Carbon Emissions and Net Zero Under Carbon Capture, Usage and Storage (CCUS) Technology

A Mahesh babu [a,1,*], Barapati Akhil [a,2], Naveen Kumar Pochampally [a,3]

[a] Department of CE, Aurora's Technological and Research Institute, Hyderabad, 500098, INDIA
[1] dramaheshbabu@gmail.com, [2] akhilbarapati272@gmail.com, [3] *nk673831@gmail.com*
* corresponding author

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ABSTRACT

The key change in the environment is the gases which emit into the atmosphere and majorly carbon emissions by urbanization with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies. According to various estimates, carbon stock consumes 30 to 40% of all energy resources. As the result, it is possible to get carbon dioxide atmosphere emissions reduction due to energy consumption reduction. In this research, we had a sample of current generation low-energy consumption and carbon storage by different techniques and usage by renewable sources, progress towards CCUS Technology.

The way the zero-energy co_2 goal is defined affects the choices designers to make achieve for this goal and whether they can claim success. CCUS will also support the transition from Blue Hydrogen to Green Hydrogen by accelerating the demand growth and creating technologies and infrastructure for the production, storage and transportation of hydrogen. Conversion of co_2 to usable chemicals and products will spur economic development and help achieve some of the SDGs like green aggregates, green ammonia and methanol and ultimately green energy. This study shows the design impacts of the definition used for CCUS and progressed goals towards CCUS goals.

1. Introduction

The International Energy Agency (IEA) defines Carbon Capture, Utilization and Storage (CCUS) as a group of technologies for capturing of CO2 from large and stationary CO2 emitting sources, such as fossil fuel-based power plants and other industries. CCUS also involves the transport of the captured CO2 (typically by pipeline and in certain situations through shipping, rail or trucks also) to sites, either for utilization in different applications or injection into geological formations or depleted oil & gas fields for permanent storage and trapping of the CO2.

CCUS also includes Direct Air Capture (DAC), which involves the capture of CO2 directly from the atmosphere, although the same is not the focus of this study, as DAC is still in its early stages and the economics.

Carbon capture has a critical role to play in the decarbonization of hard-to-abate sectors and the path towards the net zero transition. However, to deploy carbon capture at scale, it is important to look beyond just carbon capture technologies, and holistically look at the CCUS value chain.

1.1 Decarbonization Challenge and the Role of CCUS

The decarbonization challenge for India is to identify scalable and economically sustainable solutions for the decarbonization of sectors that contribute to 70% of emissions. CCUS has a critical role to play, especially for India to accomplish net zero by 2070 CCUS has applications for the power sector, given India's present reliance on coal for meeting over 70% of its electricity needs; even in the future, if India can substantially green the grid power and meet the target of 500 GW installed capacity of renewables by

2030, there would still be a need to meet the baseload power demand from fossil fuels (most likely coal) or other dispatchable sources, given the intermittency and non-dispatchable nature of solar and wind power.

India has committed to reducing emissions by 50% by the year 2050 and reaching net zero by 2070. Given the sectoral composition and sources of CO2 emissions in India, CCUS will have an important and integral role to play in ensuring India meets its stated climate goals, through the deep decarbonization of energy and CO2 emission-intensive industries such as thermal power generation, steel, cement, oil & gas refining, and petrochemicals.

1.2 Objectives of the Study:

a. A CCUS cluster framework: cluster design and infrastructure to process, store, sell and transport CO2 through centralized processing at each cluster.

b. Creation of a CCUS business model, institutional framework & opportunity: to provide a market and an effective price/premium for low-carbon products.

c. An industrial CCUS financing framework: development of a CCUS technology and infrastructure enabling funding mechanism.

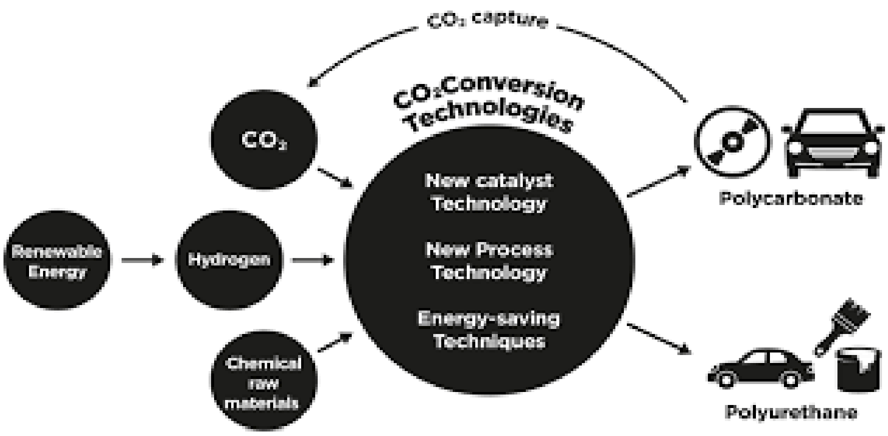

Figure 1. CO_2 Conversion Technology

To form a CCUS cluster, it is important to perform a region-wise emission analysis of power plants. The analysis aims to identify the hotspots/clusters of emissions that can be targeted for CCUS. This would also help define the policy/ credit system suitable for that region. The region-wise analysis can be carried out based on

a) Districts

b) States

The district-wise analysis yields information about the highest emitting districts, which can be the focus of initial CCUS projects in the Indian power sector. A centralized CO2 processing unit can be planned for these districts, which will make the capture and transportation of CO2 more techno-economically feasible. Only power plants with minimum CO2 emissions of 2 mtpa have been considered in the analysis. For district-wise analysis, districts that emit more than 20 mtpa CO2 have been considered.

1.3 Adsorption

The working principle of adsorption-based CO2 capture can be described in three primary steps:

a. CO2 adsorption on the surface of the adsorbent material
b. Diffusion of other gaseous molecules through the adsorbent material and exit from the system
c. CO2 desorption by either decreasing pressure or increasing temperature. While the former is known as Pressure Swing Adsorption (PSA), the latter is called Temperature Swing Adsorption (TSA)

1.3.1 Working of CO_2 ECBMR

In ECBMR, CO2 is injected into unminerable coal seams under supercritical conditions. The CO2 injected is accumulated in the coal cleats in a dense gas phase.

This CO2 is adsorbed and absorbed in the coal. Since CO2 has a higher affinity for coal than CBM, it pushes the coal bed methane towards production wells, thus enhancing its primary recovery.

Similar to CO2 EOR, ECBMR can help in permanently storing CO2 and the recovered methane can also help offset the cost of carbon capture.

This can be a viable option for thermal power plants as many large coal-based power plants are located near coalfields.

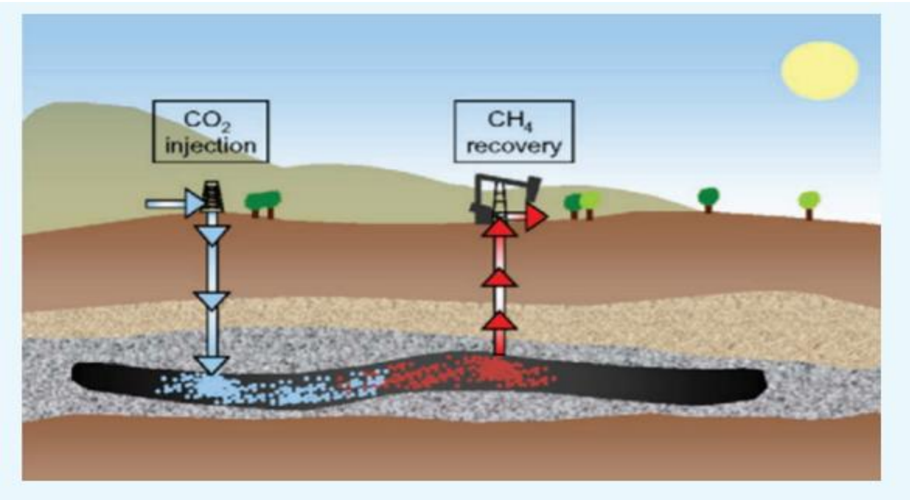

Figure 2. CO_2 ECBMR

Co2 eor storage capacity assessment the data of in-place hydrocarbon resources and Ultimate Recoverable Reserves (URR) provided by DGH in the recent exploration assessment has been used with a suitable Recovery Factor for EOR (RFEOR = 10%) to calculate the total pore volume. A conversion factor of 1.165 is used to convert the values of MMTOE to Mm3. This pore volume is used along with the formation volume factor (B0) and CO2 density at reservoir conditions to calculate the quantity of CO2 that can be stored in a particular basin. The calculation formulae in equation and are used.

$$V = URR + (OOIP \times RFEOR) \quad (1)$$

$$M = V\ B0\ \_CO2 \quad (2)$$

Storage Pathways	Theoretical storage capacity (Gt)
EOR	3.4
ECBMR	3.5-3.7
Deep Saline Aquifers	291
Basalts	97-315
Total	**395-614**

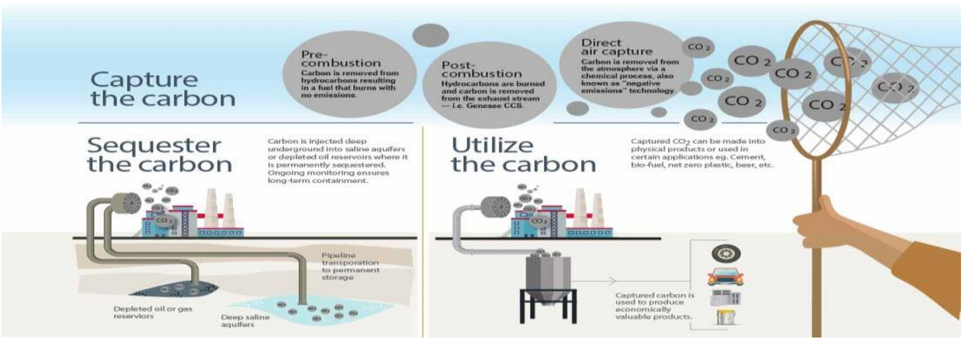

Figure 3. Carbon

1.4 Socio-Economic Impact of CCUS

The socio-economic impact of the CCUS project is manifold. CCUS will help in the production of low-C products through the decarbonization of hard-to-abate industries and power plants. Thus, it will create export opportunities for green products with a significant premium and also enable new coal-based industries such as gasification-based production of chemicals and power.

a. At the same time, other manufacturing and service sectors will be benefitted from large investments across the carbon value chain (capture, processing, transportation, utilization, storage, and EOR).

b. This will have a beneficial effect on existing as well as new industries. With targeted capture of 750 mtpa by 2050, India could become a global leader in CCUS technology, thus creating significant export opportunities. Additionally, coal-based chemical production at a competitive cost can reduce the import of chemicals like methanol, ammonia, MEG, etc. This will reduce the foreign exchange outgo and ensure future energy security.

1.5 Key Risks Associated with CCUS

CCUS projects integrate various sub-systems such as carbon capture, transportation, and sequestration. The interfaces between the sub-systems projects involve complex interfaces and lead to risks associated with CCUS projects.

1.5.1 Technical Risks

1.5.1.1 Reservoir Suitability for CO2 Flooding for EOR

The extent of CO2 abatement possible through EOR depends on the comparative performance and cost-effectiveness of CO2 EOR vis-à-vis other methods of tertiary recovery like nitrogen injection, polymer injection, steam injection, natural gas injection, and the use of foaming agents. Some of the current developments, such as the use of foams or other chemicals to improve sweep efficiency may reduce the attractiveness of CO2 EOR, while on the other hand It is also important to calibrate financial commitments to capacity expansions based on assured future offtakes for CO2 to mitigate this risk.

1.5.1.2 Change in Processes Emitting Industries:

This risk emanates from the possibility of using electricity or new clean energy carriers to replace the use of fossil fuels in industrial processes like iron & steel or cement, thereby substantially impacting the CO2 emissions available for capture. Even the power sector is not immune to such changes: for example, base-load plants may transition to only peaking operations, limiting the quantity of CO2 emissions. Therefore it is important to develop an understanding of the industrial processes and the likely trajectory of technological innovation in the industry, as well as the risk of the end-products of the industry getting replaced by alternate products.

1.5.1.3 CO2 Specification Challenges

Most carbon capture solutions try to address and meet the required CO2 specifications. The key requirement is adequate dehydration and other impurity tolerances depending on the CO2 source and capture process. However, problems may arise when integrating multiple CO2 sources and capture processes, and additional treatment of the captured raw CO2 may be required, depending on the disposition pathway for the CO2. These requirements would depend on the diversity of CO2 sources in a particular cluster, which increases the likelihood of CO2 mixing issues. The other issues to be handled are the concentration of non-condensable and inert impurities such as nitrogen and argon, that affect pipeline and reservoir capacity.

2. Conclusion

Carbon Capture Utilization and Storage (CCUS) has an important and critical role to play for India to halve CO2 emissions by 2050 and accomplish net zero by 2070. Energy transitions take decades and hence it is important to implement the framework and policy instruments for CCUS to become a reality in India and make a meaningful contribution to decarbonization.

Technology transfer of commercially proven CCUS technologies. Promoting R&D in novel technologies,

Particularly in the area of CO2 utilization, CCUS can contribute to decarbonization and transition to clean energy systems. Decarbonizing hard to abate, promotes low carbon hydrogen and removes of CO_2 stock from the atmosphere.

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