A movement towards zero-carbon scenario in India via CCUS track

Arnab Dutta
Chemistry, IDP Climate Studies
National Center of Excellence in CCUS
UrjanovaC Pvt. Ltd.
IIT Bombay
6th June, 2024
The Energy and CO₂ nexus: The current scenario

Appropriate CO₂ management

1. CO₂ capture
2. CO₂ utilization
3. CO₂ storage

CCUS Technology

Annual CO₂ emissions, 2022
Carbon dioxide (CO₂) emissions from fossil fuels and industry. Land-use change is not included.

Data source: Global Carbon Budget (2023)

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.
India Leading in CCUS

Need to reduce greenhouse gas emission at an urgent basis

India has pledged to lower the CO$_2$ emission by 45% by 2030 & Carbon neutral by 2070

>80% CO$_2$ emission from point source in India

Maintaining the growth rate

In the pursuit of a decarbonized development

Governmental Policy

CCUS Trinity

Academic Innovation

Industrial Implementation

A thriving CCUS Eco-system

Aligned outlook

Appropriate Planning
Role of Policy makers: CCUS Roadmaps in India

- NITI Aayog spearheaded the development of the ‘CCUS policy frameworks and its deployment mechanism in India’.

- Ministry of Petroleum and Natural Gas Roadmap presents short-term, medium-term and long-term actionable directions for the oil and gas sector.

- G-20 Technical and Financial reports highlight that storage assessments, acceptance in global carbon markets, and G20 level supportive policies would encourage investments in CCUS.

- Ministry of Power & Ministry of Environment, Forests & Climate Change to develop Carbon Credit Trading Scheme for decarbonization.

- Ministry of Steel established task forces to delve into various CCUS technology pathways.
CCUS in India: The Initial Step

CO$_2$ Emission

Carbon Mapping

Carbon Market

Academic Research

Start-up Culture

Governmental Support

Industrial Involvement

Fossil Fuel Extraction

Energy Conversion

CO$_2$ Emission

ITBOMBAY Campus Map
Moving Forward: Capturing CO₂

CO₂ capture in various plants
Primarily adsorbent technology
Final Product still CO₂

Power Plant
Steel Plant
Chemical Plant
Petrochemical Plant
Start-ups
The Carbon Cycle: Closing the Cycle

Converting captured CO₂
High-value chemicals
The Carbon Cycle: Closing the Cycle

- Converting captured CO$_2$
- High-value chemicals

- CO$_2$ to Methanol (Power)
- CO$_2$ to Soda Ash (Chemical)
- CO$_2$ to Biproduct (Petrochem)
- CO$_2$ to Carbonates (Start-Up)
- CO$_2$ for EOR (Petrochem)
The Carbon Cycle: Closing the Cycle

- Converting captured CO₂
- High-value chemicals

CO₂ to Methanol (Power)
CO₂ to Soda Ash (Chemical)
CO₂ to Biproduct (Petrochem)
CO₂ to Carbonates (Steel, Start-up)
CO₂ for EOR (Petrochem)
The Carbon Cycle: Closing the Cycle

- Converting captured CO₂
- High-value chemicals

- CO₂ to Methanol (Power)
- CO₂ to Soda Ash (Chemical)
- CO₂ to Biproduct (Petrochem)
- CO₂ to Carbonates (Steel, Start-up)
- CO₂ for EOR (Petrochem)
- CO₂ to Urea (Cement)
- CO₂ for Beverage (Petrochem)

Feasibility Study
The Carbon Cycle: Permanent Removal of CO$_2$

**CO$_2$ Sequestration**

- Estimating the CO$_2$ storage capacity
- CO$_2$ storage feasibility
- CO$_2$ storage prospect

Vishal and co-workers, IITB
Source-sink matching and CCS hub-clusters in India

1. 32%, 43%, and 25% large point sources fall within 100, 200, and 300 km, respectively from the Euclidean center

2. Highest emission in cluster 3 (Eastern India coal belt), lowest emission in cluster 4 (Assam basin)

3. Maximum number of large point sources in cluster 5 (Cambay) and minimum in Cluster 1 (Rajasthan)

Strengthening Academia-Industry Partnership

One-stop solution for CCUS

Carbon Capture
- Nanofluid amine based solutions
- Modified membrane based CO₂ separation
- Aqueous solution-based CO₂ capture

CO₂ utilization
- CO₂ valorization
- Methanol production
- High value organics
- CO/CH₄ generation

CO₂ sequestration
- CO₂ transportation
- Life-cycle analysis
- Bioenergy based CCS (BECCS)
- Environmental Impact Assessment

Cross-cutting systems
- Country-wide capacity assessment
- Source-sink matching
- Enhanced oil recovery
- Enhanced CBM recovery

Start-up
- Scalable and cost-effective CO₂ management

International Recognition
India to account for ~20% of global industrial CCS by 2060. - IEA

- With CCS, share of fossil energy to be 19-30%, coal up to 5%.
- Accelerated R&D, collaborative efforts, international and industrial engagements, and capacity building are required.
- Dedicated authority and policies, fund support, MRV framework, incentives and mandates need to be developed to accelerate CCUS in India.
- CCS be linked with ‘just transitions’ and provide increased social license and regional equity.
- Focus on CCS policies, capacity building, R&D and pilot projects.

Road Ahead for CCUS in India
A movement towards zero-carbon scenario in India via CCUS track

Arnab Dutta
Chemistry, IDP Climate Studies
National Center of Excellence in CCUS
UrjanovaC Pvt. Ltd.
IIT Bombay

Thank You