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Current Status of CCS Initiatives in the Major Emerging Economies

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Abstract

This paper presents an overview of the current status of the main CCS initiatives in the major emerging economies: China, India, Brazil, Mexico, Russia, and South Africa. This study first covers all six countries as a group and describes their natural resources. The second part of this study embraces each country individually and includes current initiatives and current legal and technological status of CCS. At the end, this study summarizes the main findings in the emerging economies and the potential of including CCS as part of the CDM.

Keywords: Emerging Economies, Brazil, Russia, India, Mexico, China, South Africa

1. Introduction

The IEA stated that CCS could provide some 19% of the required global CO_2 reductions by 2050, but this would mean about 18 CCS projects would be necessary by 2015, and a significant number of 3,400 CCS projects would be needed by 2050. The split was about 35% of these projects to be located in non-OECD member countries, and the remainder to be located in OECD countries [1]. On June 2010, in preparation for the G8 Summit hosted in Canada, the IEA together with the CSLF published a report entitled "Carbon Capture and Storage: Progress and Next Steps." The report bases its analysis on the G8's commitment to realize broad CCS deployment by 2020, which will require about 100 plants globally, divided evenly between developed and developing countries [2]

2. Overview of the Major Emerging Economies

According to the British Petroleum Statistics 2008 and OECD database, these six countries as group (Brazil, Russia, India, Mexico, China, and South Africa) share world reserves of 10% of conventional oil, 27% of natural gas, and 45% of coal. The potential for reducing GHG worldwide must definitely take into account these emerging economies. According to the Energy Information Administration of the US Department of Energy, by 2006 these

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countries represented almost 40% of the CO_2 emitted to the atmosphere [3, 4]. Table 1 and Figure 2 provide an overview of the primary energy consumption in these six countries. Figure 2 shows the CO_2 intensity of energy used in the emerging economies.

CCS depends on a price for carbon dioxide to underpin the justification of a project. In developed countries the carbon price will be delivered through cap-and-trade policy implementation and the necessary policy framework for CCS, including the development of a carbon price, are under development. In developing countries, cap-and-trade policy will not be implemented in the near future. An alternative carbon pricing mechanism will be needed as a transition measure. Today, such a carbon price comes through the CDM

Some estimates suggest 100 billion per annum is required to deploy CCS. In the absence of a mechanism such as CDM, it seems unlikely that investment in CCS will be achieved in many developing countries within the 10 year timeframe proposed by the G8. Financing is one of the key issues for CCS deployment because even if a huge effort on preparatory work is done and with a strong support for CCS, nothing will happen without adequate funding [5]

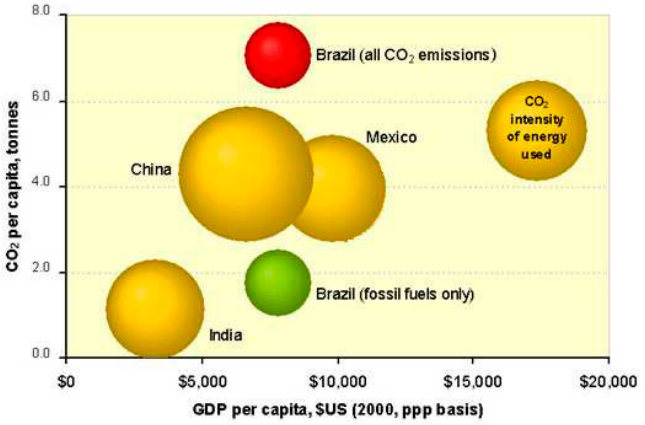

Figure 1 CO_2 intensity of energy used in the emerging economies. Source: Adapted from [6]

3. CCS Overview in the Major Emerging Economies

3.1. Brazil

Brazil has a unique electricity and emissions profile. Over 80% of its electricity is produced from hydropower with the rest being made up by a combination of fossil fuels, biomass and nuclear. This means the energy emissions in Brazil are relatively low. However, a large majority of Brazil's GHG emissions comes from burning linked to deforestation of the Amazon [7]. For Brazil, stopping the deforestation of the Amazon is the key emissions reduction mechanism.

Brazil is a vocal opponent against allowing CCS projects as part of CDM [8]. It argues that CDM is not an adequate mechanism to deal with the complexities of CCS, such as long-term liability of storage, and that including it would prevent development of renewable energy and create a positive incentive for further fossil fuel production, contrary to the ultimate objective of the climate convention [9]. This is despite the fact that PetroBras is investing heavily in CCS, seeking to overtake Statoil as the largest operator of CCS project [10]

PetroBras has 25 years of experience of CO_2 injection in aquifers and coal seams. They have produced three CCS roadmaps for Brazil including one focused on CCS and sustainability. Also PetroBras was one of the founders of the Center of Excellence in Research on Carbon Storage (CEPAC), launched in 2006 in partnership with the Pontifical University of Rio Grande do Sul. CEPAC has a number of working partnerships with CCS organizations throughout Brazil and internationally which include the Brazilian Coal Association and a number of other Universities around Brazil, the CSLF, NETLS, and the IEA.

One of the major contributions that CEPAC has made to CCS in Brazil is a study matching sources and sinks throughout Brazil. Included in this study was an analysis and ranking of storage reservoirs and also a look at regulatory issues concerning storage. CEPAC also released a storage atlas in 2009 providing preliminary mapping of storage at a country scale, and at basin scale for aquifers. This atlas estimates a storage capacity of 2,000 Gt [11]

Regarding to initiatives in financing, the Brazilian Carbon Facility was launched in 2005 by the Brazilian Mercantile and Futures Exchange (BM&F) and the Brazilian Ministry of Development, Industry and Foreign Trade. This Facility connects carbon project developers and investors through a registry of CDM projects. Although there is no mandatory scheme in Brazil for the reporting of economy-side GHG emissions, there are two voluntary programs, neither of which is underpinned by Federal government regulations: the Brazilian Cooperative GHG Emission Program, and the voluntary scheme of the São Paulo State Environmental Protection Agency [12]

3.2. Russia

Russia is relevant for international CCS diffusion as it holds the world's largest natural gas reserves, the second largest coal reserves, and the eighth largest oil reserves. Furthermore, fossil fuels account for nearly 90% of the national power generation mix [3]. The forecasted increase in coal-fired capacity creates the chance to install fossil-fuelled plants which may allow CCS. Current generating facilities may not apply CO_2 capture processes since more than 50% of the installed capacities are older than 30 years and operate at efficiencies of 27-33% [13]

The Kyoto Protocol classifies Russia as a transition country, obligating it to merely keep its 2008-2012 CO_2 emissions at the same level as 1990. Owed to significant CO_2 reductions after the collapse of the Soviet Union in 1991, Russia's Kyoto commitment does not include investments in costly mitigation technologies like CCS. Russia is more interested in H_2 production and fuel cells development than in CO_2 capture [14]. However, its ratification of the protocol creates the opportunity to participate in Joint Implementation projects which enable the introduction of innovative technologies to the national energy sector. For example Gazprom is actively working with the government on issues related to Kyoto Protocol and JI projects in particular [15]

Most of Russia's CCS related activities are mainly entailed from international cooperation. The government is a member of the CSLF, and the European Russian Energy Dialogue, which established the EU-Russia Energy Technology Centre where CCS is a top priority issue [16]

Most of Russia's geological CO_2 storage capacities are based on the data from the former Soviet Union's. It is estimated a potential of geologic storage in about 560 Gt. However most of these reservoirs are located far distant from large fossil-fired power stations and consequently CO_2 injection would require the construction of a gigantic pipeline system [17]. Also in 2009 the Russian Academy of Sciences sponsored a project to evaluate the feasibility of CO_2 storage in permafrost in the northern territories of Russia [18]

Regarding to legislation for CCS, Russia does not have a solid framework but rather a combination of rules and procedures applicable to oil and gas and environment. The Energy Strategy of Russia for the Period of up to 2020 was approved on August 2003 and emphasises the need for environmental requirements on energy intensive activities or economic stimulation for more environmentally sensitive production methods. According to this document, CO_2 levels are expected to be at 75-80% of 1990 levels and not exceed 1990 levels until 2020. On this basis, Russia will likely meet its Kyoto obligations without any legislation action on GHGs. On January 2009, the Russian government released a decree announcing their priorities for improving energy efficiency in the energy sector. The decree states an official target of generating 4.5% of Russia's electricity from renewable energy by 2020 (20% by 2020 when large hydro is included) [19]

3.3. India

Although India ratified the Kyoto Protocol in August 2002, as a non-Annex 1 country, it does not currently have binding GHG emissions reduction targets under international law. Coal is expected to remain the dominant energy source in India through at least 2050 [20]. The IEA predicts that India will be in the top three emitters of the world by 2030 in terms of total CO_2 emitted each year.

According to Cleantech Group, about 80% of the electricity supplied to homes, farms and factories in India comes from coal-fired generation plants, one third of which are old, inefficient, and emit harmful gases. If all these were modernized it would reduce emissions by 10 million to 13 million metric tones of CO_2 equivalent each year [21]

To date, the Government of India has not introduced any policies or legislation dedicated to encouraging the development of CCS and as a matter of fact, currently this technology is not a priority [22-24]. Industry stakeholders indicated that the governments of developed countries should contribute initial financing to CCS projects in India through international financing institutions such as the World Bank, the IMF, and the ADB. The resources for adaptation and mitigation of climate change will be provided from the budgets of the remaining years of the 11th Five Year Plan (2007-2012) and through to the end of the 12th Five Year Plan (2013-2017) [25, 26]

Other initiatives include partnerships with US labs such as NETL in the Big Sky Carbon Sequestration Partnership (BSCSP), the CO_2 Geological Storage Project (CO2GSP) partnership with the Pacific Northwest National Lab, the Integrated Research and Action for Development (IRADe), and the Institute of reservoir Studies.

At present, there is limited knowledge in geological capacity due to a general lack of essential data. Initial attempts at evaluating the storage potential in India were made by Singh [27] and estimated that roughly 5 Gt CO2 could be stored in unmineable coal seams, 7 Gt in depleted oil and gas reservoirs, 360 Gt in offshore and onshore deep saline aquifers, and 200 Gt via mineralization in basalt rock [28]. These capacity, however, are far from centers of emissions and may increase the cost of transportation.

Regarding to legislation, India does not have any integrated policies dedicated to encouraging the development of CCS. The National CDM Authority of the Ministry of Environment and Forestry, Government of India has initiated executive moves to investigate the potential of CCS. Analysts are of the view that linking CCS with the CDM is necessary before India can support the inclusion of CCS under the CDM umbrella [29]

3.4. Mexico

Although Mexico is a member of the OECD and contributes to nearly 1.5% of global greenhouse emissions, it is not on the list of countries mentioned in Annex I, so it has no specific target with regard to reducing GHG emissions [30]. Global warming policies in Mexico are very much influenced by the agreements signed under the UNFCCC and the Kyoto Protocol.

CO_2 emissions in Mexico are in the order of 600 million tones/year, from which 400 millions come from fossil fuels. Mexico has developed a Strategic Plan for Climate Change that covers short term actions and longer term R&D. Currently there is no prohibition for the discharge GHGs into the atmosphere and only those companies that exceed the threshold established by regulators would be required to report emissions in their annual report. Some medium term actions depend on international funding agreements for GHG reduction projects and are looking forward to a successful COP16 meeting [31]

Although geologic CO_2 storage is included in the Strategic Plan for Climate Change, it is considered as very costly. This may be compensated by financing from CDM projects. This Strategy considers CCS projects as priority field of research, due to their utility for CO_2 capture potential, as well as the opportunity for PEMEX's most important oilfield, Cantarell and other declining fields to increase oil recovery [32]

As part of Mexican initiatives in CCS, PEMEX has decided to use CO_2-EOR in a pilot project at "Cinco Presidentes" separating CO_2 from an Ammonia plant and massive implementation is expected in 2013. Also PEMEX has an inventory of depleted and depleting production wells, and of saline formations, that could be evaluated with a view of greenhouse gas producers using them for CO_2 storage. The Comision Federal de Electricidad (CFE), the monopoly that controls the Mexican electricity sector, is doing studies on the geologic formations in order to evaluate the storage capacity in partnership with other federal regulators [33]

While there is no CCS specific legislation or regulation, existing laws may be applicable to particular CCS activities. These laws also provide guidance on the future approach taken by the Government in implementing a regulatory framework. The National Strategy and the Law for the Promotion of Renewable Energy and Energy

Transition provides that the Regulatory Energy Commission (CRE) and the Ministry of Energy may impose specific targets for the reduction of GHG to PEMEX, CFE, and LyFC since these companies will have a mandate to reduce their emissions from 2010 [34]

3.5. China

Due to China's strong economic growth, there has been a vast expansion of coal-fired power plants there. Since China has large coal reserves, which it intends to use because of the country's rapidly increasing demand for energy, many experts regard the use of CCS technology here as crucial in supporting global endeavours to reduce emissions. At present China's installed capacity of power generation plant totals about 700 GWe with over 70% of that based on coal. By 2020, this capacity is projected to nearly double and still be dominated by coal. Oil import dependency is projected to exceed 60% by 2020 [35]

Although China's per capita carbon emissions are substantially lower than those of Europe or the United States, in terms of total emissions, China overtook the US as the world's largest CO2 emitter in 2008. This is mainly due to China's impressive growth and relatively high energy intensity compared to developed countries. For example, energy-intensive industries and the construction sector account for nearly half of China's energy use [36]

China's official view on CCS is that developed countries must take the lead in demonstrating CCS and provide a much stronger framework of incentives for action in developing countries. Chinese companies see CCS as a potential export opportunity and its Ministry of Science and Technology is developing a longer-term CCS R&D strategy. The cost of building a CCS demonstration plant in China is estimated to be between $350m-$650m, depending on the level of ambition. The World Bank has established a portfolio of Climate Investment Funds (CIF) including the Clean Technology Fund and the Strategic Climate Fund which could provide one source of funds [37].

The development and commercialization of CCS is not yet China's top political priority, but in June 2007, the Chinese government published a paper entitled "China's scientific & technological actions on Climate Change". In it, it resolves to establish a roadmap for the development and demonstration of CCS and to complete capacity-building activities as well as research, development and demonstration projects. CCS is one of the key topics in the area of Clean Coal Technology within the 863 and 973 programmes of the 11th Five-Year Plan (2006-2010) [38]

Although China currently has no legislation concerning CO_2, in June 2007, the NDRC issued China`s National Climate Change Program (2007-2010). The program targets a reduction in energy consumption per GDP by 20% by 2010 over 2005 levels and corresponding slow down of CO_2 emissions. China has also introduced certain regulations to control the discharge of other air and water pollutants and monitor the efficiency of energy utilization. Under the Medium-long Term Development Plan of Renewable Energy, the NDRC set a target that 10% of total primary energy consumption in China should be from renewable sources by 2010 and by 15% by 2020 [39]

China has been very active with international cooperation projects, especially with the EU (NZEC, COACH, and STRACO2 projects), Japan, the US (Regulatory Capacity and MOU for cooperation on Climate Change), and Australia (Joint Coordination Group on Clean Coal Technology) [40]

3.6. South Africa

South Africa is estimated to emit over 400 million tonnes of CO_2 annually – of which approximately 60% can be captured and potentially available for CCS [41]. South Africa is a country with high energy intensity and a major emitter of greenhouse gases (GHG). Three main causes can be identified: the importance of the industry sector to its GDP, the dominance of coal in its energy balance (80% of electrical energy consumed) and finally the generally low degree of energy efficiency (industry, housing, transport, electricity) resulting from lower energy prices (electricity distributed here is amongst the cheapest in the world) and the abundance of coal resources, which does not encourage energy conservation [42]

South Africa is pursuing an energy strategy compatible with the Copenhagen Accord to reduce emissions by 34% below the "business as usual" level by 2020, and 42% by 2025. This strategy includes meeting urgent generation expansion while committing to an aggressive programme to enhance energy efficiency measures and introducing renewable energy as well as demand-side management. The Long Term Mitigation Scenarios (LTMS) were adopted

by the Government of SA in 2008. The intention is to ensure that carbon emissions peak during 2020-2025. The South African government announced that its strategy included commitments to introducing a carbon tax, CCS for coal fired power stations, and not approving new coal fired power stations without carbon capture readiness.

The National Climate Change Response Policy was published in March 2009 with a final version to be released by the end of 2010. This document would include a CO_2 taxation scheme. The process will culminate in the introduction of a legislative, regulatory and fiscal package to give effect to DEAT's strategic direction and policy by the end of 2012 [43]

The South African Center for CCS was launched by SANERI in March 2009. This Centre will oversee the compilation of the Carbon Geological Storage Atlas (expected for release in late 2010) and drive the CCS initiative in South Africa [44]. In summary, although South Africa has identified CCS to be a national research priority, it does not have an integrated CCS policy, but the Department of Environmental Affairs and Tourism (DEAT) has stated that a climate change policy will be released by the end of 2010, and a legislative, fiscal and regulatory package implemented by 2012 [45]

4. Discussion

CCS is gaining international popularity, and developed countries including the US, Australia, Canada, UK, and Norway are already building government-funded CCS demonstration plants. Many experts believe that emerging economies have the potential to become an important provider of CCS globally due to its strong position as an efficient and large scale manufacturer of products and technologies.

CCS development in emerging economies still faces various obstacles in the areas of technology, financing, health and safety and the development of sound international and multi-industry collaborations, which will need to be overcome before it can achieve significant scale. With the challenges of meeting growing energy demand and scaling up alternative energy resources, the contribution of CCS has to grow from 3% of the global abatement portfolio in 2020 to 10% in 2030 and finally reach 19% in 2050, when it will become the largest single emissions abatement technology in the portfolio.

The inclusion of CCS under the CDM has been a contentious issue. A number of questions have been raised including whether CCS projects contribute to sustainable development and, for projects where injecting CO_2 into the subsurface results in enhanced hydrocarbon recovery, whether the whole project will lead to an overall reduction in CO_2 emissions. Other concerns raised are that CCS may not be a mature enough technology to be considered for market-based deployment, and that the technology should be developed and tested in industrialized countries first, before it is considered for deployment in other countries.

Even if CCS projects are accepted within the CDM, a number of factors are expected to affect whether CDM income would be sufficient to encourage CCS projects, including how quickly monitoring, reporting and verification (MRV) methodologies can be agreed and the time horizon over which support can be guaranteed. If CCS was to be successfully incorporated into the CDM framework, the projected price of carbon is currently too low to enable CCS projects

Table 1. Energy Resources in 2007. Source: Bp Statistics 2008 and OECD Database

Energy resources 2007	Reserves					
	Oil (1,237.9 bln bbl)		Gas (177.36 trillion m3)		Coal (847 billion tonnes)	
	Share	R/P ratio	Share	R/P ration	Share	R/P ratio
Brazil (BR)	1.0%	18.9	0.2%	32.3	0.8%	*
Russia (RU)	6.4%	21.8	25.2%	73.5	18.5%	500
India (IN)	0.4%	18.7	0.6%	35.0	6.7%	118
Mexico (MX)	1.0%	9.6	0.2%	8.0	0.1%	99
China (CN)	1.3%	11.3	1.1%	27.2	13.5%	45
South Africa (ZA)					5.7%	178

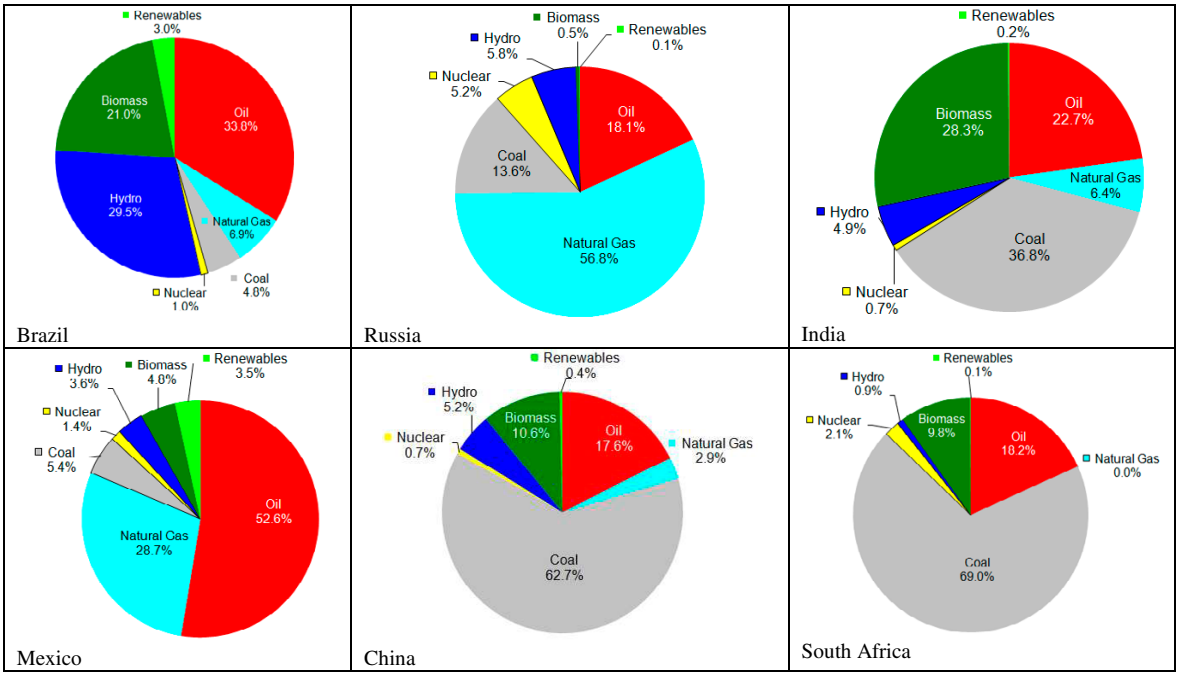

Figure 2. Primary Energy Consumption by Fuel - 2007 in the major emerging economies. Source: OECD Database

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