International Energy Forum

GLOBAL CCS INSTITUTE

# 2nd IEF - Global CCS Institute Symposium on Carbon Capture and Storage

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## Background Paper

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## 1 - Introduction

Given the projected increase in long-term demand and the prevalence of fossil fuels in the future energy mix, there is an urgent need to improve the environmental sustainability of fossil fuel production and consumption by moving toward low carbon emission technologies. Carbon capture and storage (CCS) is expected to play a vital role in the reduction of greenhouse gas (GHG) emissions. Its development and deployment offer part of the solution that can contribute, along with energy efficiency and other low carbon mechanisms, to delivering a sustainable energy future. The International Energy Agency (IEA) has suggested that CCS will need to contribute one fifth of the necessary emissions reductions to achieve stabilisation of GHG concentrations at 50% of 2005 levels in the most cost-effective manner.

CCS technology is gaining momentum on a number of fronts and its role in delivering a sustainable energy future is acknowledged in international fora.

Responding to a call-for-action from Ministers, the International Energy Forum (IEF) and the Global Carbon Capture and Storage Institute (Global CCS Institute) have jointly established a series of symposia on CCS, with the objective of sharing knowledge and facilitating the development and commercial deployment of CCS technologies.

The 1st IEF-Global CCS Institute symposium was hosted by the Energy Research Institute of the National Development and Reform Commission (ERI – NDRC) on 27-28 September 2009 in Beijing, China. The main objective of this first symposium was to assess the current state of CCS development, with particular focus on $CO_2$-EOR and its potential to enhance global energy security. Representatives from government, industry, research centres, financial and international institutions debated practical measures to address barriers to CCS deployment and developed messages to IEF Ministers regarding the importance of CCS in creating a lower carbon future.

The 12th IEF Ministerial (Cancun, March 2010) welcomed the joint IEF-Global CCS Institute initiative to organize a series of symposia on CCS and affirmed that CCS is one of the key technologies that can contribute to mitigating climate change and delivering a sustainable energy future. Ministers took note of the key conclusions of this first symposium and observed that the progress of CCS has been encouraging, but cost, knowledge sharing and the necessary regulatory infrastructure remain significant obstacles. They also reinforced the call for the inclusion of CCS in the Clean Development Mechanism (CDM) and other future financial mechanisms, as well as the need to better communicate the importance of CCS to the public to build awareness and broad support.

The 2nd IEF-Global CCS Institute symposium on CCS, supported by the Government of Algeria, will promote the exchange of technical and policy elements of CCS projects and investigate ways to accelerate its deployment particularly through enhanced cooperation and partnership. Building on messages developed in Beijing, participants will review recent progress, share views on the challenges of development, and address technological, economic and regulatory issues facing CCS to build global support at all levels both in government and industry. The Symposium aims to discuss issues, disseminate learning and develop messages that may feed into CCS and climate change fora. It represents a strategic step in enhancing international dialogue, cooperation and industry-government collaboration for the reduction of barriers and acceleration of industrial scale CCS.

The purpose of this paper is to provide background on the key topics to be discussed at the 2nd IEF-Global CCS Institute Symposium on CCS.

## 2 – CCS technology, latest developments and challenges ahead

The progress of CCS to date is encouraging; however there are still a number of technical, economic and legal barriers to large scale CCS deployment. The cost of implementation and the need to increase scale and efficiencies in the capture, transportation and storage of $CO_2$ are among obstacles still to be overcome before CCS technology attains commercial viability. R&D currently underway is expected to lower investment requirements and operational expenses. Technological improvements combined with financial incentives and regulatory measures should help accelerate CCS deployment.

2.1 – Technology

The oil industry has been using $CO_2$ injection techniques in association with enhanced oil recovery (EOR) and enhanced gas recovery (EGR) for decades with a very good safety record. The industry possesses the technology and know-how to use gas to improve recovery rates of existing mature oil and gas fields. Its ability to deploy these techniques more widely has been constrained mainly by the availability of suitable and affordable supply of $CO_2$. Transportation of the captured $CO_2$ presents no real challenge to the oil industry. The oil and gas industry's knowledge and experience in EOR, EGR and gas transport and storage can be leveraged to accelerate CCS deployment.

The technologies required for CCS are generally well understood individually; however they have yet to be integrated and applied on a large scale in key sectors such as power generation and oil refining. Implementation of the three steps - $CO_2$ capture, transport and storage - requires capital investment and additional operating costs.

- Capture: $CO_2$ capture can be applied to fossil fuel power plants, industrial processes and in the fuel production and transformation sectors. Capture technologies are based on those that have been applied in the chemical and refining industries for decades. Three main technology options currently exist for $CO_2$ capture: post-combustion, pre-combustion and oxyfueling. $CO_2$ capture requires energy, reduces overall energy efficiency and adds cost. The capture phase represents the largest cost as it requires capture-specific equipment and entails additional energy consumption. Approximately 60-80% of the cost of CCS is attributed to capture, 10-20% to transport and 10-20% to storage. Achieving reductions in $CO_2$ capture costs and their associated risks is critical for sustainable and large scale deployment of CCS.

- Transportation: there are few technical barriers to $CO_2$ transportation; pipelines have been in operation for around 30 years; the challenges lie with the high level of investment needed for new transportation infrastructure, the business model for commercial development and the management of a transport infrastructure. A transportation infrastructure that carries quantities of enough $CO_2$ to make a significant contribution to climate change mitigation will require a large network of pipelines and safety issues will undoubtedly become more complex. In the short term, a $CO_2$ pipeline operator faces high levels of financial risk due to the high cost of the asset and low returns. Transporting $CO_2$ by boat from one port to another or as far as an injection site is technically possible and could be an economically competitive solution under certain conditions.

- Storage: storage in saline formations, depleted oil and gas fields and in conjunction with the use of $CO_2$ for enhanced oil recovery are considered among the most viable storage options. Oil and gas reservoirs have been demonstrated as suitable for $CO_2$ storage to some extent and the experience of the oil and gas industry provides an important contribution to the CCS learning curve. $CO_2$ storage projects have already been operational for at least ten years in the Sleipner, Weyburn and In Salah projects. Identifying suitable storage sites and understanding the mechanisms at work in the subsurface, including how to verify the behaviour of injected $CO_2$, are some of the main areas of ongoing research in building and reinforcing the industry's capabilities in technologies associated with CCS. Storage of $CO_2$ presents a number of challenges. The main one is to identify suitable reservoirs, monitor the storage site to evaluate its integrity and to assess how the $CO_2$ is behaving. The issue of leakage is crucial in terms of public perception and acceptability of CCS. Of key importance is determining liability to cover potential leakage both during the active project and in the longer term. The Australian Government's recent agreement to accept long term liabilities arising from storage of the $CO_2$ and its approval of the Gorgon Project constitutes a milestone. Again, many of the technologies used by the oil and gas industry are playing a part. The petroleum industry has considerable experience in managing hydrocarbon extraction and there is now potential for a shift towards injection management.

2.2 - Regulatory framework and public acceptance

- Regulatory frameworks: regulatory frameworks are being designed with the objective of managing risks associated with CCS. The task is to ensure that $CO_2$ is stored safely in sites where the environmental impacts have been assessed and where provisions for management and abandonment of the site ensure that stored $CO_2$ is retained in the long term. Regulatory issues, particularly those related to liability of storage will need to be resolved. Regulators need assurance that CCS activities will not result in any adverse effects (through good site selection, operation and closure). Regulations need to be developed to remove barriers in existing legislation and build on existing laws that apply to similar activities, such as the oil and gas industry. Regulatory frameworks at national and international levels are also needed to clarify long term rights, liabilities and institutional structures. Clear, co-ordinated and cohesive policy direction is needed to give investors a signal that this is an area offering sustainable commercial returns.

- Public awareness: gaining general acceptance of CCS technologies will be necessary to demonstrating that CCS is a safe and environmentally acceptable option. Currently there are public concerns about the environmental integrity of CCS, about whether the $CO_2$ stored will remain isolated in the long-term and whether the capture, transport and storage elements present health and ecosystem risks. Public awareness of CCS is low which has lead to low acceptance rates and levels of public support for CCS technology to date. Existing plants, particularly those using EOR, provide good starting points for communicating the feasibility and value of CCS. CCS stakeholders must address public concerns and perceptions and educate and communicate on large scale CCS deployment. There has been, however, some increase in public awareness of CCS, as shown by a survey of the general US public conducted every three years by the MIT Carbon Sequestration Initiative. To the question "have you heard or read about CCS in the last year", only 4 % said yes in 2003, 5 % in 2006 and it was up to 17 % in 2009, which reflects a growing interest in CCS by governments and industry as well as its increased coverage by the press. The challenge will be to build on this and convert awareness to acceptance.

## 3 – Funding, a structural challenge

Cost and funding are key challenges facing CCS deployment. There is a high degree of uncertainty in estimating the costs of CCS due to differences in methodologies applied to existing projects and also uncertainty regarding the evolution of costs over time. Current costs levels and technology risks are a serious barrier to large scale commercial deployment of CCS. WorleyParsons modelling, as part of the 2009 Strategic Analysis of the Global Status of CCS, determined that the cost of CCS for power generation, based on the use of commercially available technology, range from $62 to $112 per tonne of CO2 avoided or $44 to $90 per tonne of CO2 captured. For projects to be economic, it is therefore crucial to reduce CCS costs and raise permit prices. Norway has recently delayed a final investment decision on the building a full-scale CCS centre at Mongstad power station on cost grounds.

According to the IEA, total CCS related investment in power generation alone will amount to USD 556 billion over the period 2010-2030. Technological improvements should help reduce costs but investment in CCS will only occur if there are suitable incentives and regulatory mandates. Commercial CCS deployment, particularly in developing economies, is contingent upon cost reduction.

Funding for near-term demonstration projects is required in order to continue to prove CCS at the commercial scale and to reduce costs. Considering the scale of investment needed, Governments will be required to address the funding gap and to help facilitate private sector investments via public-private partnerships in CCS demonstration.

In the current regulatory and fiscal environment, the benefits of reducing emissions are not yet sufficient to outweigh the costs of deploying CCS. Therefore, with CCS technology not currently eligible for use under CDM, funding is a key issue for CCS. CCS technology will need significant government support and fiscal incentives if it is to be deployed at commercial scale. There are several means we can mention to do so:

- Taxing emissions so that it is cheaper to store the $CO_2$ than emit (this worked in the Sleipner project);
- Develop cap-and-trade emissions programmes that recognise stored $CO_2$ as non-emitted (EU Emission Trading System). This can most effectively set a wholesale price of carbon;
- Offer direct government subsidies or funds to cover the CCS installation costs.

Financial mechanisms that use public finance from developed countries to support climate change mitigation in developing countries are becoming available from a number of international organisations and multilateral schemes. The newly created World Bank Climate Investment Fund, for instance, relies on donor country pledges. Donor-supported funds may also become part of a post-2012 climate agreement that includes funding commitments from developed countries.

Nearly all the major economies have announced initiatives to promote CCS and associated funding for large scale CCS demonstration projects.

The G8 has called for completion of 20 large scale CCS demonstration projects by 2020 and stimulus money in both the EU and the US has been targeted for large scale CCS demonstrations.

- In the US the recent Economic Recovery and Reinvestment Act includes USD 3.4 billion in funding for clean coal and CCS technology development. USD 1.0 billion has been allocated for developing and testing new ways to produce energy from coal, USD 0.8 billion will augment funds for the Clean Coal Power Initiative with a focus on carbon capture, and USD 1.52 billion will fund industrial $CO_2$ capture projects, including a small allocation for the beneficial re-use of $CO_2$. In December 2009 the federal government announced almost USD 1 billion of funding to fast-track the development of three new projects involving advanced coal technologies with commercial scale CCS. In addition to this amount, there will be USD 2.2 billion of private funds as part of the third round of the

Energy Department's Clean Coal Power Initiative. Adding to this momentum, the US announced an inter-agency taskforce that will develop a strategy to overcome the barriers to the deployment of CCS targeting a start up of 5-10 commercial demonstration projects by 2016.

- In addition to initiatives developed by member countries, the EU financial stimulus package includes Euros 1.05 billion for the support of seven CCS demonstration projects. The EU has also set aside the revenue from 300 million allowances within their Emissions Trading Scheme for the support of early CCS demonstration projects. Norway has announced the allocation of NOK 1.2 billion for CCS projects and UK has announced funding for up to four CCS projects. The first of these projects will be selected from projects via the CCS competition. The winner will have the additional costs of CCS covered by a government capital grant. The UK has recently announced that the remaining projects will be funded through a levy on electricity suppliers, to take effect in 2011.

- The Australian government has announced AUD 2 billion funding for large scale demonstration projects in Australia; in addition to launching the Global CCS institute to foster international cooperation, with a funding of AUD 100 million a year for three years. Four projects have been selected to move to the next stage of assessment in the government's AUD 2 billion CCS Programme.

- Canada announced the allocation of CAD 2.5 billion for large scale CCS demonstration projects. The Canadian federal government has announced financial support of CAD 1.3 billion for R&D mapping and demonstration project support, while the Province of Alberta has committed CAD 2 billion in funding to support CCS deployment.

- The Japanese government has budgeted JPY 10.8 billion for study on large scale CCS demonstration since fiscal year 2008.

This non-exhaustive list of initiatives and funding announcements shows the increasing interest in CCS technology and will contribute to facilitate its development. However, substantial additional funding is required if we are to achieve commercial-scale CCS deployment.

## 4 – Existing projects, learning by doing

A vast number of initiatives and activities are underway to support widespread deployment of CCS technology including CCS research and development, construction of pilot and larger scale CCS demonstration and the development of directives and related regulations across a number of countries. Several large scale demonstration projects have been announced in Europe, North America and Australia along with cooperative programmes in non-OECD countries.

There is a rising interest and involvement in CCS in oil and gas producing countries. Saudi Arabia is an active member of the so-called "Four Kingdom's Initiative" (together with the UK, Norway and the Netherlands), Algeria has realized a full-scale demonstration CCS project in the In Salah gas field, and the UAE is increasingly active in developing new initiatives (Masdar). CCS is also an important part of the EU-OPEC dialogue and OPEC has recently joined the IEA's Implementing Agreement on GHGs, IEAGHG Programme.

There is a triple challenge behind existing projects: A technical challenge, which consists of showing that CCS technology actually works and works well; an economic challenge which consists of carrying out these operations with acceptable costs; and finally the challenge of public acceptability.

At the present time there are four key large-scale CCS projects in operation each storing at least one million tons of $CO_2$ a year: Sleipner started in 1996, followed by Weyburn (2000), In Salah gas field (2004), and Snøhvit (2008). The Gorgon Project in Australia is now under development and aims to mitigate emissions of more than three million tons of $CO_2$ equivalent per year by 2010. These projects are operating or being executed under existing hydrocarbon production regulations.

1) The Sleipner Project: located in the North Sea in Norwegian waters, the Sleipner pilot is the benchmark in the field of the geological storage of $CO_2$ from a natural gas field into an upper saline aquifer, more than 800 meters below the sea floor. This project has contributed to the understanding of mapping, $CO_2$ migration and ascertaining whether it remains confined within the storage structure beneath the principal cap rock. It is providing a clearer picture of the reservoir's sealing efficiency - a major component in the development of models predicting $CO_2$ migration in a heterogeneous geological environment.

2) The Weyburn-Midale $CO_2$ Project: the first full-scale $CO_2$ measuring, monitoring and verification (MMV) initiative in association with EOR. Launched in 2000, this project studies $CO_2$ injection and storage underground in partially depleted oil fields. Around three million tons per year of $CO_2$ is produced at a North Dakota gasification plant and transported by a 320 km pipeline north to the Weyburn and Midale oil fields in Saskatchewan, Canada. The project involves government, industry and academia, nationally and internationally to collaboratively fund research and share results.

3) The In Salah Project: $CO_2$ capture and injection began at the In Salah gas field, Algeria, where one million tons of $CO_2$ is reinjected each year into a deep geological formation below the Sahara desert avoiding its release in the atmosphere. Since the In Salah gas fields have high $CO_2$ concentrations, the $CO_2$ produced is reinjected at the periphery of the gas field, into the saline aquifer at a depth of 1,800 meters, which helps maintain the gas field reservoir pressure while confining the $CO_2$ underground. This pilot represents a remarkable underground laboratory where numerous tools have been deployed to observe and at least anticipate reservoir behaviour during and after injection.

4) The Snøhvit gas field: located in the Barents Sea, $CO_2$ is separated from natural gas at the LNG plant onshore and transported through a 145 km pipeline back to the Snøhvit field where it is injected into the geological layer of porous sandstone containing salt water, 2,500 meters below the sea floor. At full capacity 0.7 million tons of $CO_2$ per year are stored. A monitoring program has been set up for investigating the behavior of $CO_2$ underground, partly financed by the European Union (EU).

5) The Gorgon Project: the world's biggest carbon injection project has started construction in Western Australia as part of the Gorgon LNG venture. About 3.4 million tons a year of $CO_2$ will be injected underground at Gorgon. Last August the Australian Government took the decision to assume long term liability for $CO_2$ storage. The Gorgon Joint Venture is liable during the operation phase, expected to start in 2014 and last up to 60 years and for at least 15 years after the project closes down. Any liability for future damages to third parties passes to the state shared 80 % by the Federal Government and 20 % by the Government of Western Australia.

The oil and gas industry with its knowledge in $CO_2$-EOR/EGR has the ability to effectively demonstrate that, with the appropriate level of site assessment, monitoring and verification, the injected $CO_2$ could remain contained for long periods within the formation layers that have been targeted. The fundamental challenge in increasing the use of $CO_2$-EOR is the need to ensure sufficient volumes of $CO_2$ at the right place and the right cost. Growing support for CCS is likely to boost the use of EOR and improve EOR techniques and rates of recovery.

## 5 - CCS development, the road from Copenhagen

Addressing barriers to CCS deployment requires the joint and coordinated efforts of all stakeholders through the implementation of effective policies and measures, and international collaboration. These include developments in technology efficiency, the creation of legal and regulatory frameworks which provide an environment conducive to investment in CCS projects, improvements in public awareness and acceptance and increased levels of funding.

Accelerating CCS deployment demands measures that “push” technology advances through investment and cost reductions as well as policies that “pull” CCS through regulatory frameworks, incentives, private-public partnerships, international cooperation and an enhanced producer-consumer dialogue.

A precondition to the broad deployment of CCS is the creation of a global portfolio of integrated CCS demonstration projects to demonstrate the technology at an industrial scale. To this end, the G8 recommended the establishment of 20 large-scale CCS demonstration projects be launched globally by 2010 with a view to beginning the broad deployment of CCS by 2020. However, the timing and quantum of expenditure on CCS projects may be behind schedule to achieve this.

One source of funding which, might accelerate deployment in developing countries, if CCS projects had access to it, is the Clean Development Mechanism (CDM) under the Kyoto Protocol. The question of whether CCS should be included in the CDM has been debated in climate change negotiations since 2006 and was discussed most recently in the UNFCCC 15 COP in December 2009 in Copenhagen.

The intention was to come to a decision on the inclusion of CCS in the CDM at Copenhagen. However, despite many nations speaking in favour of inclusion, a decision was deferred to the next UNFCCC - to be held in Mexico in December 2010 - due to a lack of consensus. A small number of parties remain opposed to the inclusion of CCS in the CDM and have cited concerns around storage safety, as well as legal and accounting issues. Some also argue that it would divert investments away from energy efficiency and renewable energy. A coordinated approach by proponent governments (including non Annex 1 countries) would be required to address CCS inclusion.

On the positive side, the Copenhagen Accord provided for a new “Copenhagen Green Climate Fund” to support immediate action on climate change (including mitigation and adaptation). Developed countries will collectively commit about USD 30 billion to the fund by the end of 2012, rising to USD 100 billion a year by 2020, to help developing countries cut emissions and adapt to climate change. It is possible (but not clear at this stage) that CCS projects might be able to access some of these funds.

## 6 - Conclusion

CCS should be considered in the suite of solutions to mitigate climate change, along with other measures including energy efficiency and renewable energy. CCS is the third most powerful solution for mitigating $CO_2$ emissions after energy efficiency and renewables.

According to IEA Blue Map Scenario, the commercial deployment of CCS in the power and industry sectors represents 19 % of total emissions reductions in 2050.

The technologies involved in CCS have been mostly proved independently, the big test facing governments and industry is integration that is safe, at a reasonable cost and on a large enough scale to make a meaningful dent in global $CO_2$ emissions.

International cooperation and government-industry collaboration are prerequisites to the acceleration of CCS deployment on a commercial scale. In addition to demonstrating technology performance, it will contribute to better use of funding, knowledge-sharing, local capacity-building, and shortening the CCS learning curve. Governments can provide the long-term policy and regulatory framework that enables commercial scale deployment while industry can provide know-how, technology innovation and the capital needed to develop large scale projects.

Public-private partnerships that involve cost and risk-sharing for CCS demonstration are also required.

International mechanisms for funding deployment of CCS in developing countries are a key element that should be discussed in future international forums. CCS projects in developing countries will need to be funded either via inclusion in the CDM or through a new mechanism.

CCS technology should continue to be advocated in international fora including the next climate change summit in Mexico, December 2010.