and do not necessarily represent the views of all participants or those of their companies, organisations, the International Energy Agency or its member countries."

Please note that this publication is subject to specific restrictions that limit its use and distribution. The terms and conditions are available online at:

<http://www.iea.org/Textbase/about/copyright.asp>.

© OECD/IEA, 2007 all rights reserved

Contact information: Debra.Justus@iea.org; www.iea.org

NEAR-TERM OPPORTUNITIES FOR CARBON DIOXIDE CAPTURE AND STORAGE

*International Energy Agency -
Carbon Sequestration Leadership Forum*

Summary Report of the Global Assessments Workshop
Oslo, Norway June 2007

Table of Contents

1. Overview
 - Context
 - Carbon Dioxide Capture and Storage in the G8 Process
 - Introduction
 2. Main Cross-Cutting Themes
 3. Role of CCS in Carbon Dioxide Emissions Mitigation
 4. Global Lessons Learned
 - Why Is CCS Needed Now?
 - What Is Needed to Advance CCS?
 - What May Not Work?
 5. Assessment of Regional CCS Policies and Industry Experiences
 - European Union
 - Americas
 - Australia
 - Rest of the World
 6. Review of CCS Pathways and Policy Options for Global Concerted Action
 - Public Awareness and Acceptance
 - Legal and Regulatory
 - Technical
 - Commercial/Financial/International Mechanisms
 7. Conclusions and Definition of Inputs to Recommendations Workshop
- Annex 1 Proposed Full-Scale CCS Projects for Power Generation
- Annex 2 Major Commercial and R&D Projects for Storage of CO₂

NEAR-TERM OPPORTUNITIES FOR CARBON DIOXIDE CAPTURE AND STORAGE

Summary Report of the Global Assessments Workshop

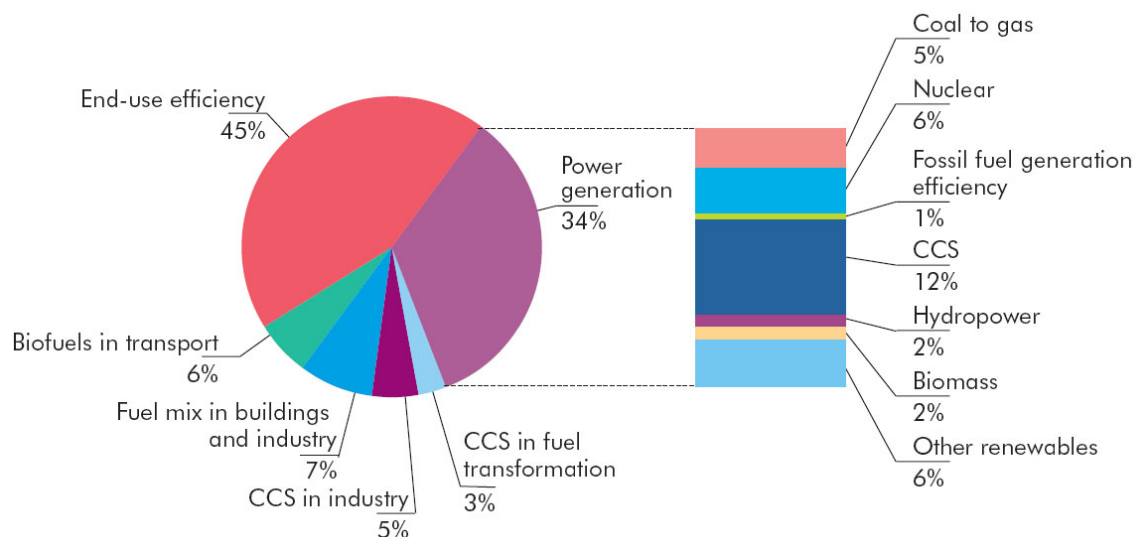
1. Overview

1.1 Context

Today, fossil fuels provide about 80% of global energy demand and the outlook is that they will remain the dominant source of energy for decades to come. Consequently global energy-related CO₂ emissions increase 55% between 2004 and 2030 in a business-as-usual outlook.¹ It is increasingly clear that this development path is not sustainable.

Carbon dioxide capture and storage (CCS) is a critical technology to significantly reduce CO₂ emissions. In a global CO₂ emissions stabilisation scenario, CCS in power generation, industry and fuel transformation could account for 20% of CO₂ savings (6.5 Gt of CO₂ captured and stored annually in 2050).² Accelerating investment in R&D and demonstration projects will be needed if CCS is to make a significant contribution. CCS along with other mitigation measures could significantly reduce the costs of stabilising greenhouse gas concentrations and increase the flexibility to achieve that goal.

Relative Contributing Factors to Bring CO₂ Emissions to 2003 levels in 2050 by Technology Area, ACT-MAP Scenario (IEA)



¹ International Energy Agency (IEA), *World Energy Outlook*, OECD/IEA, Paris 2006.

² IEA, *Energy Technology Perspectives: Scenarios & Strategies to 2050*, OECD/IEA, Paris, 2006.

1.2 Carbon Dioxide Capture and Storage in the G8 Process

The leaders of the Group of Eight (G8) countries addressed the serious and long-term challenges of secure and clean energy systems, climate change and sustainable development at their Gleneagles Summit in 2005. Agreeing to act with resolve and urgency, they adopted a Plan of Action and launched a dialogue with other significant energy consumers. In the Plan of Action, the G8 leaders agreed that they would work to accelerate the development and commercialisation of carbon capture and storage by:

... inviting the International Energy Agency to work with the Carbon Sequestration Leadership Forum to hold a workshop on short-term opportunities for CCS in the fossil fuel sector; including from enhanced oil recovery and CO₂ removal from natural gas production.

The IEA and Carbon Sequestration Leadership Forum (CSLF) responded favourably to the G8 request and in fact have expanded the notion to a co-ordinated series of three workshops in 2006 and 2007 which will lead to recommendations to the G8 for their summit in 2008 in Japan.

The objective of the workshops is to facilitate the G8 goal of accelerating the near-term opportunities for development and commercialisation of CCS. Near-term opportunities are defined as *those opportunities for CCS that are technically and economically viable or ready for demonstration or commercialisation in the near term and include both sources and sinks and all fossil fuels*. Examples of near-term opportunities include:

- enhanced oil recovery;
- high concentration sources;
- “capture ready” electricity generation plants;
- natural gas production;
- hydrogen production;
- early demonstrations (pilot projects).

Today, a low cost opportunity might include CO₂ capture in natural gas processing or ammonia or hydrogen manufacturing where the CO₂ is already separated in combination with a short transport distance and storage option that can generate revenue such as enhanced oil recovery.

The three international workshops raise relevant policy and technical issues, facilitate a dialogue among stakeholders and provide a basis for specific recommendations to the G8 leaders to facilitate the acceleration of CCS technology as a key CO₂ mitigation option. The workshops are integrated in the following progression.

- Near-term Opportunities for CCS - Issues Identification Workshop (August 2006, San Francisco, California).
- Global Assessment Workshop to assess the specific issues and opportunities set out in the first workshop (June 2007, Oslo, Norway).
- Recommendations Workshop will lay out the technical, economic, regulatory and fiscal conditions necessary for near-term deployment of CCS and provide policy recommendation on how to create these conditions (November 2007, Calgary, Canada).
- Report and recommendations to the G8 at its July 2008 summit.

The G8 summit in Heiligendamm, Germany in June 2007 set out the following points to accelerate development and deployment of CCS:

- Prioritise national and international R&D efforts ...
- Encourage RD&D of clean coal technologies...
- Support national and international geoscientific and political efforts...
- Encourage ... governments to design mechanisms to stimulate the construction and operation of a growing number of large-scale demonstrations of sustainable fossil fuel technologies in commercial power generation.
- Encourage industry to consider the concept of capture-ready when developing new fossil fuel power plant.

1.3 Introduction

The purpose of this report is to summarise the key points from the global assessment of near-term opportunities in carbon dioxide capture and storage (CCS) workshop held in Oslo, Norway in June 2007. Its aim was to assess the priority issues that were identified in the first workshop in San Francisco by considering lessons learned from experiences to date and exploring pathways for accelerated deployment of large-scale CCS.³ This will serve as definition and input into the third workshop for developing recommendations.

The main message from the first workshop was that realising the promising potential of CCS depends on tackling the economic, legal and regulatory, technical and other challenges (summarised in Box 1).

Box 1

HIGH PRIORITY ISSUES IDENTIFIED IN SAN FRANCISCO WORKSHOP

Technical Issues:

- ◆ Address long-term liabilities.
- ◆ Facilitate commercialisation through the provision of incentives, insurability and reasonable permitting processes.
- ◆ Accelerate capture technology RD&D.

Commercial and Financial Issues:

- ◆ Create value for CO₂ and a global market.
- ◆ Governments need to create a framework for business value.

Legal and Regulatory Issues:

- ◆ Establish regulatory framework.
- ◆ Develop monitoring and remediation procedures.

Public Awareness Issues:

- ◆ Prioritise key messages on CCS and prepare communication strategy.
- ◆ Ensure effective education and outreach activities with early CCS demonstration projects.

International Mechanisms Issues:

- ◆ Need an economic incentive for CO₂ capture and storage.
- ◆ Ensure an effective international framework to support CCS development.

³ Issues Identification Workshop Summary Report is available at:
http://www.iea.org/Textbase/work/2006/ccs/summary_report.pdf

Several elements underscore the rationale for early action on CCS:

- **Climate science is compelling and implies urgent action.**⁴
- **CCS costs must be reduced. Cost-cutting innovations come from accumulating field experience, *i.e.* learning-by-doing.**
- **Retrofitting power plants for CCS is much more costly than for new plants, or making new plants capture-ready.**
- **Delay brings significant risks of carbon lock-in.**

The CCS process chain has three stages: (1) *capturing* CO₂ from fuel and industrial processing, electricity generation plants and compressing it; (2) *transporting* the CO₂ by pipeline or tanker; (3) *injecting* the CO₂ into a suitable geological formation for long-term isolation from the atmosphere. Most of the necessary technologies have been in use in other applications for decades, albeit not in an integrated fashion with the intent of CO₂ emissions reduction.

CCS technology needs to move forward. In the near-term this will require an intensification of public and private research, development and demonstration effort to get to the market deployment stage. In addition, large-scale deployment of CCS will require appropriate remuneration of investors for the additional capital and operating costs of CO₂ capture facilities. Companies need clear indications that CO₂ emission reductions will be sufficiently compensated over a long period to support the rollout of CCS.

CO₂ separation is a common application in natural gas and other industrial processing. However, there is limited experience with its use to separate CO₂ emissions in electricity generation. There are several capture technologies that could be used, but their application for commercial-scale power plants needs to be demonstrated. Captured CO₂ must be pressurised to 100 bar or more for transport and storage, which adds to the energy intensity of CCS. A number of demonstrations for coal and natural gas-fired power plants with CO₂ capture are in various stages of planning in Europe, Australia and North America.

CO₂ can be stored underground in geological formations (onshore and under the sea bed) such as deep saline aquifers, depleted oil and gas reservoirs or un-mineable coal seams. In some cases, there is a commercial value. For instance, CO₂ has been used for three decades by the oil and gas industry for enhanced oil recovery (EOR) and it can be used for coal-bed methane recovery. Monitoring technologies allow for the tracking of CO₂ in sub-surface layers. Initial findings show that favourable geological sites are widely available and, taken together, represent a large and geologically diverse potential storage capacity.⁵ More research is needed on identifying suitable formations and long-term interactions between the CO₂ and underground minerals and fluids. The prospects for ocean storage within the water column are hampered by environmental concerns.

One of the main challenges for wide deployment of CCS is high costs. CCS technologies will not make a major impact without economic incentives to reduce CO₂ emissions. However, the same reasoning applies to other low carbon electricity production options with high costs. There are also non-economic challenges of legal issues related to long-term storage and public awareness and acceptance.

⁴ Intergovernmental Panel on Climate Change (IPCC), 4th Assessment Report, Draft Report of the 26th Session, Bangkok, May 2007.

⁵ IPCC, *Carbon Capture and Storage*, Special Report, Cambridge University Press, 2005.

More than 150 invited experts from industry, government, academia and civil society participated in the Global Assessments Workshop in Oslo. The workshop concept resembled a “talk show”, which was meant to facilitate highly interactive and integrated discussions. Two facilitators, three screens, visual and audio multimedia, and a large technical staff provided a dynamic workshop setting. Panel discussions took place on stage. Workshop participants were grouped by various categories at tables at which they discussed the main points of a session and had the opportunity to ask questions of the panellists and make comments.

All the presentations and speeches made during the sessions are available at: www.q8-ccs-assessment.com

2. Main Cross-Cutting Themes

Good news for advancing CCS in the year since the first workshop includes progress in international work, e.g. the London Convention; more national/regional activities in assessments and institutional frameworks; broader media coverage of CCS as a mitigation option; deeper knowledge and confidence of the science of climate change and strategies to tackle it, e.g. IPCC 4th Assessment Report and the Stern Review. Much remains to be done, however, as there are no full-scale plants that demonstrate all aspects of CCS. The key challenges are a lack of a value for carbon dioxide emissions, costs of CCS and uncertainty. The issues outlined in Box 1 rest at the top of the agenda for advancing CCS to fill a viable role in decoupling CO₂ emissions from use of the world’s vast fossil fuel resources.

In assessing these issues through lessons learned and what needs to be done to support and accelerate CCS, four main themes of a cross-cutting nature were emphasised: value, size, timing and infrastructure.

- ◆ **A value for carbon dioxide is needed.** This will establish a value to all parts of the CCS chain.
- ◆ **Size matters.** The magnitude of CO₂ emissions that need to be captured and retained in long-term sequestration by 2050 is on the order of 6 000 projects similar to the Sleipner facility in Norway that has been sequestering 1 million tonnes of CO₂ per year for a decade.
- ◆ **Urgency is called for** to enable CCS to make a contribution to meaningful CO₂ emissions reductions by 2050. This calls for early action to put full-scale demonstration plants in operation in the coming decade. The IPCC finds that to stabilise the greenhouse gas (GHG) concentration in the 445 to 490 ppm CO₂-eq range that global emissions need to be reduced 50 to 85% by 2050. The lower the stabilisation level, the more quickly the emissions need to peak and decline thereafter. Therefore mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. There is a need to speed the pace of demonstration projects to increase learning-by-doing and to facilitate cost reductions.
- ◆ For CO₂ transport, **infrastructure is a critical enabler** for the large-scale deployment of CCS, i.e., pipelines and facilities.

3. Role of CCS in Carbon Dioxide Emissions Mitigation

Carbon dioxide capture and storage offers a significant opportunity to reduce CO₂ emissions and to lower mitigation costs. In responding to the G8 request, the International Energy Agency evaluated emission reductions by sector in accelerated technology scenarios to 2050. Results show that energy efficiency is the single largest contributor to CO₂ emission reductions. CCS is the second largest contributor in an optimistic technology scenario with 20% of the total 32 GT reduction in 2050 from power generation, fuel transformation and industry (see figure in section 1). The challenges to get to this level are large. Decision makers need to awake to the scale that is needed to achieve the level of CCS to enable the continued use of coal which is cheap, plentiful and important for energy security. This implies substantial exploration and commissioning, equipment supply and education and training of technical experts.

The pace of CCS development and deployment needs to be brisk and at commercial scale. Experience will lead to lower costs in time to ensure early uptake and facilitate the gigatonnes of CO₂ storage needed. Accelerated CCS deployment will also stem the lock-in effect of high carbon, long-life technologies. Enhanced oil recovery (EOR) is an important early market that can help to reduce costs. However, it is essential to demonstrate and multiply CCS applications in power generation. Given the current pace of deployment of coal-fired power generation there is a risk of carbon lock-in if a number of actions are not taken including incorporation of the concept of capture-ready plant.

Making new plants capture-ready calls for an agreement on the characteristics, deployment in economies that are expanding fossil fuel power generation, assessment of storage site suitability and incentives and/or regulations. Elements of capture-readiness are being considered by the IEA, CSLF and the IEA Greenhouse Gas R&D Programme (IEA GHG) as part of the process for the G8 summit in 2008. They are expected to address engineering aspects, space and proximity to storage sites.

CCS is one element of a portfolio of mitigation options that are needed to curtail climate change. Much improved energy efficiency in both energy supply and end-use, renewable and other low-carbon resources are imperative mitigation options. CCS can provide a significant wedge of the needed emissions reduction and is highly important as fossil fuels are very likely to remain a dominant fuel in many areas of the world for decades to come.

Presentations highlighted the **CCS challenges in a global context**:

- ◆ Predictable economic incentives are needed in the medium and long-term as there is a lack of a global and long-term value for CO₂. CCS costs are high and currently investment risks are significant.
- ◆ Technology advances are needed to reduce the cost of capture and reduce the energy requirements of the capture, transportation and injection phases.
- ◆ Infrastructure is a critical enabler for CCS. What does it take to put it in place? Should it be a public/private endeavour and how should it be financed? Are there relevant lessons from large network developments such as natural gas pipelines, electricity grids and highways? How complete are assessments of existing infrastructure? (Noted that such an assessment is currently underway by Norway and the United Kingdom in the North Sea; European Commission is preparing a communication on supporting early demonstration of sustainable power generation from fossil fuels, including infrastructure needs, which is expected in late 2007; regional assessments are underway in Canada and the United States.)

- ◆ More experience is needed to prove long-term storage retention in various geological structures. Robust sub-surface methodologies are needed for risk management, including site assessment, injection, monitoring and verification and post-closure procedures. International co-operation is needed to develop best practices for different geological structures and to demonstrate monitoring and remediation methodologies.
- ◆ It is imperative to gain public acceptance of CCS as a safe and predictable mitigation option. Demonstration projects have an important role to play here by being transparent and providing high quality information, as do coherent communication strategies.
- ◆ Demonstration projects need streamlined regulatory approaches via existing or project specific regulations. Experience gained in these projects can inform the development of full legal and regulatory regimes particularly for monitoring and verification approaches. There is a transitional role for governments in partnership with industry to counter act the risk profile in an unregulated framework and in the absence of an appropriate value for carbon.
- ◆ National, regional and international legal and regulatory frameworks are needed. (Noted that international marine environment protection instruments are making important progress; Australia has national CCS guidelines and is moving towards legislation in the near-term; European Commission anticipates release of its draft enabling legal framework in late 2007; IEA's *Legal Aspects of Storing CO₂ : Update and Recommendations* was released on the occasion of the Oslo workshop.)

To accelerate CCS deployment, national, regional and international policies should:

- ◆ Facilitate the development of CCS technologies through support of R&D and demonstration projects. At least 10 full-scale demonstration projects to characterise CCS under different conditions (capture technology and storage formations) are needed by 2015.⁶ This will pave the way to deployment at the gigatonne scale that is needed in the necessary timeframe.
- ◆ Create a balanced policy framework that recognises the potential of CCS along with other mitigation technologies.
- ◆ Facilitate the establishment of appropriate legal and regulatory frameworks.
- ◆ Support public awareness campaigns.
- ◆ Include CCS in the Kyoto Protocol flexible mechanisms and in the European Trading Scheme.

⁶ IEA, *Prospects for CO₂ Capture and Storage*, IEA/OECD, Paris 2004.

4. Global CCS Deployment - Lessons Learned

Key Messages

- ◆ Incentives are needed for early action to advance CCS as currently there is only a weak market. Price is the best signal.
- ◆ Political will is fundamental to drive the needed legal and regulatory frameworks. However, early developments should be facilitated through existing, complementary regulations which will help to inform the development of specific CCS procedures.
- ◆ Need to conduct resource assessments to match sources and sinks and to determine infrastructure requirements.
- ◆ Public/private partnerships are key for R&D technology advances and to support a variety of demonstration projects in the coming decade.

Key factors that enable or inhibit CCS were discussed in a series of questions from the facilitators as summarised below. Panellists were affiliated with Statoil, Shell International Renewables, Mitsubishi Heavy Industries and the Geological Survey of Canada.

4.1 Why Is CCS Needed Now?

- ◆ Energy demand will double by 2050 and energy systems will aim to be cheap, convenient and clean. Fossil fuels meet the cheap and convenient objectives and by closing the circle with CCS economic development can progress across the globe. Coal and unconventional hydrocarbons such as oil sands will be important sources and EOR will be increasingly required as conventional resources become more difficult to extract.
- ◆ The Sleipner project in Norway started because of a need to reduce the CO₂ content of natural gas and a carbon tax (~\$50/ tonne). It was undertaken in co-operation with authorities rather than as a result of regulation as there was no established legal and regulatory framework for CCS. An emphasis on transparency, for example seismic data, contributed to the success. With a decade of experience, Sleipner provides useful experience in the injection and storage of 1 million tonnes of CO₂ per year for ten years.
- ◆ Technology blocks for CCS are available now: they are being used for EOR; stripping CO₂ from natural gas and for acid gas disposal.
- ◆ The ten full-scale demonstration projects called for need to gain experience in a number of different CCS configurations. Technology roadmaps for the demonstrations are needed. (Noted the European Union's Flagship Programme.)
- ◆ Delay of such projects will reduce the potential contribution of CCS to CO₂ emission reductions. Climate change will remain a high priority and more policies and measures for mitigation will be employed to reduce GHG emissions. This can be expected to impact on future energy mix and supply structure. Thus, CCS will play an increasingly important role in the development of the energy supply mix.

- ◆ The near-term opportunity of EOR is low hanging fruit for CCS in that lessons learned will help to reduce costs and gain public acceptance. CCS for EOR is only applicable in specific geological conditions, but it provides a useful learning experience. The availability of affordable CO₂ is a critical economic factor for the viability of EOR projects.

4.2 What Is Needed to Advance CCS?

- ◆ A long-term framework that provides a value for carbon and an appropriate regulatory regime. Political will to establish the frameworks is fundamental. Some examples in this regard include Norway's carbon tax, the EU zero emissions platform and the California clean power initiative. Industry, technology providers and NGOs have roles to assist governments in setting the frameworks.
- ◆ One avenue is a cap and trade system that creates a carbon price and facilitates interchange and connected trading systems. However, taken from today's experience with the European Union Emissions Trading Scheme (EU ETS) the likely carbon values would probably not be high enough in the short term to really accelerate CCS demonstration, and their fluctuations increase investment risks.
- ◆ RD&D to further CCS technology and to reduce costs, particularly in the capture phase.
- ◆ Co-operative action between government and industry is essential as there are currently no market drivers for CCS, other than niche EOR opportunities. Incentives are needed to spur early actions. Public/private partnerships are needed to deal with risks as CCS develops as a significant CO₂ mitigation measure.
- ◆ Clear responsibility for short and long-term liability.
- ◆ Conditions that reward early movers.
- ◆ Raise public awareness of CCS as a viable climate change mitigation measure to gain acceptance. The Sleipner experience shows that despite considerable media attention, few Norwegian nationals are aware of the pioneering effort.
- ◆ Infrastructure is a critical enabler for CCS.

4.3 What May Not Work?

- ◆ "Bolting" on CO₂ transport and storage without adequate design considerations. Not all oil and gas pipelines are suitable for CO₂ transport. Assessment needs to look at how a reservoir may perform in a depletion strategy for potential CCS suitability.
- ◆ The "Capture Ready" concept causes concern as it may entail investment if no clear indication is given on when or if it will be needed. Does the concept imply storage – ready?
- ◆ Casting CCS as the sole or primary option that will mitigate CO₂ emissions in the energy sector.

5. Assessment of Regional CCS Policies and Industry Experiences

Key Messages

- ◆ The fact that there is no or insufficient economic value for CO₂ is a principal deterrent for CCS. Lacking a market signal, there is little rationale or reward for capturing and storing carbon other than in niche areas such as EOR.
- ◆ Natural resource endowments and levels of economic development mean that CCS opportunities differ between countries and regions.
- ◆ Yet across countries the common barriers to CCS deployment are high costs, and uncertain legal and regulatory frameworks for CO₂ transport and storage. Liability, project risks and a lack of economic incentives also discourage CCS opportunities.
- ◆ Government, industry and public collaboration is an effective partnership model to share risks, lessons learned and avoid duplication to accelerate CCS deployment.
- ◆ Infrastructure issues need to be addressed more thoroughly.
- ◆ Public awareness and support for CCS as a climate change abatement option require significant efforts to provide credible messages on the benefits and risks of CCS. Experience gained in Norway, the EU Zero Emissions Platform, Australia's regional partnership forum and FutureGen can be instructive.

Four panels were convened to discuss regional policies and experiences. To varying degrees they spoke about the issues and drivers for CCS in the region, successes, obstacles and opportunities.

Panellists were representatives of : *European Union session* – BP, Statoil, Geological Survey of Poland, European Commission DGTREN; *Americas session* – Brazil/Petrobras Research Center, FutureGen project (US), ConocoPhillips, Suncor; *Australia session* – Australia Department of Industry and Tourism, CSIRO research organisation, Geological Survey of Australia, Anglo America; *Rest of World session* – India/Geophysical Research Institute, UAE/Shell Middle East, Indonesia/PT PLN, Egypt/Cairo Electricity.

5.1 European Union

- ◆ It is an important driver that the European Union (EU) has CO₂ targets and a carbon market (albeit with low CO₂ value). This has fostered strong collaboration and consensus. While it has taken some time to mature, initiatives such as the Zero Emissions Platform (ZEP) have brought together diverse players. ZEP is now getting traction. This consortium of government, industry and NGOs could be a useful model for others. Another example is the European Commission goal to build up to 12 large-scale demonstration projects by 2020.
- ◆ A commercial developer of a CCS project needs to know that it is legal and that it makes economic sense. The EU ETS carbon price is too low and too short term to drive investment in CCS. A carbon price signal in the 20 to 30 year range is needed to

stimulate mitigation options such as CCS. The legal and regulatory regime for storage and long-term liability issues is missing or inadequate.

- ◆ The European Commission is developing a legal and regulatory communication which is expected in late 2007.
- ◆ Poland indicates that it has the legal and regulatory framework and has experience in storage and monitoring from injecting CO₂ and H₂S since 1995.
- ◆ More resource assessments that map sources and sinks are needed.
- ◆ Experience shows that a focus on communication in industrial commercial and demonstration projects fosters progress on common plans to move forward and transparency as projects proceed is vital to assuring public acceptance.
- ◆ Three hurdles for financing: 1) the size of investment required will require an agreement on state aid for projects; 2) can the EU ETS be used as a vehicle to pay for the cost premium for CCS in power plants?; 3) how can an infrastructure network be financed? (Noted that the EC is preparing a communication on supporting early demonstration of sustainable power generation from fossil fuels, including infrastructure needs to 2020.)

5.2 Americas

There is no driving force of a CO₂ target. North American governments are grappling with policy options for CO₂ abatement.

- ◆ Approaches appear to be somewhat more independent in comparison with the EU collaborations. Nonetheless there are seven regional sequestration partnerships in North America. They have announced five demonstration projects and completed an atlas of sources and sinks in United States, Alberta and Saskatchewan.
- ◆ Public opinion in North America is more supportive of measures to combat climate change in recent years which is making politicians more willing to take action.
- ◆ Action is constrained by a lack of long-term policies to reduce CO₂ emissions that would encourage investment in mitigation options. There is no value chain for carbon dioxide. Market-based mechanisms and regulation are needed.
- ◆ As in other large “public good” developments, e.g. major highway systems, urban transport, there is an important transitional role for governments in helping to deal with the risks of investment and long-term liability. Who is ultimately going to take the risks? If capture – ready plant is imposed or encouraged, can the costs be passed on to electricity consumers? Today there are no economic drivers to spend additional capital to make new power plants capture – ready.
- ◆ Brazil’s energy system is not heavily based on fossil fuels. Its main CO₂ emitters are from industries that are not necessarily located near sedimentary basins where storage is possible. There is almost no public awareness of CCS and little technical CCS capacity in Brazil.

5.3 Australia

- ◆ While there are no commercial-scale CCS facilities in Australia, a number of proof of concept projects are underway. A driver is the high priority the government places on mitigating emissions both in its own use in power generation and as a leading coal exporter. The Government has announced in a white paper that Australia will be a leader in CCS. Plans to initiate an emissions trading scheme by 2012 could further drive economic consideration of CCS as a mitigation option.
- ◆ An agreed set of *Australian Regulatory Guiding Principles for Carbon Dioxide Capture and Geological Storage* has been developed to provide access and assign property rights, initially in offshore waters and intended for state consideration for onshore environments to provide a nationally consistent approach to CCS regulation. It was noted that this process has been tougher and taken longer than expected. A key consideration has been balancing the interests of existing offshore users as well as providing investment certainty to CCS proponents. Furthering the draft legislation and monitoring and verification procedures are on a priority tract as the Government wants to release offshore acreage for bid in 2008.
- ◆ The Low Emissions Technology Development Fund supported by the Australian Government provides A\$ 500 million to support large-scale demonstrations of energy technologies with long-term potential to reduce GHG emissions, including CCS initiatives. The largest coal producing states have committed to provide about A\$ 500 million to support development and demonstration of CCS technologies.
- ◆ Australia's coal industry identifies a portfolio of priority CCS technologies as part of the COAL21 Action Plan. It supports demonstration projects via a voluntary levy by the industry of A\$ 1 billion over ten years (<http://www.coal21.com.au>).
- ◆ Mapping storage sites in the 1990s and early 2000s was a catalyst for strong public/private collaboration. This provided a wealth of information on which to base assessments, project concepts and regulatory principles. It was noted that this co-operation was challenged by competitive tensions for available public money. Efforts are underway to rebuild consensus through more intensive storage mapping and advancing the regulatory regime.
- ◆ Australia has supported co-operative R&D initiatives, including an educational focus to produce graduates with skills relevant to industry needs. It has also produced a CCS technology roadmap to set short and long-term directions for CCS development in the country.
- ◆ The near-term opportunities for CCS development in Australia are processes that produce high-concentration by-product CO₂ – natural gas processing and coal gasification to produce liquid fuels or chemicals. CCS for power generation has substantially higher capture costs and therefore requires substantially greater financial support to be viable as an early development opportunity.
- ◆ Experience in Australia with public education and outreach shows that a structured engagement programme needs to be conducted in project specific areas as well as with the wider community to inform on the range of GHG mitigation technologies and the role of CCS.

5.4 Rest of the World

- ◆ Providing power to people is a primary concern in India. Given the costs of CCS, deployment is not expected soon unless it is financed through international means. Intellectual property rights issues may increase CCS costs in technology transfer.
- ◆ Today the drivers for CCS in the Middle East are low. EOR will be high on the agenda, but many years in the future. Shell has a view of carbon management to match sources and sinks in the Gulf Cooperative Council, but needs a master plan for energy access to connect sources and sinks. Periods of high oil prices could support development of regional infrastructure.
- ◆ Energy security and sustainability are key in Indonesia. Feasibility assessments of CCS in some islands are economically unattractive. Developing countries need demonstration projects funded by international sources.
- ◆ The strategy for power generation in Egypt is to move from heavy fuel oil to natural gas, hence reducing the carbon footprint and a strong effort in solar and wind developments funded by the World Bank. CCS could be of interest in the future.

6. Review of CCS Pathways and Policy Options for Global Concerted Action

Key Messages

- ◆ There was broad consensus among the 150+ experts on the challenges to accelerate the development of CCS applications at this assessment workshop. What is needed is political will, money, collaboration and research, development and demonstration.
- ◆ Increasing public awareness and gaining acceptance for CCS is critical. Efforts should support development of knowledge networks and foster dialogue among stakeholders, including NGOs and the media. It needs to be clear that CCS is an important part of a portfolio of measures and technologies to reduce CO₂ emissions.
- ◆ Relevant national and international legal and regulatory frameworks for CCS are needed that adequately deal with the classification of CO₂ and liability issues for storage. Streamlined regulatory approaches are needed to accommodate demonstration projects. This can provide useful feedback from actual experience to mature the regulatory regime development.
- ◆ Prioritise national and international collaborative R&D to: reduce costs and efficiency losses of the different carbon capture technologies; clarify geo-technical conditions for secure CO₂ storage; support a portfolio and diversity of CCS demonstrations, including infrastructure; and to optimise the use of public funding. Public/private partnerships can be a useful model.
- ◆ Create a value for CO₂ emissions and a global market.
- ◆ Foster an effective international framework to support CCS development.

The aim of the session was to explore pathways for international concerted action to accelerate large-scale deployment of CCS. The discussion was focussed on essential elements for acceleration of CCS through near-term opportunities based on the issues identified in the topical breakout sessions at the San Francisco workshop and on the lessons learned as presented on the first day of the Oslo workshop.

Four sessions covered these categories with panellists affiliations noted:

- 1) *Public Awareness and Acceptance* – European Technology Platform on Zero Emission Fossil Fuel/ Bellona Foundation, BP International;
- 2) *Legal and Regulatory* – EU Commission DG Environment, Australia Department of Industry and Tourism, IEA Secretariat;
- 3) *Technical* – Norway Centre for Sustainable Gas Technologies, ConocoPhillips;
- 4) *Commercial/Financial/International Mechanisms* – GE Energy, ExxonMobil, Rio Tinto, Point Carbon.

The format was discussion among the panellists prompted by questions from the facilitator. This was followed by questions and comments from selected table leaders. The main points of the presentations and discussion from the panellists are summarised below.

6.1 *Public Awareness and Acceptance*

- ◆ Gaining public acceptance of CCS is a critical element to accelerate deployment. It calls for both general education and outreach on the role CCS can play in providing energy services while closing the loop on CO₂ emissions from fossil fuel combustion and direct public collaboration for specific projects. Neutral parties can be important messengers as there may be low trust of industry and governments to carry the CCS message. Make effective use of media, education and NGOs to communicate.
- ◆ Allocate some outreach focus on the rationale for using public money to develop CCS infrastructure and demonstration projects.
- ◆ CO₂ is less harmful than natural gas processing, pipelines and storage, but the public is not generally aware of this.
- ◆ An Australian research organisation, supported by the coal association, has developed a roadmap of CCS communication strategies around the world. It shows the bulk of effort is in surveys of public awareness. It requests additional input from CCS outreach activities in all regions (Peta.Ashworth@csiro.au).

6.2 *Legal and Regulatory*

- ◆ A global approach to a broad legal and regulatory framework for CCS is desirable, particularly for international elements such as interaction between emission trading schemes and the Clean Development Mechanism. However, one size does not fit all for a legal and regulatory regime.
- ◆ EU analysis indicates that energy efficiency and renewables will not be sufficient to meet climate change targets; therefore CCS is needed as a mitigation option. Two elements are key to the framework development: managing risks and incentivising the technology. The

safety risks associated with CO₂ capture and transport may be less than those for natural gas. The main issue is storage for very long periods of time. Storage integrity is critical and models need to be verified with actual experience. This creates a chicken and egg dilemma in the initial phases of regulatory development. The forthcoming EU enabling legal framework will be consistent with the IPCC guidelines and with developments on CCS risk management in the London Convention and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR).

- ◆ Australia is more advanced than the EU in setting out a legal and regulatory framework to enable CO₂ storage. It prescribes a broad framework that can be amended through regulation as experience is gained from early movers. Some sub-national jurisdictions have moved ahead to develop state regulations for particular projects. Government and industry are still grappling with how to provide the “one-stop shop” for permitting and regulation that investors desire.
- ◆ CO₂ should be considered as a commodity and not regulated as a waste stream. The oil and gas industry and natural gas storage can serve as models for CCS regulatory frameworks.
- ◆ Following on from recommendations at the San Francisco workshop, the IEA has provided a compendium of the status of legal and regulatory models and how they might impact near-term CCS opportunities in a publication released in association with the Oslo workshop.⁷ The key messages are:
 - An urgent need for full-scale demonstration projects to generate monitoring and verification data to inform the development of legal and regulatory guidelines.
 - Leeway to “fast track” early projects by modifying applicable existing regulations.
 - Facilitate CCS inclusion in the Kyoto Protocol flexibility mechanisms.
 - Build on the London Protocol amendment to clarify CCS elements in other marine conventions such as OSPAR.

6.3 Technical

- ◆ Governments need to be a regulator, a facilitator of progress and a partner to industry for an innovative technology such as CCS.
- ◆ A vision in Norway is to develop natural gas-fired power generation with CCS. As a facilitator of the progress, the Government has set up an organisation to provide funding and advice to advance technology development. Gasnova and the Research Council of Norway have a Euro 250 million fund to support technology development, cost reduction and to provide advice to government. They are looking at new business models because CCS is a complex value chain across numerous boundaries, e.g. businesses, sectors, jurisdictions, international frontiers.

⁷ IEA, *Legal Aspects of Storing CO₂: Update and Recommendations*, IEA/OECD, Paris, June 2007.

- ◆ Early movers need support for costs and risks. In Norway, Government and five international industrial partners are cost sharing a CO₂ test centre at Mongstad refinery as an arena for technology development. A similar model was used to develop the offshore oil and gas industry in Norway. Cost and information sharing is a key driver for this collaboration.
- ◆ Lack of a sufficient value for CO₂ is the biggest obstacle for CCS. It is all about costs as far as companies are concerned.
- ◆ ConocoPhillips believes that the value of CCS projects can be maximised by taking advantage of synergies between large combined heat and power facilities with the production of industrial gas and commodities such as ammonia. Large integrated industrial facilities offer numerous benefits. Even with many synergies, costs are in the range of US\$ 40 to 70/ tonne of CO₂.
- ◆ EOR may not enable CCS in most locations because it requires additional infrastructure and reservoir management, whose cost may outweigh the production benefit. Current EOR projects in the United States support CO₂ values of US\$ 10 to 24/tonne, delivered at the injection point largely because they leverage existing infrastructure.
- ◆ The CSLF has contacted some twenty CCS projects underway and requested information on what people are working on and technology gaps.

6.4 Commercial/Financial/International Mechanisms

- ◆ In the absence of a global and long-term price signal for carbon, industry recognises that it will have to work with a variety of mechanisms to develop early opportunities that establish a value for carbon such as the EU ETS, capping mechanisms, efficiency performance standards. But because carbon is basically an artificial market created by governments what industry needs are clear “rules of the road”. It is governments’ role to set the rules.
- ◆ Valuing CO₂ should start with a cap and trade system that tightens over time and moves to a tax basis in the longer term.
- ◆ The EU ETS does create a price for CO₂, even beyond 2012. While it currently does not include CCS and may also be too low to stimulate near-term CCS projects, it is important to differentiate between regulatory certainty and CO₂ price. Carbon price alone is not enough to stimulate near-term CCS developments as industry requires returns from its financial investments.
- ◆ Addressing the issue of a timeframe for a Kyoto II or other mechanism for international action to address climate change, panellists indicated a need for a long-term signal and broad global participation.
- ◆ The insurance industry should be engaged at this point in CCS matters in order to develop standards for coverage for CO₂ transport and storage.

7. Conclusions and Definition of Inputs to Recommendation Workshop

Key Messages

- ◆ CCS can make a significant contribution to mitigate CO₂ emissions from energy combustion as part of a portfolio of abatement measures.
- ◆ The G8 focus on CCS adds a political imperative to accelerate CCS developments.
- ◆ Governments and industry need to co-operate to overcome the cost and regulatory uncertainty hurdles for near-term CCS opportunities.
- ◆ The final workshop should build upon the numerous inputs to the workshop process, the CSLF and IEA Greenhouse Gas R&D Programme and the multitude of relevant analyses to develop precise, ambitious and action oriented recommendations to feed into the G8 process.
- ◆ The strategy will be to distribute draft recommendations prior to the third workshop. Experts will be requested to provide specific input on the draft recommendations for discussion and consensus building at the November workshop. The results will help to formulate the messages and recommendations to the G8 leaders at the next summit in July 2008.

What We Have Learned since the San Francisco Workshop:

- ◆ No full-scale plants are in operation that demonstrate all aspects of CCS.
- ◆ High costs and regulatory uncertainty remain dominating hurdles.
- ◆ Many more national activities on CCS are underway in a number of countries and industries.
- ◆ Progress has been noted in international marine conventions with regard to CCS, in particular the London Protocol.
- ◆ Communication and public perception remains an issue; transparency has shown good results.
- ◆ Industry supports the need for regulation: Not one size fits all, but international exchange on key issues is important.
- ◆ Demonstration projects are key to learn about the technology, reduce costs and inform the development of legal and regulatory frameworks.
- ◆ Infrastructure for CCS needs more attention to define opportunities and develop financing options.

ANNEX 1

Proposed Full-scale (~100 MWe and above) CCS Projects for Power Generation (Known to IEA Secretariat) September 2007

Company/Project Name	Fuel	Plant Output/Cost	Technology	Start
BP/SSE DF1, Peterhead/Miller <i>Scotland</i> (Project cancelled May 2007)	Natural gas	350 MW, (\$600 M)	Conversion H ₂ /CO ₂ + separation + precombustion capture, storage in oilfield – EOR	2010
BP DF2, Carson <i>United States</i>	Petcoke	500 MW, (\$1 bn)	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture, storage in oilfield – EOR	2011
Centrica/Progressive Energy, Teeside <i>United Kingdom</i>	Coal (petcoke)	800 MW (+H ₂ to grid) (\$ 1.5 bn)	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	2012
China Huaneng Group (CHNG), GreenGen <i>China</i>	Coal	100 MW	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	2015
E.ON, Killingholme, Lincolnshire coast <i>United Kingdom</i>	Coal	450 MW (£1bn)	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture? (may be capture ready)	2011
Ferrybridge, Scottish & Southern Energy <i>United Kingdom</i>	Coal	500 MW retrofit £250m, capture £ 100m	Pulverised Coal (supercritical retrofit) + post-combustion capture	2011
FutureGen <i>United States</i>	Coal	275 MW (US\$ 1 bn)	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	2012
GE / Polish utility <i>Poland</i>	Coal	1000 MW	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	
Karstø <i>Norway</i>	Natural gas	430 MW	Natural Gas Combined Cycle + post-combustion amine capture, potential storage in oilfield – EOR	2009

Mongstad <i>Norway</i>	Natural Gas	(see footnote) ⁸	Combined Heat and Power with post-combustion CCS	Phase 1: 2010 ⁹ Phase 2: 2014 ¹⁰
Nuon, Eemshaven <i>The Netherlands</i>	Coal / biomass / natural gas	1 200 MW	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	2011
Powerfuel, Hatfield Colliery <i>United Kingdom</i>	Coal	~900 MW	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	2010
RWE <i>Germany</i>	Coal	450 MW (€1 bn)	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion, capture storage in saline reservoir	2014
RWE, Tilbury <i>United Kingdom</i>	Coal	1 000 MW (£ 800 m)	Pulverised Coal (supercritical retrofit) + post-combustion (may be capture ready)	2016
SaskPower, Saskatchewan, <i>Canada</i>	Lignite coal	300 MW	Pulverised Coal + post-combustion capture or oxyfuel, storage in oilfield – EOR	2011
Siemens <i>Germany</i>	Coal	1 000 MW EUR 1.7 bn	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture	2011
Stanwell, Queensland <i>Australia</i>	Coal	100 MW	Gasification (IGCC) → syngas, conversion H ₂ /CO ₂ + separation + precombustion capture, storage in saline reservoir	2012
Statoil/Shell, Halten CO ₂ <i>Norway</i> (Project cancelled)	Natural gas	860 MW	Natural Gas Combined Cycle + post-combustion amine capture, storage in oilfield – EOR	2011

⁸ The plant is planned for an electricity output of 280 MW and 350 MW of heat.

⁹ Includes testing of capture facility (100 000 tonnes of CO₂, storage site to be determined).

¹⁰ Full-scale CCS.

ANNEX 2

Major Commercial and R&D Projects for Storage of CO₂ (in addition to projects listed in Annex 1)

Project Name and Location	Source of CO ₂	Type of Geological Formation	CO ₂ stored*
Sleipner <i>Norwegian North Sea</i>	Stripped from natural gas	Saline reservoir	1 Mt/year since 1996
In Salah <i>Algeria</i>	Stripped from natural gas	Gas/saline reservoir	1.2 Mt/year since 2004
K12b <i>The Netherlands</i>	Stripped from natural gas	Gas field - EGR	More than 0.1 Mt/year since 2004
Snohvit <i>Norwegian North Sea</i>	Stripped from natural gas	Gas/saline reservoir	0.75 Mt/year, started September 2007
Gorgon <i>Australia –offshore</i>	Stripped from natural gas	Saline reservoir	129 Mt over the life of the project, starting between 2008-2010
Weyburn <i>Canada/United States</i>	Coal ¹¹	Oil field –EOR	1 Mt/year since 2000
Permian Basin <i>United States</i>	Natural reservoirs and industry	EOR	500 Mt stored since 1972
Frio Brine <i>United States</i>		Saline reservoir	3 Kt injected in 2005-2006
Nagaoka <i>Japan</i>		Saline reservoir	10.4 Kt in 2004-2005
Ketzin <i>Germany</i>		Saline reservoir	60 Kt total , starting 2006
Otway, Victoria <i>Australia</i> R&D project http://www.co2crc.com.au/pilot/OBPPDL/ResearchProjectUpdate_01.pdf	Stripped from natural gas	Depleted gas field	50 Kt/year, starting 2007
Callide, Queensland <i>Australia</i>	Coal	Underground sandstone formation	More than 30 Kt/year, starting 2010
Monash, Latrobe Valley, Victoria <i>Australia</i> http://www.monashenergy.com.au/	Coal		50 t/day, starting 2008

¹¹ The CO₂ used for the EOR project in Weyburn is supplied by the Great Plains Synfuels Plant, a coal gasification plant located in Beulah, North Dakota, United States.

* For comparison, a 500 MW coal-fired power station emits about 3 Mt of CO₂ per year.

The Online Bookshop

International Energy Agency



All IEA publications may be bought
online on the IEA website:

www.iea.org/books

You may also obtain PDFs of
all IEA books at 20% discount.

Books published before January 2006
- with the exception of the statistics publications -
can be downloaded in PDF, free of charge,
from the IEA website.

IEA BOOKS

Tel: +33 (0)1 40 57 66 90
Fax: +33 (0)1 40 57 67 75
E-mail: books@iea.org

International Energy Agency
9, rue de la Fédération
75739 Paris Cedex 15, France

CUSTOMERS IN NORTH AMERICA

Turpin Distribution
The Bleachery
143 West Street, New Milford
Connecticut 06776, USA
Toll free: +1 (800) 456 6323
Fax: +1 (860) 350 0039
oecdna@turpin-distribution.com
www.turpin-distribution.com

**You may also send
your order**

to your nearest

OECD sales point

or use

the OECD online

services:

www.oecdbookshop.org

CUSTOMERS IN THE REST OF THE WORLD

Turpin Distribution Services Ltd
Stratton Business Park,
Pegasus Drive, Biggleswade,
Bedfordshire SG18 8QB, UK
Tel.: +44 (0) 1767 604960
Fax: +44 (0) 1767 604640
oecdrow@turpin-distribution.com
www.turpin-distribution.com