

Review Article

THE FUTURE OF CARBON CAPTURE AND STORAGE (CCS) IN NIGERIA

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ABSTRACT

Carbon Capture and Storage (CCS) is one of the techniques for greenhouse gas (GHG) emissions reduction. This article reviews the current status of CCS technology, highlights costs and discusses legal and regulatory issues of CCS. The main purpose of the article is to review CCS and CO₂-EOR experience from ongoing projects in different parts of the world and give recommendations on how this knowledge can be applied in Nigeria. A potential demonstration CO₂-EOR project in Nigeria under the Clean Development Mechanism (CDM) is discussed.

Keywords: Carbon Capture and Storage; Clean Development Mechanism; CO₂-Enhanced Oil Recovery; Nigeria

INTRODUCTION

Global warming is the increase in the average temperature of the earth. This effect is caused by anthropogenic greenhouse gases (GHG) released to the atmosphere. There are six greenhouse gases covered by the Kyoto Protocol with carbon dioxide (CO₂) considered to be the principal greenhouse gas due to the very large quantities emitted.

Carbon capture and storage (CCS) is one of technological solutions for emission reduction being given serious consideration globally. It is a technique used to capture CO₂ from large stationary sources and store it in underground formations, thereby reducing the effects of global warming. Examples of large sources of CO₂ are fossil fuel power plants, major CO₂-emitting industries such as cement and steel production, etc. Geological storage options include deep saline aquifers, depleted oil and gas reservoirs, enhanced oil and gas recovery, and enhanced coal bed methane recovery (IEA, 2008). The focus in this article is on CO₂-Enhanced Oil Recovery (CO₂-EOR) and geological storage in Nigeria.

According to Hendriks *et al.*, (2004), estimates of CO₂ storage potential in Africa vary widely from 6 to 220 Gt in aquifers and 30 to 280 Gt in oil and gas fields. West Africa, and particularly Nigeria, represents the highest potential for CO₂-EOR and CO₂ storage in oil and gas fields. However, there should be public policies and

legal framework in place to influence the private sector to apply CO₂-EOR techniques for tertiary recovery.

Galadima & Garba (2008) discussed potential implementation risks of CCS in Nigeria. The main barriers identified include long implementation time, inefficient technology, gas leakage from geological storage, and high capture and storage costs.

In order to overcome some of these barriers, joint projects with developed countries under the Clean Development Mechanism (CDM) could be implemented in Nigeria. CDM is an arrangement under the Kyoto Protocol allowing industrialized countries that have a greenhouse gas reduction commitment to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. It allows net global greenhouse gas emissions to be reduced at a much lower global cost (UNFCCC, 2009). It is hoped that CCS will be recognized under the CDM during the course of 2009.

Companies have already started to identify opportunities in applying CDM in Nigeria. Recently, Abu Dhabi and Nigeria have reached an agreement to identify and develop carbon emissions reduction projects in the oil and gas sector in Nigeria under the Clean Development Mechanism (Eye of Dubai, 2009). The recognition of CCS under the Kyoto Protocol would also provide additional support for the uptake of this activity in West Africa. Also more work has to be done to evaluate the reservoir characteristics of existing oil and gas fields. An infrastructure for the transport and storage of CO₂ has to be established.

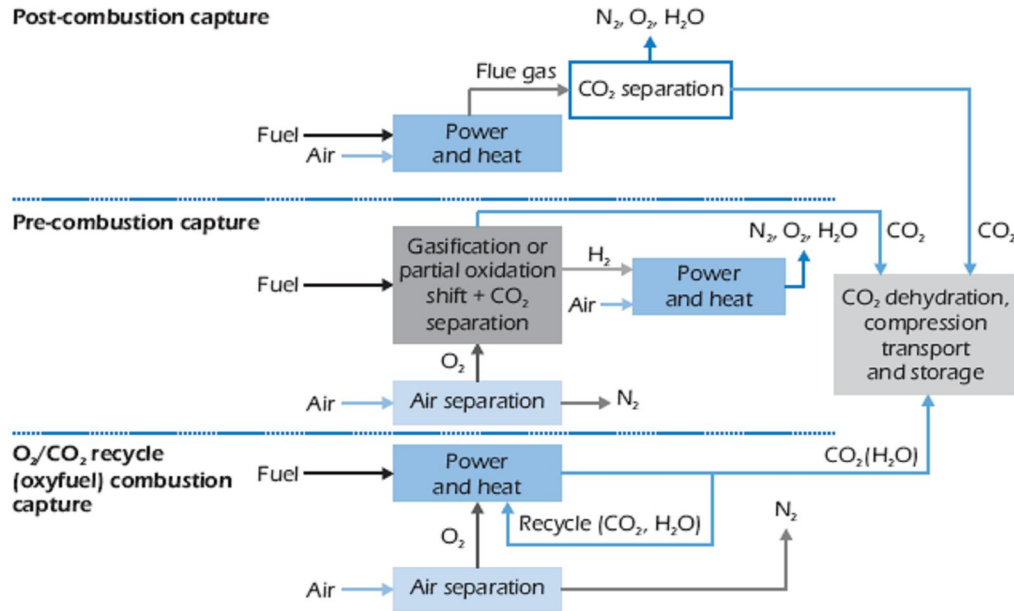
The main objective of this article is to review CCS and CO₂-EOR experience from ongoing projects in different parts of the world and give recommendations on how this knowledge can be applied in Nigeria. Other objectives include the estimation of potential for CO₂-EOR projects under the CDM. If CO₂-EOR project were to be implemented in West Africa, additional oil could be recovered as emissions are reduced. This project can generate revenues to help offset the costs of CCS.

CO₂ CAPTURE, TRANSPORT AND STORAGE

Current status of CCS technology: According to the recent IPCC report on Carbon Dioxide Capture and Storage (IPCC, 2005), the technical maturity of different components of CCS system varies greatly. For example, the interest of our research, CO₂-EOR is a feasible technology widely used worldwide. However, if this technology is "used for CO₂ storage, it is only economically feasible under specific conditions" (IPCC, 2005). This feasibility is related to oil prices, CO₂ costs and the value of CO₂ in the marketplace.

CO₂ capture: There are three main technology options to capture CO₂: post-combustion, pre-combustion and oxyfuel combustion (Fig. 1). The choice of CO₂ capture technology depends on the power plant characteristics and type of fuel used. Post-combustion capture is usually applied to coal- and gas- fired power plants.

The CO₂ is separated from flue gases produced by the combustion of the fuel in air. It is based on chemical absorption using different organic solvents, for example monoethanolamine (MEA), or ammonia. Post-combustion is the only retro-fittable technology for existing facilities.



Source: IPCC 2005

FIG. 1. CO₂ CAPTURE PROCESSES

Pre-combustion capture is the coal fired integrated gasification combined cycle (IGCC) process. This process can also be used in natural gas-based plants. In this technology, the fuel is partially reacted first with oxygen and steam to produce heat to volatilize the remainder of the coal. Then, it is further processed in a shift reactor and a mixture of hydrogen and CO₂ is produced. The CO₂ is captured, and hydrogen is used to generate electricity and heat.

Oxyfuel systems use oxygen instead of air for fuel combustion with a recirculation of an approximate 70 % flue gas stream to dilute the oxygen. The flue gas produced consists mainly of water vapour and CO₂ (IPCC, 2005, IEA 2008).

It should be noted that post-combustion and pre-combustion systems are economically feasible under specific conditions; oxyfuel combustion is still in demonstration phase (IPCC, 2005).

CO₂ capture at the power plants is the largest cost component in the whole CCS system. CO₂ capture reduces efficiency, increases resource consumption and cost of electricity. The cost of CCS ranges from 0.02 – 0.05 US\$/kWh for pulverized coal (PC) power plants and 0.01 – 0.03 US\$/kWh for NGCC plants (both using post-combustion capture). However, when used with CO₂-EOR, the cost of CCS can be reduced by approximately 0.01-0.02 US\$/kWh due to revenues from the EOR (IPCC, 2005). With further development of CCS technology, it is believed that the cost of building and operating CCS systems will decline.

Commercial application of CO₂ capture technology is still in an early development stage. The Saskatchewan Power Corporation

(SaskPower) in Canada is currently working on the development of one of the first and largest integrated clean coal/carbon capture demonstration projects in the world. The project would rebuild one of the units of Boundary Dam Power Station in Estevan, Saskatchewan with post-combustion carbon capture technology (SaskPower, 2009). This 150 MW unit is expected to be fully operational by 2014. The CO₂ capture unit would capture approximately one million tonnes of carbon dioxide annually.

The main barriers for implementation of CO₂ capture technology at power plants in developing countries such as Nigeria would be lack of technology and practical knowledge, increased cost of electricity due to CO₂ capture, and a lack of regulations and incentives from government to offset the cost of CO₂ capture.

CO₂ transport: Transport of CO₂ by pipeline is a well established technology that has excellent safety records. The CO₂ is compressed to a pressure above 8 MPa before the transportation in order to make it easier and decrease the cost (IPCC, 2005). Other options of CO₂ transport include ships, road and rail tankers where CO₂ is transported as a liquid. Transport of CO₂ by ship may be more economically attractive if CO₂ is transported over large distances. The cost of ship transport, including intermediate storage facilities, harbour fees, fuel costs, cost for liquefaction, and loading and unloading activities varies from US \$15 for 1,000 km to US \$30 per tonne of CO₂ for 5,000 km (IEA GHG, 2004; IPCC, 2005).

The properties of liquefied CO₂ are similar to those of liquefied petroleum gases (LPG) that are already transported by ships on a

large commercial scale. This option can be feasible in case of a CDM project, when the CO₂ has to be moved from developed countries to Nigeria.

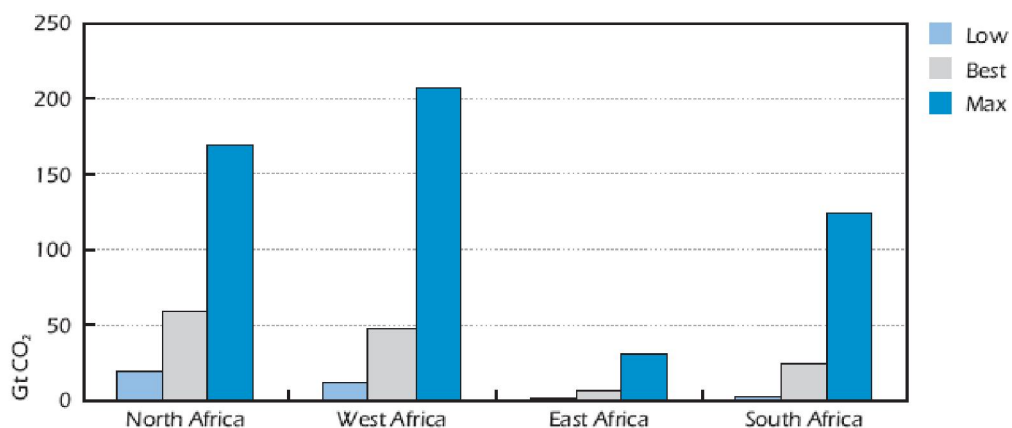
With development of CCS, the standard for CO₂ pipelines would emerge. Currently, the CO₂ pipelines are built mainly to transport CO₂ for EOR operations. The CO₂ for EOR requires low nitrogen content, a requirement that would not be important for storage applications within reason (high levels of N₂ would make compression prohibitively expensive). Other contaminants may be more problematic, for example, if the pipeline passes through a populated area, the H₂S content may be regulated (IPCC, 2005). The CO₂ leakage from pipelines is very small. In case of transport by ship, the total loss of CO₂ to the atmosphere is about 3 to 4 % per 1,000 km if boil-off and exhaust from ship engines are included.

CO₂-EOR: EOR using CO₂ injection is a mature technology that has been applied on a commercial scale in several projects around the world. This technique helps to extract an additional 5 to 20 % of the original oil in place from depleted or marginal wells (Tzimas *et al.*, 2005; Stevens *et al.*, 2001). Two processes have been developed for CO₂-EOR. These are miscible displacement and immiscible displacement (Tzimas *et al.*, 2005). Under favourable reservoir conditions (generally >22 °API oil gravity and >1200 m reservoir depth), injected supercritical CO₂ becomes miscible with residual oil (Stevens *et al.*, 2001). When injected, it decreases oil viscosity and improves its mobility, thus increasing oil recovery. The conditions in some reservoirs (i.e. low pressure) and crude oil composition (i.e. heavy oil) prevent CO₂ to become fully miscible with oil. However, in the case of immiscible oil displacement, the injection of CO₂ in a reservoir can also increase oil recovery. The role of CO₂ in immiscible displacement is similar to that of water in

secondary oil recovery – it helps to raise and maintain reservoir pressure (Tzimas *et al.*, 2005). Much of the CO₂ injected in reservoir is produced with oil, then separated and re-injected into the reservoir. At the end of the oil recovery, the CO₂ will be stored in the depleted oil reservoir.

Onshore miscible displacement is a commercial technology. The USA is leading in implementation of the method with 94% of the world CO₂-EOR oil production (Tzimas *et al.*, 2005). CO₂-EOR has a large potential for development in West Africa and particularly in Nigeria. The reservoir and crude oil characteristics are favourable for miscible displacement. However, reservoir geology and petrophysics need to be well studied before beginning any project. According to the latest data, with EOR, total production costs (excluding CO₂ costs) are approximately 45-90 US\$/t of oil (IEA 2008). It should be noted that most of the oil reservoirs in Nigeria are offshore. It will add costs to implementation of CO₂-EOR projects compared with onshore operations.

CO₂ storage: Suitable formations for CO₂ storage can occur in both onshore and offshore sedimentary basins. IEA report on Carbon Capture and Storage (IEA, 2008) identifies that highly prospective geological basins for CO₂ storage are mainly found in the United States and Canada, Siberia, the Middle East, and North and West Africa within existing oil and gas regions. Hendriks *et al.*, (2004) indicates that in Africa the CO₂ storage capacity in aquifers varies from 6 to 220 Gt and in oil and gas fields from 30 to 280 Gt (Fig. 2). North and West Africa have the highest potential for CO₂ storage in oil and gas fields. All areas except for East Africa also have significant storage space in aquifers (15-60 Gt each). Only South Africa has ECBM potential from 8 Gt to 40 Gt (Hendriks *et al.*, 2004; IEA, 2008).



Source: IEA 2008

FIG. 2. CO₂ STORAGE POTENTIAL IN AFRICA

The injection of CO₂ in geological formations involves technologies that are already in use in the oil and gas industry, such as well-drilling and injection, computer simulation of reservoir dynamics and monitoring methods. The reservoir depth for CO₂ storage should be below 800 meters. At this depth, CO₂ is in a liquid or supercritical state. Under these conditions, the density of CO₂ is close to density of crude oils, reducing the buoyant forces that tend to drive CO₂ upwards. The IPCC report (IPCC, 2005) defines

three main mechanisms for CO₂ storage in the subsurface and with water present as one of the fluid phases in the reservoir:

Physical trapping. These can take two main forms: static trapping where upwards movement of CO₂ is blocked by impermeable layer of shale or clay rock, also called a “cap rock”, and residual-gas trapping in a porous structure provided by capillary forces.

Chemical trapping. This occurs by dissolution or by ionic trapping. Once dissolved, the CO₂ reacts chemically with minerals in the geological formation (mineral trapping) or adsorbs on the mineral surface (adsorption trapping).

Hydrodynamic trapping. The CO₂ migrates upward at a very low velocity and is being trapped in intermediate layers. Large quantities of CO₂ could be stored using this mechanism, since the migration to the surface would take millions of years.

The CO₂ storage in geological formations is expected to last for thousands of years. However, there is a small possibility that CO₂ will leak from the reservoir. Some potential leakage pathways include undetected faults and fractures in the subsurface; geological faults and new and abandoned wells intersecting the storage formation; permeable zones existing in the cap rock; fractures caused by seismic movements. Estimates of CO₂ storage costs vary from 0.5 to 8 US\$/tCO₂ injected. Some additional costs include cost of monitoring that is estimated to be 0.1-0.3 US\$/tCO₂ (IPCC, 2005).

Financial, legal and regulatory issues of CCS: The IEA Special report on Carbon Capture and Storage (IEA, 2005) identifies four major non-technical challenges for successful implementation of CCS. These are: Financing demonstration projects; Setting a long-term, stable price for CO₂; Establishing legal and regulatory frameworks; and Increasing public awareness and acceptance.

CCS reduces power plant efficiency, increases fuel consumption and the cost of electricity. It is unlikely that countries will proceed with commercial implementation of CCS without incentives from the government. CO₂-EOR can provide attractive opportunities for development of CCS infrastructure due to the value of additional recovered oil. However, a reasonable, long-term and stable price of CO₂ should be set to make these projects profitable and predictable.

There is also a lack of a legal and regulatory framework for CO₂ storage in geological formations. A few countries have begun to work on the development of relevant legislation. Existing laws from oil and gas, mining and industrial sectors do not provide effective regulatory mechanisms for CO₂ storage (Clifton Associates, 2004; IPCC, 2005). For the successful implementation of CCS projects, more work is needed to establish procedures for site selection, injection, abandonment and monitoring. The consultations and discussions with the public should also be conducted to expose the public to the concept of CO₂ storage and its inherent risks.

CURRENT CCS PROJECTS

Geological storage of CO₂ is ongoing in a number of projects worldwide. Three large industrial scale projects are described here: the Sleipner project in the North Sea, the Weyburn project in Saskatchewan, Canada and the In Salah project in Algeria.

Weyburn project, Saskatchewan, Canada: The IEA GHG Weyburn CO₂ monitoring and storage project is a large scale CO₂-EOR project located in Weyburn oilfield in southeastern Saskatchewan, Canada. The main goal of Weyburn project is to assess and verify the ability to safely store CO₂ in oil reservoirs. A Canadian company, EnCana, is the operator of the Weyburn oil field. The field contains approximately 1.4 billion barrels of original oil in place, and is one of the largest medium-sour crude oil

reservoirs in Canada (EnCana, 2008). The project is using CO₂ from a North Dakota (USA) coal gasification facility. The CO₂ is transported via 320-kilometer pipeline and injected into the reservoir (Wilson & Monea, 2004). A significant portion of the CO₂ injected for EOR is produced with the oil, from which it is separated and then re-injected. At the end of oil recovery, the CO₂ will be stored in the geological formation (approximately 30 million tonnes).

The first phase of the research project began in 2000 and was concluded in 2004. From Phase I it was learnt "that EOR works well as a storage mechanism for CO₂" (IEA GHG Weyburn, 2009). Several technologies and techniques (i.e. 4D seismic surveying) were identified and used effectively to observe and track CO₂ movement in the reservoir. The project demonstrated that the method is safe and economically and technically feasible. The final phase of the research project is now underway, even though the oil field operations will continue until approximately 2030. More than 14 million tonnes of CO₂ have been sequestered in the oil reservoir since the beginning of CO₂-EOR operations (EnCana, 2008), making this the largest CO₂ storage project globally.

In Salah project, Algeria: The In Salah CCS project was launched in 2004. In Salah is a joint venture between Sonatrach, the Algeria national energy company, BP and StatoilHydro. It is a multi-field natural gas development in the Algerian desert. The gas fields contain from 1 to 9% CO₂ which must be removed prior to sale. Rather than venting the CO₂, it is being compressed and injected back to the reservoir. Around 1.2 million tonnes of CO₂ is injected into the reservoir every year (Riddiford *et al.*, 2006). The goal of the project is to demonstrate that secure CO₂ geological storage can be cost-effectively verified, and that short-term monitoring can provide a long-term safety assurance (Wright, 2006).

Sleipner project, Norway (North Sea): Sleipner is a gas field in the middle of the North Sea in Norway. The gas contains from 4 to 9.5 % of CO₂ that is being separated from the natural gas and re-injected into a saline formation, which lies 1,000 meter below the sea bottom (Solomon, 2007). An important driver for the project was a CO₂ emissions tax. It was more economical to store the CO₂ once captured than to vent it.

The Sleipner project is operated by the Norwegian oil and gas company Statoil. The company has been injecting one million tonnes of CO₂ per year since 1996 without leakage. The project demonstrated that CO₂ storage in deep saline aquifers is safe, and CO₂ is secure stored in such formations.

ROLE OF CDM IN DEVELOPMENT OF CCS PROJECTS IN NIGERIA

Ongoing economic reforms in the oil and gas sector in Nigeria are aimed at making the sector more vibrant and attracting more investment. Some of these reforms include the Nigerian Gas Master Plan and ongoing legislation on gas flaring (NNPC, 2009). Despite the potential economic benefit of natural gas, much is still being flared away, thereby causing huge revenue loss and environmental hazards. However, the Nigerian government is presently working on measures that will eliminate the issue of gas flaring (Malumfashi, 2007).

These ongoing reforms herald an excellent background for CCS projects under the Clean Development Mechanism (CDM). The

CDM under the Kyoto Protocol provides a mechanism to assist developed countries (Annex I Parties) to meet their GHG emissions reduction targets. CDM is a project-based mechanism that involves Annex I Parties financing the implementation of GHG emissions reduction projects in developing countries (non-Annex I Parties). CDM provides investment incentives for reducing GHG emissions beyond a business-as-usual scenario (IEA, 2008). Two projects under the CDM are currently underway in Nigeria. These are "Recovery of Associated Gas at the Kwale Oil-Gas Processing Plant" and "The Ovade Ogharefe Gas Capture and Processing" projects. Both projects capture and process associated natural gas, thus eliminating gas flaring.

Kwale project: The Kwale project is run by Nigerian National Petroleum Corporation (NNPC), Nigerian Agip Oil Company Ltd and Phillips Oil Company Nigeria Ltd. The recovery and utilization of gas started in 2006. The project utilizes a large fraction of the associated gas produced at the Kwale oil and gas field and transports it via pipeline to the Okpai combined cycle gas turbine power plant for generation of electricity. Total emissions reduction generated by the project to date is 791,325 tonnes of CO₂ eq. (NAOC, 2007).

Ovade Ogharefe project: The developer of this CDM project is Pan Ocean Oil Corporation, Nigeria. The project captures processes and sells associated natural gas from the Ovade Ogharefe oil field. The gas processing plant to treat the associated gas and the pipeline to transport the dry gas to the existing gas grid were built. The gas capture began in 2007 and expected to continue for 22 years. The estimated emission reduction for the first 10 year period is 25,315,000 tonnes of CO₂ eq. (UNFCCC, 2005).

Currently, the CDM is the only mechanism that has the potential to provide incentives for development of CCS in Africa. Thus, the approval of a CCS project methodology under the CDM is an important step to help developing countries to begin mitigating their greenhouse gas emissions (IEA, 2008).

The benefits of CDM to Nigeria include attracting an increased flow of investments and capital-intensive projects; stimulating technology transfer of the most innovative technologies used in power and oil and gas sectors; promoting and creating market for its natural gas; and developing infrastructure.

A demonstration CO₂-EOR project would be a good addition to the ongoing CDM projects discussed above. Experiences learned from Weyburn CCS project in Canada can be utilized in implementation of CO₂-EOR project in Nigeria. Since CO₂ capture at the power plant in Nigeria presents number of technical and financial difficulties, the CO₂ may be sourced from Europe. The transport of CO₂ by ship overseas is a technically and economically viable solution. The ship on its way back to Europe may take liquefied or compressed natural gas (LNG/CNG). At the end of oil recovery the CO₂ may be stored in the depleted oil reservoir.

Implementation of such demonstration project in Nigeria would help to build confidence in CCS technology. It can also be a starting point for development of legal and regulatory framework to regulate CCS in the country, in addition to generating revenues to offset costs of CCS.

Finance for CCS project may be available through the African Development Bank (AfDB). However, the bank has not yet developed the capacity to implement climate change projects. It is currently establishing a unit that could handle issues of CDM (Bakker *et al.*, 2007).

CONCLUSIONS AND RECOMMENDATIONS

The current state of CCS technology was reviewed in this article. Three main technologies are used to capture CO₂ from power plants: pre-combustion, post-combustion and oxyfuel combustion. Pre-combustion and post-combustion systems are economically feasible under specific conditions, while oxyfuel combustion technology is still in demonstration phase. The spread of these technologies in Nigeria in the near future is unlikely. Even in developed countries large-scale commercial operations of CO₂ capture systems are still in the infancy stage. Other barriers foreseen for use of CO₂ capture techniques in Nigeria include lack of experience with modern technologies, lack of incentives and regulations from the government and increased fuel consumption due to CO₂ capture, increased cost of operations, and consequently, an increase in electricity prices.

If CCS technology is to be applied in Nigeria, the CO₂ infrastructure needs to be developed. No major problems with onshore pipeline transportation of CO₂ are anticipated. The pipeline technology is well developed and has been in use in both developed and developing countries for decades. CO₂ can also be transported as a liquid in ships. This option may be economically viable for a demonstration CO₂-EOR project under the Clean Development Mechanism, where CO₂ is to be transported from developed countries for EOR and geological storage in Nigeria. CO₂-EOR may also help to develop the CO₂ infrastructure and offset costs of CO₂ capture due to revenues from additional oil produced.

Geological storage of CO₂ is ongoing in three large industrial projects in the world: the CO₂-EOR Weyburn project in Saskatchewan, Canada; the offshore Sleipner natural gas processing project in the North Sea, Norway; and the In Salah natural gas project in central Algeria. All projects demonstrated that CO₂ can be economically and safely stored in the geological formations.

The potential demonstration CO₂-EOR project in Nigeria is proposed in this article. The project may be implemented under the CDM and will help to transfer and develop CCS technologies and expertise in Nigeria. Potential revenues may be generated from additional oil recovery and sales of natural gas. If CCS is implemented under the CDM, carbon credits may also be received.

CCS is a promising solution to reduction of greenhouse gas emissions. However, more research and demonstration projects, as well as development of legal and regulatory framework and incentives from the government are necessary for successful implementation of CCS technologies.

REFERENCES

Bakker, S. J., de Coninck, A.; H. C.; Ba, L.; Zhou, P. P. (2007). Advancing CCS and CDM in Africa. Outcomes of two workshops in Africa. Energy Research Centre of the Netherlands. ECN-E--07-079, October 2007.

- Clifton Associates (2004). The Long Term Storage of CO₂. A Regulatory Requirements Project. Final report. Clifton Associates Ltd. Regina, Saskatchewan, Canada. March 25, 2004.
- EnCana (2008). Operations profile:Weyburn. December 2008. <http://www.encana.com/operations/canada/weyburn/pdfs/p006504.pdf> Accessed 9 March, 2009.
- Eye of Dubai (2009), Masdar to pursue carbon reduction projects in Nigeria. January 21, 2009. <http://www.eyeofdubai.com/v1/news/newsdetail-27634.htm>. Accessed 3 March, 2009.
- Galadima, A. & Garba, Z. N. (2008). Carbon Capture and Storage (CCS) in Nigeria: Fundamental Science and Potential Implementation Risks. *Science World Journal*, 3 (2):95-99.
- Hendriks, C.; W. Graus & van Bergen, F. (2004). Global Carbon Dioxide Storage Potential and Costs, ECOFYS report EEP-02001, 2004.
- IEA (2008). CO₂ Capture and Storage. A key carbon abatement option. OECD/IEA 2008.
- IEA GHG (2004), Ship Transport of CO₂. Report PH4/30, United Kingdom.
- IEA GHG Weyburn (2009). IEA GHG Weyburn CO₂ Monitoring and Storage Project. IEA Greenhouse Gas R&D Programme, UK. <http://www.ieagreen.org.uk/glossies/weyburn.pdf>. Accessed 9 March, 2009.
- IPCC (2005), IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change. [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442 pp.
- Malumfashi, G. I. (2007). Phase-out of gas flaring in Nigeria by 2008. The prospect of a multi-win project (Review of the regulatory, environmental and socio-economic issues). Swiss National Centre for Competence in Research (NCCR), Berne, Switzerland. <http://www.nccr.trade.org/> Accessed 10 March, 2009.
- NAOC, (2007). First Monitoring Report on Recovery of Associated Gas that would otherwise be flared at Kwale Oil-Gas Processing Plant, Nigeria. Nigerian Agip Oil Company Ltd., September 24, 2007.
- NNPC, (2009). Gas Investment Opportunities. Nigerian National Petroleum Corporation. <http://www.nnpcgroup.com/nigeriagas.htm> Accessed 10 March, 2009.
- Riddiford, F.; Wright, I.; Bishop, C.; Espie, T., and Tourqui, A. (2004). Monitoring Geological Storage. The In Salah Gas CO₂ Storage Project. 7th International Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada. <http://uregina.ca/ghgt7/PDF/papers/nonpeer/529.pdf>. Accessed 9 March, 2009.
- SaskPower (2009), SaskPower's CLEAN CO₂AL™ Project. <http://www.saskpower.com/cleancoal/> Accessed 16 March, 2009.
- Solomon, S. (2007), Security of CO₂ storage in Norway. The Bellona Foundation Fact Sheet, Oslo, Norway, 21/02/2007. http://www.bellona.org/filearchive/fil_Factsheet_Security_of_CO2_storage_in_Norway_-_english_-_rev_16aug07.pdf. Accessed 10 March, 2009.
- Stevens, S.H.; Kuuskraa V.A.; Gale, J. & Beecy, D. (2001). CO₂ Injection and Sequestration in Depleted Oil and Gas Fields and Deep Coal Seams: Worldwide Potential and Costs. *Environmental Geosciences*, 8(3):200-209.
- Tzimas, E.; Georgakaki, A.; Garcia Cortes; C. & Peteves, S.D. (2005). Enhanced Oil Recovery using Carbon Dioxide in the European Energy System. DG JRC, Institute for Energy, Petten, The Netherlands.
- UNFCC, (2005). The Ovade Ogharefe Gas Capture and Processing Project. Clean Development Mechanism, Project Design Document Form, UNFCC, 20 October, 2005.
- United Nations Framework Convention on Climate Change (UNFCCC) <http://cdm.unfccc.int/index.html>. Accessed 3 March, 2009.
- Wilson, M. & Monea, M. (eds) (2004). IEA GHG Weyburn CO₂ monitoring and storage project summary report 2000-2004. Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies, 5-9 September 2004, Vancouver, Canada.
- Wright, I. (2006). CO₂ Geological Storage: Lesson Learned from In Salah (Algeria). Presentation at SBSTA Meeting, Bonn, May 20th 2006. http://unfccc.int/files/meetings/sb24/in-session/application/pdf/sbsta_may_20th_in_salah_wright.pdf. Accessed 9 March, 2009.