Ambit of Carbon Capture Technology in India

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ABSTRACT. Carbon capture is one of the most improving technology of late, with the advent of climate change globally. Work behind carbon capture is still at a progressive stage as far as India is concerned. Carbon capture involves state of the art technology and heavy economic value addition. Since Carbon dioxide is known for its devastating threat towards mankind and habitat, hence developing and adopting carbon capture mechanisms would lead to draining back ecological balance. In this paper we would be trying to come out with possible technologies that can be implemented for carbon capture and further sequestering it. Additionally the scope of carbon capture in Indian industries, the governing policy framework and the limitations.

1. INTRODUCTION

One of the first thought that occur to us in finding out what initiatives are to be taken to combat global climate change are mitigation efforts. Now broadly mitigation efforts can be further explained as the usage of makeshift technology from conventional fuel to non-conventional. Renewable energy is therefore a colossal supplement to the existing conventional infrastructure. India has been trudging ahead heavily on the improvement of renewable energy implementation, with the Indian government making policies on non-conventional energy, like the Renewable Purchase obligation (RPO). Most of the major sectors in India which are highly energy intensive like Power, Railways, Iron & Steel, Oil & gas, are adapting measure on the renewable front to cut down on the usage of fossil fuels.

Climate Change is a serious global environmental concern. It is primarily caused by the building up of Green House Gases (GHG) in the atmosphere. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. Global Warming is a specific example of the broader term, "Climate Change" and refers to the observed increase in the average temperature of the air near earth's surface and oceans in recent decades. Its effect particularly on developing countries is adverse as their capacity and resources to deal with the challenge is limited

Carbon capture in India is relatively a newer concept, though it is established in many countries like Canada and US, India is still on the building phase. Carbon capture technology involves a lot of technical expertise and monetary support which is yet on the developing phase in India.

Carbon capture technology is classified into few processes like Pre-capturing, Post-Capturing, and Oxy Fuel Separation methods. These mentioned methods are already proven and established. Further researches are carried out on the capturing front.

Post capturing, storing the captured carbon dioxide is a challenge though technologies are being used to store it deep underground. But storing underground in areas of human invasion or natural resource will not only hamper the habitat but also will harm the natural resource underground. So a suitable alternative would be to store in a place which neither has human invasion nor would threat the naturally existing resources. The probable location that was ascertained was depleted oil and gas beds, or exhausted mines.

Locating out places with exhausted oil and gas beds or even mines is technically very challenging. India is expected continue its dependency on coal for the next 150 years. With the advancement of emissions, it is unlikely that global temperatures wouldn't alter. Climatic conditions are expected to vary aberrantly in the upcoming few decades.

Carbon capture and sequestration is an interrelated process, wherein it comprises a number of steps starting from capture till storage.

The government of India has shown great intent in taking up initiatives against climate change in India. India today stands as the 5th largest power generator. India also has the 5th largest capacity of wind energy generation in the world. Economic growth, increasing prosperity a growing rate of urbanization and raising per capita energy consumption has widened access to energy in India.

2. Carbon Emissions

Fig 1. Sectoral break-up of India's CO₂emissions

Fig 2. Break-up of emissions from energy sector

3. METHODOLOGY

Carbon Capture Process:

3.1 Pre Capture separation

Pre Capture is widely applied in fertilizer, chemical, gaseous fuel (H_2 , CH_4), and power production. In this the fossil fuel is partially oxidized, for instance in a gasifier. The resulting syngas (CO and H_2) is shifted (water shift reaction) into CO_2 and H_2 . The resulting CO_2 can be captured from a relatively pure exhaust stream. The H_2 can be used as fuel, the carbon dioxide is removed before combustion takes place. There are several advantages and disadvantages when compared to conventional post combustion carbon dioxide capture. The CO_2 is removed after combustion of fossil fuels, but before the flue gas is expanded to atmospheric pressure. This scheme is applied to new fossil fuel burning power plants, or to existing plants where re-powering can be done.

3.2 Post capture separation

The CO_2 is removed after combustion of the fossil fuel this would be applied to fossil-fuel burning power plants. Carbon dioxide is captured from flue gases at power stations or other large point sources. The technology is well understood and is currently used in other industrial applications, although not at the same scale as might be required in a commercial scale power station.

3.3 Oxy fuel separation

The fuel is burned in oxygen instead of air. To limit the resulting flame temperatures to levels common during conventional combustion, cooled flue gas is recirculated and injected into the combustion chamber. The flue gas consists of mainly carbon dioxide and water vapor. The result is an almost pure carbon dioxide stream that can be transported to the sequestration site and stored. A certain fraction of the CO_2 generated during combustion exhaust up in the condensed water. To warrant the label "zero emission" the water would thus have to be treated or disposed of appropriately. The technique is promising, but the initial air separation step demands a lot of energy

4. Indian Scenario in Capturing Carbon

In India there have been certain initiatives that are being taken up as voluntary initiatives from organizations. Though there are many lab scale experiments which have failed to get converted into larger scale for more than one reason.

Most Indian Research and Development (R&D) activities related to CCS occur under the supervision of Department of Science and Technology (DST) of the Indian Ministry of Science and Technology. The DST set up the National Program on Carbon Sequestration (NPCS) Research in 2007, with a view to competing with other countries in this area with respect to both pure/applied research and industrial applications.

Table 1. CCS Projects in India

Organization	Project
Rajiv Gandhi Technological University, Bhopal	Modelling and simulation of Carbon Recycling Technology through conversion of CO_2 into useful multi-purpose fuel
National Environmental Engineering Research Institute (NEERI), Nagpur	Pilot Bio-reactor using biological and chemical carbon dioxide sequestration (Integrated Biological and Chemical CO_2 sequestration)
National Geophysical Research Institute (NGRI), Hyderabad	Sequestration of carbon dioxide (CO_2) into geological environment (Gas Hydrate): Laboratory Studies
National Chemical Laboratory (NCL), Pune	Development and Characterization of porous Solid Adsorbents for sequestration of Carbon Dioxide (CO_2) (Metal Silicates for pre-combustion High Temperature CO_2 Removal (IGCC Conditions))
Centre for Energy and Environment Science and Technology (CEESAT), NIT, Tiruchirapalli	Experimental and simulation studies on CO_2 sequestration using solar/ chemical methods
Integrated Research and Action for Development (IRADe), New Delhi	Analysis of Carbon Capture and storage (CCS) technology in the context of Indian Power Sector

National Bureau of Soil Survey and Land Use Planning, Nagpur	Predicting Soil Carbon changes under different bioclimatic systems in India
Institute of Himalayan Bio-resources Technology, Palampur, Himachal Pradesh	Improving carbon and nitrogen sequestration: A Transgenic approach to lower greenhouse gas
Department of Botany, Andhra University, Vishakhapatnam	Carbon Di-oxide Sequestration through Culture of Medically useful Micro-algae in Photo-bio-reactor linked to Gas outlets of Industries
AMM MurugappaChettiar Research Center, Chennai	CO ₂ Sequestration using Micro algae – Efficient use of CO ₂ from bio-hydrogen production facility
Jawaharlal Nehru University and Dehi University, Delhi	Carbon Sequestration by higher plants and algae at elevated carbon di-oxide
Director, National Research Center for Agroforestry, Jhansi	Carbon Di-oxide Sequestration Potential of Agro Forestry System under Irrigated and Rain fed Conditions
Department of Soil Sciences & Agriculture Chemistry, Tamilnadu Agriculture University, Coimbatore	Mycorrhizal Symbiosis to Promote Carbon Sequestration for Sustainable Fertility and Environment Safety
University of Calcutta, Kolkata	Mechanism and the dynamics of carbon storage in the Sundarban Mangrove
Bharathidasan University, Tiruchirappalli	Marine cyanobacteria a promising candidate for carbon-dioxide sequestration with multiple utilization
Bharathidasan University, Tiruchirappalli	Carbon sequestration potential in wetlands of Vedaraniyam, south east coast of India
Jadavpur University, Kolkata	Carbon Sequestration through Afforestation for Mitigating CO ₂ emission from Thermal Power Station
Department of Biotechnology School of Life Sciences, North Maharashtra University	Chemo-photosynthetic conversion of carbon dioxide into algal biomass with biotech potentials
G.B.U.A.&T. Ag. Research Station, Nainital, Uttarakhand	Monitoring of Carbon sequestration through Micro propagating Bamboo Plantation in Himalayan region
Indian Institute of Chemical Technology, Hyderabad	Development of carbon composites Materials for CO ₂ capture
Global Hydro geological Solutions, New Delhi	Development of screening criteria for saline aquifers and other geological sinks
National Geophysics Research Institute, Hyderabad	Aqueous mineral carbonation of silicates and mineral trapping of CO ₂ in the tholeiite- picrite assemblage of Thakurvadi Formation, Deccan Basalt Volcanic Province, India: Geological, stable isotope and Experimental studies
Indian Institute of Technology, New Delhi	Carbon sequestration by mineral carbonation in cement kiln dust
Bharathidasan University, Tiruchirappalli	Evolution of RuBisCohypermorphs for enhanced CO ₂ sequestration and its utilization for polymer products
Anna University, Chennai	Mineral CO ₂ sequestration by carbonation of industrial; Alkaline solid residues
University of Calcutta, Kolkata	Study On Carbon Stock and Response Of Estuarine Phytoplankton To Iron Fertilization
University of Delhi, Delhi	CO ₂ sequestration studies on volcano-sedimentary succession of the eastern Deccan volcanic province
K S Rangasamy College of Arts and Science, Tiruchengode	Carbon dioxide sequestration using anoxic microbial consortium for the production of methane fuel and oxygenic microbial consortium for bioconversion of methane to methanol

5. POLICY FRAMEWORK FOR CCS

5.1 Oil and gas

Indian Petroleum Act, 1934: Rules for production and transportation of petroleum products, can be applied for transportation of compressed CO₂. The Oilfields (Regulation and Development) Act, 1948 (53 of 1948): Royalties in respect of mineral oils. The Petroleum Mineral Pipelines (Acquisition of Right of User in Land) Act, 1962: Provides for the acquisition of user in land for laying pipelines for the transport of petroleum and minerals and for matters connected therewith. This law may be applied for transportation of compressed CO₂ to storage sites. The Oil Industry (Development) Act, 1974, an act to provide for the establishment of a Board for the development of oil industry and for that purpose to levy a duty of excise on crude oil and natural gas and for matters connected therewith. Petroleum and Natural Gas Rules, 1959: An act to provide petroleum exploration license and mining leases. Government of India is looking after development of Coal Bed Methane production under Ministry of Petroleum and Natural Gas

5.2 Groundwater

Water (Prevention and Control of Pollution) Act 1974 enacted by Ministry of Environment and Forest, Government provide for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water in India. CCS has environmental impacts in terms of chances of groundwater contamination and this act could be suitably modified to include contamination of groundwater in case there is any leakage of stored CO₂.

5.3 Environmental impact assessment

Amending the Environmental Protection Act, 1986 would prove beneficial to facilitate demonstration projects and may be done on a project-specific basis before broader amendments can be established. CO₂ has to be transported across states and be stored in a region different to the point of collection, regional coordination groups will need to be established to address issues related to CO₂ transport and storage. Retrofitting of CO₂ capture capability to existing power plants may be done under the Environment Impact Assessment Notification S.O.60 (E) (under the provisions of the Environment (Protection) Act 1986). The applicant must submit an application to the Secretary of the Ministry of Environment and Forests, New Delhi to obtain environmental clearance.

5.4 Financing and investment

Given the higher initial investment as well as operating costs, CDM (Clean Development Mechanism) and carbon markets in their present state would prove very difficult to support and promote CCS. Policy for financing and investment should be such that the additional energy penalty due to retrofitting of the power plant for CCS is partly or wholly covered by earnings from CDM/carbon markets. Many multilateral financing institutions like the World Bank, International Monetary Fund, and the Asian Development Bank may take a lead in developing specific financial packages and instruments, those countries that are technologically advanced in CCS should come forward in supporting, including capacity development, initial CCS projects in India.

6. Limitations of CCS in India

India is a developing country hence the first major drawback lies in the strengthening of its economy. With the advent of research and development in India, limited work has been done on CCS.

Worldwide, CCS is still in the maturing phase. One major barrier to CCS deployment in India is the lack of accurate geological storage site data, since before capture technology can be installed in power plants or other sources, the location, capacity, permeability, and other characteristics of the sinks must be known. The issue of CCS drastically increasing the cost of electricity while reducing net power output is often cited as being one of the biggest barriers to acceptability of CCS in India.

Clarity is needed on how CCS implementation via retrofit of capture equipment to existing plants will change the Terms of Reference of the plant. In particular, the fresh environment clearances required. Access to funding from financing agencies such as the World Bank, Asian Development Bank, etc. might require further governance requirements in addition to the existing requirements e.g. around monitoring, measure and verification. These may be dependent on CCS-specific clearances being available from the Ministry of Power and/or other Government bodies, in addition to the existing clearances required. Readying of CCS on a large scale requires specialized workforce and suitable infrastructure, which may not be available in India at present. Monitoring the stored CO₂ to assure against leakage is essential if the central purpose of CCS implementation is to be fulfilled. Ensuring rigorous monitoring is needed over long time scales and techniques developed internationally in this area need to be introduced to Indian stakeholders. Legal issues related to land acquisition; ground water contamination, CO₂ leakage, etc. need to be addressed before any large scale transport and storage of CO₂ can be permitted.

7. CONCLUSION

Climate Change is a serious global environmental concern. It is primarily caused by the building up of Green House Gases (GHG) in the atmosphere. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture. Global Warming is a specific example of the broader term Climate Change and refers to the observed increase in the average temperature of the air near earth's surface and oceans in recent decades. Its effect particularly on developing countries is adverse as their capacity and resources to deal with the challenge is limited.

Carbon sequestration process and its vulnerability has a great potential for defending climate change, and to bring across this change it is equally important to supplement it with proper knowledge and economy.

Since Climate Change has been such a threatening issue over the last few years, it's high time to take adequate steps in encountering it. Emphasis lies in keeping the global temperature below the 2degree Celsius which was previously set through U.N. conventions, greenhouse gas emissions will have to drop by 40-70% by 2050.

In the first decade of the 21st century, emissions rose by 2.2% per year, for which countries with population and economic growth like China and other parts of the developing world are highly responsible. The U.N. is working toward a far-reaching new global climate pact, to be completed in late 2015 and to take effect in 2020. But the major challenge has been getting rich and poor nations to agree on a plan at a common platform.

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