International Energy Forum - Global CCS Institute
Symposium on Carbon Capture and Storage

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Challenges and the way forward in accelerating CCS development and deployment, in particular in oil and gas producing countries

Background Paper

Purpose

The purpose of this paper is to provide background on the key topics to be discussed at the IEF-Global CCS Institute Symposium on Carbon Capture and Storage (CCS) being held in Beijing, on 27 and 28 September 2009. The symposium will examine the current state of CCS development and deployment including opportunities and challenges with a special focus on policy issues and the potential for CCS to be deployed in conjunction with enhanced oil recovery (EOR).

Participants will review critical issues related to CCS and investigate ways to accelerate its deployment, particularly through enhanced cooperation and partnerships. The Symposium aims to disseminate learning and to develop responses that may feed into CCS and climate change fora including the Carbon Sequestration Leadership Forum, the International Energy Agency Ministerial Meetings, the 15th United Nations Conference of the Parties (December 2009) and the 12th IEF Ministerial Meeting (Mexico, 29-31March 2010).

The key issues and questions to be addressed by participants include: the progress of CCS to date; actions needed to move from pilot project to commercial scale projects; reduction of barriers to CCS deployment; structural challenges; EOR as an accelerant for CCS deployment; the role of and action required by various stakeholders including industry, governments and financial institutions; policies to support and accelerate CCS deployment; and avenues for further cooperation and dialogue between producing and consuming countries.

1- Introduction

In a carbon-constrained world, the issue of global energy security is becoming more critical. Given the level of projected long-term energy demand and continuing dominance of fossil fuel in the future energy mix, there is an urgent need to improve the sustainability of hydrocarbon production and consumption, especially with regard to its environmental footprint.

While the current global economic crisis is likely to influence short-term political and economic decisions, it is unlikely to alter the long-term energy picture. Established trends including the significant share of fossil fuels in the global energy mix will prevail over the long-term.

According to the IEA, global primary energy demand is expected to grow by more than 40% by 2030. Non-OECD countries are expected to account for 87% of this increase with China and India accounting for 51% and the Middle East, with 11%, emerges as a key demand centre. Under this scenario, fossil fuels will remain the dominant source of energy, accounting for 80% of the primary energy mix in 2030.

Worldwide, 61% of greenhouse gas (GHG) emissions are linked to energy production, delivery and use. At current trends, global energy-related CO_2 emissions are expected to rise by 45% from 28Gt to 41Gt in 2030. 97% of emissions growth is expected to come from non-OECD countries with China, India and the Middle East responsible for three-quarters of this increase. According to some estimates, the Middle East is on track to double its CO_2 emissions by 2030, which will make it the third largest growth area in CO_2 emissions globally.

New, coordinated and cohesive policies must be implemented and concrete actions taken to change the path of this scenario and curb GHG emissions. However, any effective global climate-change strategy will require strong participation from the major oil and gas producing and consuming countries.

CCS is among the most promising GHG reduction technologies and has been singled out for its potential to achieve cuts in CO_2 emissions from fossil energy. The deployment of CCS in conjunction with enhanced oil recovery (EOR) in particular, is demonstrating significant potential to contribute towards global emissions reduction. Economic stimulus and financial rescue packages around world provide a unique opportunity for CCS with the equivalent of US$ 20 billion being made available to progress its development and deployment.

The imperative to accelerate CCS deployment is also gaining momentum on a number of fronts. The 11th IEF (Rome, April 2008) concluded that *"a sustainable energy future implies efficiency improvements, technological advances in both production and consumption of fossil fuels, and development of alternative low-carbon energy sources".* IEF Ministers noted that CCS is an important option to reduce GHG emissions from fossil fuels.

The G8 Summit in Hokkaido (July 2008) acknowledged *"the need to act now to commit by 2010, to at least 20 fully integrated industrial-scale demonstration projects for the broad deployment of CCS technology by 2020".* The recent G8 meeting in L'Aquila, Italy in July 2009 subsequently concluded that *"the development and deployment of innovative technologies such as CCS is expected to contribute substantially to reducing emissions",* and reaffirmed their commitment to: accelerate the design of policies; regulatory frameworks and incentive schemes focused on the development and deployment of CCS technology; work to identify sources of financing for CCS demonstration projects; identify investment needs and overcome obstacles including the potential development of innovative partnerships.

2 - CCS deployment, where do we stand?

A vast number of initiatives and activities are underway to support widespread deployment of CCS technology including CCS research and development, construction of pilot-scale CCS demonstration projects 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 noticeable in producing countries regarding CCS development. Saudi Arabia is an active member of the so-called "Four Kingdom's Initiative" (together with the UK, Norway and the Netherlands). CCS is also an important part of the EU-OPEC dialogue and OPEC has recently also been admitted to the IEA's implementing agreement on GHGs. Algeria has realized a full-scale demonstration CCS project in the In Salah gas field. The UAE is increasingly active in developing new initiatives (Masdar).

The progress of CCS to date is encouraging; while there are still a number of technical, economic and legal barriers to large scale CCS deployment, particularly regarding its cost and energy consumption. Research and development efforts, currently underway, are expected to lower investment requirements and operational expenses. These technological improvements combined with financial incentives and regulatory measures should help accelerate CCS deployment.

2.1 – Technology

CCS technologies are generally well understood but need to be scaled up and integrated along the value chain. CCS comprises three steps that have been tested and technically mastered in pilot plants: CO_2 capture, transport and storage. Implementation of these steps requires capital investment and imposes additional system operating costs related to capture equipment, energy for the capture process, transportation and storage systems.

- 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 exist for CO_2 capture: post-combustion, pre-combustion and oxyfueling. CO_2 capture requires energy, reduces overall energy efficiency and adds costs. The capture phase represents the main cost as it requires capture-specific equipment and entails additional energy consumption. Approximately 80% of the cost of CCS is attributed to capture, 10% to transport and 10% to storage. Achieving reductions in CO_2 capture costs is critical for the sustainable large scale deployment of CCS.

- CO_2 pipelines have been in operation for around 30 years and an estimated 5,000km of pipeline currently exists. However, deploying CCS on a scale large enough to have a significant impact on climate change mitigation will require new transportation infrastructure to link sources and sinks. This transportation system will need a high level of investment, particularly given the cost increases that have occurred in the last five years.

- Storage of CO_2 presents a number of challenges. Storage in saline formations, depleted oil and gas fields and use of CO_2 for enhanced oil recovery are considered the most viable storage options given the costs and the time involved. The single most fundamental challenge is to identify suitable reservoirs. Oil and gas reservoirs have been demonstrated to 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. The main challenge is to demonstrate the integrity of storage sites; monitoring activities for leakage will be undertaken and where necessary appropriate remediation action taken. Moreover the costs of CO_2 storage have followed the same rising trends as upstream oil and gas production costs over the last decade. CO_2 storage projects have already been operational for at least ten years in Sleipner, Weyburn and In Salah.

2.2 - Regulatory framework, financing and public acceptance

- Regulatory frameworks are being designed around managing the risk 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.

- Costs and financing: there is a high degree of uncertainty in estimating the costs of CCS due to differences in methodologies applied to existing projects. There is also uncertainty regarding the evolution of costs over time. Technological improvements should help reduce costs but investment in CCS will only occur if there are suitable incentives and regulatory mandates.

- Public acceptance: existing pilot plants, particularly those using EOR, provide good starting points for communicating the feasibility and value of CCS. CO_2-EOR projects demonstrate the win-win potential of optimising the economic value of existing resources, contributing to greater energy security and managing GHG emissions effectively. CCS stakeholders must address public concerns and perceptions and educate and communicate on CCS deployment at a large scale.

3 - Combined with enhanced oil recovery, CCS is a double win option

CCS technology used in conjunction with carbon dioxide/enhanced oil recovery (CO_2-EOR) is a "double-win" option as it reduces GHG emissions while increasing recoverable reserves in mature oil fields, contributing to global energy security.

Improvement in the global oil recovery rate - estimated to average 35% today - through innovation and technological advancement helps to increase recoverable reserves of oil and gas. In some oil fields, companies are already producing at a recovery rate of over 50%, and according to some estimates, an increase of one percentage point in the average recovery rate of existing oilfields would be equivalent to two years of world oil consumption, at current rates.

EOR technology is projected to contribute 6 mb/d to world oil supply in 2030 - with CO_2-EOR accounting for most of the increase. Cumulative production in 2007-2030 amounts to 24 billion barrels. About 9.8 gigatonnes of CO_2 are captured and stored in CO_2-EOR projects over the projection period (IEA WEO 2008) which demonstrates its importance to early confidence building in CCS technology.

EOR-associated oil production currently amounts to 2.5 mb/d with the largest share coming from thermal process and CO_2 injection. The worldwide potential of CO_2-EOR is of the order of 160 to 300 billion barrels, i.e. 7-14 % of current remaining conventional recoverable oil resources. The Middle East and North America are thought to hold the greatest potential.

Even before climate change concerns appeared, the oil industry had been using CO_2 injection techniques in association with EOR efforts for decades, and did so 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 gas fields. Its ability to deploy these techniques more widely has been constrained only by the availability of suitable supplies. Transportation of the captured CO_2 presents no real challenge to the oil industry.

The economic attractiveness of CO_2 EOR projects is determined by the marginal value of oil, the underlying production costs and the potential cost of supply of CO_2. According to estimates, the injection of one tonne of CO_2 leads to an incremental recovery of between two and three barrels of oil. The value of the extra oil would be compared to the cost of the CCS process.

EOR techniques already play an important role in improving production efficiency, and are set to become more widespread on the back of increasing long term future demand and with more technical oil to develop in the future. The use of CCS-EOR will grow further if CCS projects develop on a scale large enough to contribute significantly to climate mitigation. The development of CCS projects has the potential to provide a significant boost to the use of EOR.

There are four large-scale CCS projects in operation: the In Salah gas field in Algeria (1.2Mt CO_2/yr), Sleipner (1Mt CO_2/yr) and Snohvit (0.7Mt CO_2/yr) in Norway and Weyburn (2.4Mt CO_2/yr) in Canada. The Gorgon project in Australia is now under development and aims to mitigate emissions of more than 3 million tonnes of CO_2 equivalent per year by 2010. These projects operate under existing hydrocarbon production regulations.

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.
The oil and gas industry's knowledge and experience in EOR and gas transport and storage can be leveraged to accelerate CCS deployment.

4 - The way forward: enhanced cooperation and dialogue to promote CCS

Although CCS technology holds significant potential, there is still a long way to go before it makes a tangible impact on GHG emissions. There is a need for more commercial-scale demonstration projects and international partnerships to help CCS become commercially viable.

Barriers must be overcome before commercial deployment of CCS technology becomes a reality. These include technology efficiency developments, the creation of legal and regulatory frameworks and improvements in public awareness and acceptance. Regulatory issues, particularly related to storage liability will also need to be addressed. Uncertainties surrounding costs should be tackled and funding solutions need to be found to support the demonstration project phase. All these actions require joint and coordinated efforts by all CCS stakeholders (i.e. governments, industry, academia and NGOs).

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

A demonstration programme of integrated CCS projects would help prove CCS technologies at commercial scale, identify risks and achieve public acceptance.

A survey conducted by McKinsey in September 2008 with industry players, NGOs, academics and other stakeholders identified four key potential barriers to the deployment of CCS: public safety and lack of support, lack of specific frameworks, inadequate funding for demonstration projects and an absence of operational commercial units.

- Public acceptance: there are currently public concerns about the environmental integrity of CCS. There are questions 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. The public awareness of CCS is also low leading to low acceptance rates and support of CCS technology.

- A legal framework: regulatory issues, particularly those related to the 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 will have to be developed to remove barriers in existing legislation and build on existing laws that apply to similar activities such as oil and gas industry. A regulatory framework at national and international levels is 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.

- Cost and funding: the challenge facing CCS deployment is the reduction of capital requirements and operating costs. There is high degree of uncertainty in estimating the costs of CCS and how costs will develop with time. Economies of scale, operating experience and technological advances will gradually improve project economics. The human resources factor is another constraint to CCS deployment given the high demand for reservoir engineers and other skilled workers. Recent IEA analysis estimates that US$ 30-50 billion needs to be invested to achieve the stated G8 goal of launching 20 full scale CCS demonstration projects in the next few years. Cutting CO_2 emissions by 50% from current levels by 2050 would require additional estimated capital expenditure of US$ 14-15 trillion from 2005 to 2050.

Accelerating CCS deployment requires the joint and coordinated efforts of all stakeholders, working together to address existing barriers to the adoption of these technologies and to develop effective policies and measures to overcome them including proposed steps for implementation through international collaboration. The cost of climate change mitigation should be addressed through government fiscal and regulatory incentives and the creation of appropriate public policy.

Including CCS in the Clean Development Mechanism can contribute to accelerate CCS development and deployment and improve the economics of CO_2-EOR projects.

During the IEF-IFP symposium, held in Riyadh (December 2008), the participants discussed technological development in the upstream sector and concluded that "*CCS development and deployment can play a crucial role in delivering a sustainable energy future"; they welcomed all initiatives aiming at making CCS technology deployment economical at large scale and called "for CCS to be included, as soon as possible, in the Clean Development Mechanism".*

Industry and governments both have a key role to play in achieving the full potential of CCS. Industry can provide know-how, technology innovation and the capital needed to develop large scale projects, while governments can provide the long-term policy and regulatory framework that enables the move to commercial scale deployment. Government-industry cooperation is also needed to communicate on CCS technology and to gain public acceptance.

Cooperation between developed and developing countries and between producing and consuming countries is needed to accelerate CCS deployment, harvest its potential and meet climate change goals. Information-sharing in CCS technology, structural and regulatory capacity building as well as additional R&D on CCS will play an important role in shortening the CCS learning curve.

Some new and innovative schemes are appearing. ExxonMobil and Petrochina signed an LNG contract recently which included a greenhouse gas abatement agreement meaning the CO_2 emitted during the liquefaction process will be captured and sequestered underground. Other milestone events include 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 on Barrow Island.

5 - Conclusion

CCS should be considered in the suite of solutions to mitigate climate change, along with other measures including energy efficiency, energy conservation and renewable energy.

The scientific community, industry and governments are increasingly recognizing CCS as a strategy that can contribute to meet the twin objective of achieving global climate goals and enhancing global energy security.

However CCS technology has some way to go to move demonstration projects to a commercial scale capable of significant impacts on GHG emissions. Efforts must be made to reduce CCS costs by increasing investment in R&D and technological advancement, addressing long-term policy, regulatory frameworks and financial incentives to justify investment.

Cooperation between producing and consuming countries, developed and developing countries, industry and government is a prerequisite to the acceleration of CCS deployment on a commercial scale. An international mechanism for funding deployment of CCS in developing countries is a key element that can be discussed in future international forums.

Given its potential to curb GHG emissions, development and deployment of low carbon technologies such as CCS will certainly be one of the main topics of discussion at the UN Conference on climate change in Copenhagen next December.

This symposium provides an opportunity to discuss issues and to develop messages to international fora in support of the continued development and deployment of CCS. It represents a strategic step in enhancing the producer-consumer and industry-government dialogue and aims to enhance international cooperation for the reduction of barriers and acceleration of industrial scale CCS.