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Carbon Capturing and Storage Technology & current CCS initiatives in India (Emerging Technology in the field of Environmental Engineering)

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***Abstract*:** The major concern for developing countries like India has been reducing their Carbon emissions and lowering their pollution levels. India has always made serious attempts in reducing its level of pollution. The government of India has pledged to reduce its Carbon emissions by 33% to 35% from 2005 levels by 2030 for facing the climate Change issue that has been posing as a major threat to the world. At the landmark Paris Climate Conference in December 2015, India has also committed that 40 % of its electricity would be coming from non fossil fuel based sources like wind and Solar power, by 2030. In an effort to reduce pollution, there are many technologies coming up. One such Technological advancement has been made in the field of carbon capturing and storage. In this paper, various approaches for Carbon Capture & Storage (CCS[1]) are reviewed along with currently taken CCS initiatives in India. CCS is a technology where carbon dioxide gas releasing from various sources is being captured like from fossil fuel power plants and transported to storage location and get it deposited where it would not enter into the atmosphere. The objective of this technology is to prevent the release of large amount of CO_2 into the atmosphere as it is one of the major contributors for Global warming. Another important point to note here is that since the technology is novel, the Terms used might vary such as Carbon capture and storage (CCS) is used or sometimes Sequestration is used. The EU, the UNFCCC and the IPCC have adopted the term CCS.

Keywords*—sequestration; carbon; technology; pollution; carbon capturing*

INTRODUCTION

The need of reducing pollution levels and Greenhouse gases has always been alarming. Various developed and developing nations have been brainstorming about several innovative technologies for eradicating the menace of rising pollution levels in their respective countries. The industrial revolution has been playing an important role in not only improving their economy but also bringing them in limelight for various developmental projects that have been carried out to tackle the rising population needs and satisfying them. Carbon capturing and Storage is one the latest greenhouse gas reducing technology by which Carbon dioxide gas releasing into the atmosphere can be prevented to contribute significantly for Global warning and related consequences. One of the major benefits includes energy security and solution for green house gases accumulating in atmosphere. In addition, there have been several projects that have implemented the sequestration technology like that of in Salah Gas Project in Algeria and in Weyburn, Saskatchewan, Canada, using CO_2 captured from a coal gasification power plant[2,3]. Also, several Governmental as well as non governmental entities have published various summarized documents, both National and International works and other documents related to CCS technology[4]. The captured carbon can be stored in various ways such as deep sea formations; oil and gas fields or direct release into ocean water area.

One of the major challenges in capturing carbon dioxide is to separate CO or CO_2 from synthetic fuels which are derived from fossil fuels, or to separate CO_2 from fuel gas. The structure of futuristic CCS industries can take a number of possible forms depending on the mutual relations of Carbon dioxide producers, Carbon dioxide pipeline operators and geological storage site operators.

Approaches to mitigate Climate Change globally

There are various efforts made and widely adopted by several nations to lower their Carbon emissions and improvise their energy efficiency. Such steps also help in energy conservation that also includes using low carbon fuels and employing Non conventional energy sources such as Wind, Solar, bioenergy and Hydropower. These increase usage of low carbon fuels, and Natural gas. Another major approach is CO_2 capture and storage (CCS).

Table 1 shows comparison between all above said approaches w.r.t area of application, advantages and limitations[5]. Few of these efforts are associated with reduction at sources of emissions such as adoption of clean fuels, clean coal technologies whereas others energy conservational approaches. Each of these approach has its own Advantages and restrictions which will decide its ultimate area of application. Out of all different approaches, CCS is capable of reducing carbon dioxide emissions i.e. about 80 – 90% from large point sources such as Power producing plants etc. CCS involves various techniques such as different processes for CO_2 capturing, separation, transport, storage and Monitoring. Each of these steps is discussed in the paper.

TABLE 1: Summary of different approaches for CO_2 Reduction

Approach	Area of Application	Advantages	Limitations
1. Increased use of Clean fuels	Coal being replaced by Natural gas	Natural Gas releases 45% lesser CO_2 due to low carbon content than coal	Quite expensive
2. Preferring Clean technology for Coal	Replace usual combustion practices by IGCC or PFBC i.e. Integrated gasification combined cycle and pressurized fluidized bed combustor respectively.	Coal is used that liberates low air pollutants.	Requires Investments.
3. Using Non Conventional Energy sources	Wind, Solar, bio energy and Hydropower used	Almost negligible Greenhouse gas emission.	Depends on availability of local resources. Some renewable energy sources can prove costly.
4. CCS	Can apply where there are large sources of emission	May have capture efficiency of about 80%	Its techniques yet to be proved at full commercial scale

CO_2 capture technologies

CO_2 is released during combustion and the type of process used for combustion will decide the particular removal process for CO_2. These technologies are available as expensive and contribute to around 70-80% of the total cost incurred in a full CCS system including its capture, transport and storage. [6]

There are basically three capturing systems for carbon dioxide that are linked with different combustion processes namely Post combustion, Pre combustion and Oxy fuel combustion.

Post combustion: This Combustion process removes CO_2 from the flue gas after Combustion has occurred. These are also preferred for retrofitting existing power plants. The technology has been proven at small scale with CO_2 recovered at the rate of up to 800t/day[7]. At the same time, the major challenge for post combustion CO_2 capture is its large parasitic load. Since there is quite lower level of CO_2 , the energy penalty and associated costs becomes higher for the capture unit to reach the concentration of CO_2 .[8;9;10]

Pre-combustion: Here, the fuel like Coal or Natural gas is pre treated before the combustion process. The Coal involves a gasification process conducted in a gasifier under low oxygen level forming a syngas which is consist of mainly Carbon Monoxide and Hydrogen gas and is mainly free from other pollutant gases. Pre combustion capture can be applied to IGCC power plants[7] where coal can be used as fuel but at the same time, it will incur an efficiency loss of 7-8%

Oxyfuel combustion: Instead of air, oxygen is used for Combustion. It leads to reduction of amount of nitrogen present in exhaust gas which impacts the separation process to be used. Another benefit of this process is reduction in amount of thermal NOx[11]. This process is technically possible[11] but also consumes a large amount of oxygen coming from an energy intensive air separation unit[12].It may lead to an expensive and higher penalty with a plant without CCS[13;14].

Current CCS activities in India

India is having one of the emerging economies in the world. Coal is expected to be the major source of energy atleast by 2050[19]. Most of the Research and Developmental activities associated with CCS happen under the Department of Science and Technology (DST) of the Indian Ministry of Science and Technology. The DST set up the National Program on Carbon Sequestration Research in 2007. They had a view to compete with other several nations in the area of CCS with respect to both pure as well as applied research and industrial applications. Four main areas of research were found out i.e. Network Terrestrial Agro-forestry Sequestration, CO_2 Sequestration through Micro algae Bio-fixation Techniques, Carbon Capture Process Development and Policy development Studies. Table 2 indicates the list of few projects out of many that are related to CCS approved by Inter sectoral Science and Technology Advisory Committee (IS-STAC) of the DST[16,17]. In addition to above, The DST and the Research Council of Norway (RCN) have started a programme for joint funding of Indian-Norweign joint research projects in the field of Climate research and CCS under the Agreement of Cooperation in Science & Technology concluded between Government of India and the Government of Norway[18]. ONGC Ltd. was having plans to set up a pilot EOR project in Gujarat to supply carbon dioxide gas released from the gas processing plant at Hazira to the Ankleshwar oil field. The objective was to produce a high purity gas stream from the offshore Hazira Plant.

Table 2 List of Few DST projects related to CCS

Project Title	Organisation	Year approved	Duration in years
Sequestration of carbon dioxide (CO_2) into geological environment (Gas Hydrate): Laboratory Studies	National Geophysical Research Institute (NGRI), Hyderabad	2007-08	3
Experimental	Centre for Energy and	2007-08	3

and simulation studies on CO_2 sequestration using solar/ chemical methods	Environment Science and Technology(CEESAT), NIT, Tiruchirapall		
Pilot Bio-reactor using biological and chemical carbon dioxide sequestration (Integrated Biological and Chemical CO_2 sequestration	National Environmental Engineering Research Institute (NEERI), Nagpur	2007-08	3
CO_2 Sequestration using Micro algae – Efficient use of CO_2 from bio-hydrogen production facility	AMM MurugappaChettiar Research Center, Chennai	2008-09	3
Carbon Sequestration through Afforestation for Mitigating CO_2 emission from Thermal Power Station	Jadavpur University, Kolkata	2009-10	3
Carbon sequestration by mineral carbonation in cement kiln dust	IIT, New Delhi	2010-11	3
Mineral CO_2 sequestration by carbonation of industrial; Alkaline solid residues	Anna University,Chennai	2011-2012	3

The International Energy Agency has predicted that India will be top three emitters of the world by the year 2030 in terms of carbon dioxide emitted each year. Cleantech group estimates that more than half of energy supplied to farms, factories and houses of India actually comes from coal powered plants out of which one third proportion releases harmful gases in the atmosphere. If it can be upgraded, it has the potential of reducing emissions by 10 million to 12 million metric tons of CO_2 equivalent each year[20].

Till present time, the Indian Government has not implemented CCS technology with all time priority[20,21,22] . Stakeholders in Industries have also indicated that developed nation's Government should invest in CCS projects and initiatives in India as well. This can be accomplished with the help of financing institutions such as the World Bank or the IMF. Various financial resources for adaptation and mitigation efforts for tackling climate change will be provided from the budgets of the remaining years of 11th Five Year Plan (2007-2012) and through to the end of the 12th Five Year Plan (2013-2017)[23,24].

Other initiatives also include partnerships with US labs such as NETL in the Big sky carbon Sequestration Partnership (BSCSP) and with the Pacific Northwest National Lab. With regard to legislation, India does not have any policy dedicated to development of CCS. So as to check out the CCS potential in India, the National Clean Development Mechanism Authority of the Ministry of Environment and Forestry, Government of India has initiated some steps as well.

An Indian Public Sector Undertaking, NTPC Ltd., formerly known as National Thermal Power Corporation Limited, have been conducting research on CCS. They have also organized a workshop on CCS in collaboration with Ministry of Power in 2011.The Indian institute of petroleum has also been working effectively to develop latest adsorbents for post combustion Carbon dioxide capture. Private power companies such as Reliance Power and Tata Power are also coming into CCS technologies but storage challenges and other issues are acting as obstacle in successful implementation of large scale activities.

Discussion

Carbon capturing technology is gaining a lot of popularity among all nations. Whether it is a developed country or developing, all are taking serious attempts so as to tackle the menace of global warming and climate change. The developed nations such as USA,UK, Canada are already active and investing in CCS technology which is mostly Government funded. Many large scale power plants are under construction like Kemper County and Petra Nova WA perish in Mississippi and Texas respectively[25].

Many experts believe that a developing nation like India who is emerging as powerful economy in the world have a lot of potential to operate CCS technology since it has been producing products at a larger scale. India ia lacking behind developed nations in terms of active implementation of CCS technology. The government of India really needs to focus on CCS technology than current scenario. In an emerging economy like India, major hindrances come on the path of CCS initiatives such as Finances, health, safety and International collaborations. Another challenge faced by implementation of CCS technology is its ambiguity on sustainable development. Other issues raised are that CCS should be tested in developed and highly industrialized countries before taking it to developing Nations.

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