Carbon Capture and Storage in China: Options for the Shenhua Direct Coal Liquefaction Plant

By Hui Su and Jerald J. Fletcher*

Introduction

In this carbon constrained world, climate change driven by carbon intensive energy sources is receiving wide attention. Carbon capture and storage (CCS) is defined as the collection of CO_2 from industrial or utility plants including power plants, oil refineries and chemical works, and subsequently storing it in secure underground reservoirs. Cited as a "potentially important climate change mitigation measures in the coming decades" (Philibert et al., IEA, 2007; OECD/IEA, 2006), CCS is under consideration as an important carbon management option. CCS is expected to be the second most important emission reduction technology (OECD/IEA, 2006) by 2050, second only to energy efficiency improvements. It is considered the only option that can provide long-term greenhouse gas (GHG) mitigation while allowing for continued large-scale use of the existing fossil infrastructure and abundant fossil energy resources (Herzog, 1998). As a critical element within a mitigation portfolio, CCS is also becoming increasingly important for China. Any efforts from China would inevitably play an important role in global carbon management efforts since China is the leading consumer of coal-derived energy and carbon dioxide emitter.

Motivation for China's CCS Options

Climate change considerations are motivating factors for China's development of CCS mitigation options. With rapidly increasing GHG emissions, China is facing increasing international pressure to reduce emissions and commit to long-term reductions under the post-Kyoto framework. During the 11th five-year planning period (2006-2010), the Chinese government set goals for reducing energy consumption per unit of GDP by 20% and CO_2 emissions by 1.32 billion tons by 2010 (NDRC, April 2007; NDRC, June 2007). President Hu's speech at the UN climate change conference on September 22, 2009 emphasized that China would "endeavour to cut carbon dioxide emissions per unit of GDP by a notable margin by 2020 from the 2005 level."

However, coal, the most carbon-intensive type of fossil fuel, will remain the dominant component of China's energy mix in the foreseeable future. Given that most energy-related CO_2 emissions come from the use of fossil fuels, China's attempts to increase energy security through the use of domestic resources, primarily coal, make GHG emission abatement difficult. Successful large scale application of CCS technologies in China would reduce CO_2 emissions while enabling the continued use of coal.

CCS is a key component of China's development of integrated gasification combined cycle (IGCC) clean coal technologies. IGCC is a process in which coal is gasified to synthesize chemicals and fuels and hydrogen produced to drive turbines to generate electricity. In contrast with the halt of the U.S. Department of Energy (DOE) advanced IGCC demonstration project (FutureGen), China is actively developing its clean coal technologies and establishing its own set of IGCC projects (GreenGen) – the first in 2009 in Tianjing (Technology Review, 2008). IGCC plants produce far less pollution than conventional coal plants while providing a CO_2 stream pure enough to store. Rapid development of such clean coal technologies in China provides an ideal opportunity for commercial CCS development.

Developing CCS technologies provides an opportunity for Chinese enterprises to take a leadership role in the application of carbon mitigation alternatives. The Chinese government is expected to allocate funds equivalent to a quarter of the US$ 586 billion stimulus package to environmental related projects, renewable energy development and improvement of energy efficiency as measures to simulate China's economy[1]. These funds provide governmental incentives for Chinese power companies. Accordingly, the development of CCS would increase economic activity through the creation of new business opportunities and associated jobs to sustain economic growth while responding to the current global economic crisis.

It is worth noting that any climate change mitigation including CCS could improve China's standing in the world. China hopes to be seen as a responsible and constructive force for dealing with the most critical global issues of the 21st century (Lieberthal and Sandalow, 2009). Any positive action in climate change mitigation can be expected to enhance its international prestige.

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See footnotes at end of text.

Development of CCS in China

In 1998, China began its first CO_2 storage project CO_2-EOR in the Liaohe oil field in the Bohai Basin in North-East China (IPCC, 2005). In 2003 China joined the Carbon Sequestration Leadership Forum (CSLF), a ministerial-level organization initiated by DOE. The initiative promotes collaborative research, deployment and demonstration of CCS projects among the CSLF signatory member countries[2]. Among the seven recognized and completed CSLF projects, two are located in China. The first one is the China United Coal Bed Methane Corporation and the Alberta Research Council of Canada joint venture for extracting coal-bed methane via CO_2 injection (CO_2-ECBM) in the Qinshui Basin of eastern China in 2005[3]. A second project is the Regional Opportunities for CCS in China, lead by Battelle, U.S. Pacific Northwest National Laboratory (PNNL) and the Chinese Academy of Sciences. This project estimated market opportunities for CCS in China by compiling characteristics of large anthropogenic CO_2 sources and candidate geologic storage formations across China[4] (Dahowski, 2005). Meng (2007) estimated the potential of Chinese coal-fed ammonia plants for CO_2 storage in saline aquifers. The estimated cost for compressing, transporting and storing CO_2 in saline aquifers ranged from $15 to $21/t of CO_2. In 2007 China's Ministry of Science and Technology (MST) and the British Geological Survey launched a pilot CCS project looking into the possibility of storing carbon in depleted oil and gas fields and unmined coal seams[5]. China's HuaNeng Group and Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) collaborated on a post-combustion capture (PCC) pilot plant for thermal power stations in Beijing in 2008[6]. More recently, the UK Department of Energy and Climate Change invested more than £3 million in developing CCS in China[7].

Introduction to the Shenhua DCL Project

The Shenhua Group (Shenhua) is one of the largest energy companies in China and the world's largest coal producer. The Chinese National Council provided about $1.3 billion US from the "Coal Replace Oil" fund to Shenhua to initiate coal-to-liqiud (CTL) development in Janary 1998. Since then Shenhua has developed a business strategy and began CTL development in northwestern China's major coal production areas. Increases in crude oil prices further stimulated Shenhua's CTL development. With support from China's National Development and Reform Commission (NDRC), Shenhua has allocated about $10 billion USD to the development of its coal coversion projects.

The Chinese government's initial encouragement to pursue CTL development was driven by energy security considerations. China's efforts to increase clean coal utilization to mitigate the environmental impacts of traditional coal combustion also factor into Shenhua's CTL developememt decisions. Shenhua has primary responsibility for the coal related goals of the Chinese National Energy Security and Alternative Fuel Program (WVU, 2009). The China Shenhua Coal Liquefaction and Chemical Company Ltd. (CSCLCCL) is developing the world's first modern commercial direct coal liquefaction (DCL) facility to produce transportation fuels. The DCL plant completed a trial run in January 2009 that provided information for further development. The second trial run is now underway as of September, 2009. When fully operational, the DCL plant is expected to produce nearly 1 megatonnes (Mt) of oil products per year, equivalent to approximately 25,000 barrels of oil per day. The estimated total cost of the first phase of the DCL plants is $1.5 billion US.

Geologic CCS Potential in Ordos Basin

In conjunction with transportation fuels, the plant will also produce nearly 3.4 megatonnes (Mt) of CO_2 per year. In 2008, the Chinese government curtailed the coal liquefaction program due to concerns about pollution and excessive water consumption. Shenhua's DCL plant is one of two major facilities approved to proceed while others were suspended (Reuters, 2009). In addition, in recent years the Shenhua DCL plant has drawn worldwide attention as the world's first modern, commercial DCL demonstration project.

Shenhua is considering alternative methods to permanently store or sequester CO_2 in geological formations in the Ordos Basin. Geologic CCS is particularly well suited for large point sources such as the DCL project since CO_2 can be efficiently captured (Bode and Jung, 2006). Over 80% of CO_2 emissions in the DCL process, equivalent to approximately 3 Mt of CO_2 per year, can be stored directly without additional capture costs. The CTL project with CCS technology enjoys a comparative advantage over CCS projects for traditional coal-fired sources.

Conclusions

CTL production with CCS potentially offers a route towards widespread reduction of CO_2 emissions.

The development of a CCS project related to the Shenhua DCL plant will contribute to China's CO_2 emission control program as well as to the feasibility of continued growth of the coal gasification and liquefaction industry. If the proposed CCS plan comes to fruition, its economic viability and environmental sustainability may well determine the future of the CTL industry in China.

More importantly, the success of the Shenhua CCS plan may well determine the potential for CCS as one of a portfolio of mitigation options in China and represent a significant step towards China's carbon management efforts.

Footnotes

[1] Reference available at http://www.renewableenergyworld.com/rea/news/article/2009/03/chinas-new-generation-driving-domestic-development

[2] Reference available at http://fossil.energy.gov/programs/sequestration/cslf/

[3] Reference available at http://www.cslforum.org/projects/china.html

[4] Reference available at http://www.cslforum.org/projects/china_regional.html

[5] Reference available at http://www.reuters.com/article/environmentNews/idUSTRE5370EY20090408

[6] Reference available at http://www.scidev.net/en/news/china-ventures-into-carbon-capture.html

[7] Reference available at http://www.frankhaugwitz.info/doks/cdm/2009_02_09_China_UK_CCS.pdf

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