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Carbon Capture and Storage Usage in India to Combat CO_2 Reduction: A Review

Chinmaya Kumar Sahu[1], Naveen Kumar Bind[2], Ravi Kiran[3]

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Abstract

An enormous threat to world health and security is posed by the extraordinary rate at which the Earth's atmosphere is changing. Anthropogenic carbon production and natural carbon absorption systems were in equilibrium prior to the industrial revolution. Nevertheless, with an increase in anthropogenic carbon emissions of between 15% and 40% during the industrial revolution, the situation altered. In 2030, coal will still provide for over 60% of India's energy needs, despite the increasing emergence of alternatives like solar and wind. The Earth's atmosphere is changing at an unprecedented rate, posing a huge danger to world health and security. There is broad scientific agreement that human actions, namely how we transform and utilise fossil fuel energy, are to blame for growing CO_2 concentrations in the atmosphere and climate change. Finally, in terms of carbon dioxide emissions, it appears that CCS is currently one of the best available technologies for drastically reducing greenhouse gas emissions from certain industrial processes, and it is a key technology option for decarbonizing the power sector, particularly in countries where fossil fuels are heavily used in electricity production.

Keywords: CO_2 concentrations; CCS; GHG emission; Sequestration; Climate change.

INTRODUCTION

During the next 20 years, it is anticipated that the world's energy demand will climb by 50%, and by 2050, there will be an additional 1 billion people on the planet. 26% of global warming is caused by the atmosphere's current CO_2 content. On the other hand, it is anticipated that the world's energy needs will quadruple by 2030, with the bulk of those needs being satisfied by fossil fuel sources due to their affordability and the availability of existing infrastructure. Just 13% of our overall energy supply comes from renewable sources, with fossil fuels (coal, gas, and oil) making up 80% of the world's energy mix. 52% of the current global CO_2 emissions (15 billion tonnes CO_2 emissions/year) are produced by fossil fuel power plants, heavy industries, and refineries, which leads to climate change. By 2050, emissions must be reduced by 50 to 80 percent from 1990 levels in order to meet the target set forth in the Paris Agreement. As of 2021, there were 27 large-scale carbon capture and storage plants in operation throughout the world. There are 17 CCS operations that are now in operation

Author's Affiliation: [1,2]Research Scholar, [3]Professor, Department of Agrometeorology, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttarakhand, India.

Corresponding Author: Ravi Kiran, Professor, Department of Agrometeorology, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttarakhand, India.

E-mail: ravikiransaxena@rediffmail.com

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throughout the globe, collecting 31.5Mt of CO_2 annually, of which 3.7 Mt is stored geologically. In order to reduce the cost of collecting and determine the potential for carbon dioxide storage in geological reservoirs, additional research and development in the capturing technology is required. Global CO_2 emissions from energy increased by 0.9% or 321 million tonnes, in 2022, hitting a record high of more than 36.8 billion tonnes. The increase in emissions was far slower than the world economic growth rate of 3.2%. According to IEA estimates, India's total emissions from energy usage in 2018 were 2,251 Mt CO_2 (metric tons of carbon-dioxide). Power generation and industry contributed 53% and 25% of total emissions, respectively. This was followed by transportation and residential sources, which contributed 14% and 4% of total emissions, respectively. To solve the issues that CCS faces in India, an ecosystem supporting CCS facilities in the Indian market must be developed and evolved. The success of CCS is hampered not just by the advancement of technology in the coming years, but also by the lack of a policy environment. The ecosystem should be established and strengthened around the critical pillars of research and development, policy, funding, and governance.

Carbon Capture and Storage (CCS)

CCS is a process of sequestration where carbon dioxide emitted from large power plants or heavy industries is captured and stored before reaching the atmosphere. The goal is to avoid substantial amounts of CO_2 from being released into the atmosphere as a result of the usage of fossil fuels in power generation and other sectors. It is seen as a critical climate protection technology for coal-rich nations such as India, with the ability to significantly reduce CO_2 emissions when compared to any other existing technology.

India's concerns

- India is the world's third largest coal producer, with the fifth largest coal reserves and around 0.5% of the world's oil and gas reserves.
- As of 2018, 66% of India's energy generating capacity comes from thermal power plants, with coal accounting for around 85% of the country's thermal power generation. India is the world's fourth greatest emitter of CO_2.

Components of CCS

Carbon Capture and Storage has 3 components:

Capture: The process of separating CO_2 from other gases produced at major industrial process facilities including steel mills, cement plants, oil and gas plants, coal and natural gas power plants, and coal and natural gas power plants.

Transport: Once separated, the CO_2 is compressed and transported via pipelines, trucks, ships or other methods to a site suitable for geological storage.

Storage/Sequestration: CO_2 is injected into deep underground rock formations, up to at depths of one km or more.

Process Flow of CCS

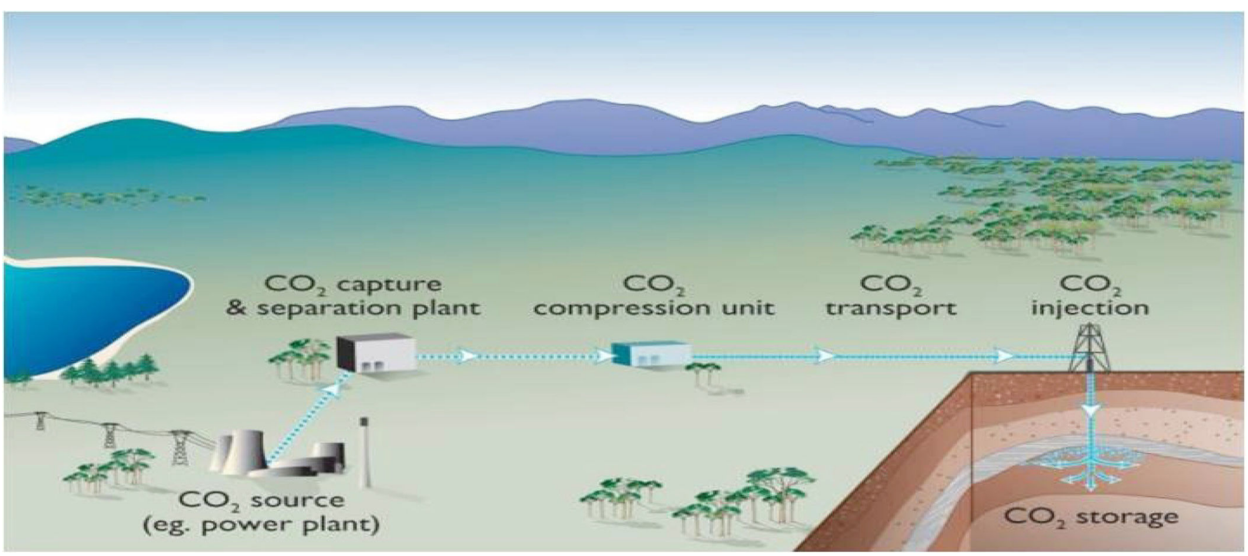

Fig. 1: Different processes/steps of Carbon Capture and Storage

Carbon Capture Technologies:

There are 3 technologies to capture CO_2 such as:

- **Pre-combustion:**

  Where CO_2 is captured before fuel is burned
- **Oxy-fuel:**

  Where CO_2 is captured during fuel combustion
- **Post-combustion:**

  Where CO_2 is captured after fuel has been burned

Why should we go for CCS?

- CCS is a key technology for tackling climate change
- Delivering economic growth and regional prosperity
- The International Energy Agency claimed that CCS might help to reduce world CO_2 emissions by 19% by 2050, making it one of the tools against global warming.
- CCS can be used in Fossil fuel based electricity producing plants, such as coal or gas-fired power plants, which are a key source of energy for our country.
- In the transition to a low-carbon economy, CCS will be crucial for low-carbon power.

Process after capturing CO_2

1. Underground geological storage

- Storage is possible in many different geological settings.
- As they physically trap the carbon dioxide, salt beds, low-permeability shale, and cap rocks are the best places to store CO_2.
- Also used for enhanced oil recovery (EOR).

Stored in: Saline formations, Oil and natural gas reservoirs, Unmineable coal seams and Basalt formations.

2. Ocean storage

- CO_2 stored in the ocean by:
- Direct injection
- Dissolution of carbonate materials
- Production of a CO_2 lake

CCS in India:

- Because India's electricity sector accounts for half of all CO_2 emissions in the country, substantial attention must be paid to this sector in order to minimise (GHG) emissions in the environment.
- Carbon Capture and Storage (CCS) is now used as a bridge technology and a realistic alternative for coal-fired power stations to capture CO_2. However, CCS implementation in coal-fired power plants in India remains low.
- India pledged to reducing its carbon intensity by 30%-33% by 2030 at the UNFCCC Paris Summit.
- The next 10-15 years will be critical for India to achieve technological improvement in order to deploy large-scale CCS plants.
- There are just three commercial CCS plants in India: the Phulpur Urea Plant, the Jagdishpur Urea Plant, and the Aonla Urea Plant.

Challenges of CCS in India:

- In India, public comprehension of CCS technology is quite low, which may lead to significant civilian opposition; consequently, public education on the concerns is required.
- Because of public concerns regarding subterranean CO_2 storage, the government has expressed little interest in domestic demonstrations of the technique.
- Lack of R&D effort
- Need for comprehensive national study on Geological storage
- Lack of financing and inflow of foreign direct investment (FDI)
- Environmental and legal concerns
- Cost scenario
- Political and policy making
- Public opinion
- Foreign policies

Roadmap to Successful CCS in India:

- Policy & Regulatory Framework
- Identification of Suitable CO_2 Storage
- Improvement and Cost Reduction of Capture Technologies
- Development of CO_2 Transport Infrastructure.

Advantages of CCS:

- When CCS is used in current conventional power plants, CO_2 emissions to the atmosphere can be reduced by 80–90% in comparison to facilities without CCS.

- One of the most effective ways to permanently remove carbon emissions from the environment is carbon capture and storage.
- It produces jobs for qualified engineers, technicians, and labourers.
- It may be possible to generate sustainable geothermal energy by recovering geothermal heat from the location where it was injected using geologically stored carbon dioxide.
- Carbon dioxide from CCS may be used to produce polymers and other compounds, like polyurethanes.
- CCS could reduce the social cost of carbon
- The captured carbon dioxide is incorporated into concrete to reinforce it and increase the infrastructure's endurance.

CONCLUSION

Carbon Capture and Storage will enable us drastically lower our CO2 impact in the future. CCS's importance extends much beyond that of a clean coal technology. The availability of this technology in the future is dependent on current R&D and implementation investments. For more new projects to become operational in recent years, an extended project pipeline is required. Carbon dioxide Capture and Storage is a viable and feasible strategy for mitigating climate change. The post combustion approach is superior than the other two strategies for carbon capture. It is reasonable and doable to use the carbon dioxide capture and storage approach to lessen the effects of climate change. The expense of the CCS is a problem that the government must seriously address. This will give this technology fresh life when Indian policies and attitudes change.

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