Capturing Carbon, Creating Change

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Capturing Carbon, Creating Change: India's Sustainable Future

Context

- India has committed to achieving **net-zero emissions by 2070**, aligning with its pledge under the **Paris Climate Agreement**.
- To achieve this, India is adopting multiple technological and policy measures, including a focus on **Carbon Capture, Utilization, and Storage (CCUS)**.
- CCUS is particularly important for decarbonizing **hard-to-abate sectors** such as thermal power, steel, cement, and oil refining.
- The technology gained global attention during the **COP28 Climate Summit in Dubai (2023)**, where it was seen as essential for deep decarbonization strategies.

What is CCUS (Carbon Capture, Utilization, and Storage)?

- CCUS refers to a suite of technologies aimed at **capturing carbon dioxide (CO_2)** emissions from major sources before they enter the atmosphere.
- Once captured, CO_2 is either:
    - **Stored** in geological formations such as **saline aquifers or depleted oil and gas fields**, or
    - **Utilized** in the production of chemicals, fuels, or building materials.
- It is seen as a **transitional solution** to support countries like India in meeting climate goals while continuing to use fossil-based infrastructure.

Three Key Stages of CCUS

1. Capture Stage

- The process involves separating CO_2 from industrial gas streams.
- Technologies used:
  - **Chemical solvent-based methods** – suitable for gas streams with low CO_2 concentrations.
  - **Physical solvent-based methods** – used when CO_2 concentrations are high.
  - **Adsorption techniques** – applied to medium concentration streams like **Steam Methane Reforming (SMR)**.

2. Utilization Stage

- Captured CO_2 is converted into **value-added products**, such as:
  - **Green urea**
  - **Dry ice**
  - **Carbonated beverages**
  - **Building materials**
  - **Industrial chemicals**

3. Storage Stage

- Long-term storage is done in secure geological locations:
  - **Saline aquifers**
  - **Depleted oil and gas fields**

- **Deep unmineable coal seams**

- These formations act as permanent CO_2 sinks to prevent atmospheric release.

Potential Benefits of CCUS for India

- **Direct emission reduction** – CCUS captures CO_2 before it enters the atmosphere.
- **Decarbonization of industrial sectors** – Useful for high-emission sectors such as:
  - **Coal-based power**
  - **Steel**
  - **Cement**
  - **Oil refineries**
- **Support for clean fuel production** – Captured CO_2 can be used to synthesize:
  - **Green hydrogen**
  - **Ammonia**
  - **Synthetic methane**
- **Climate change mitigation** – Reduces overall greenhouse gas load in the atmosphere.
- **Job creation** – Opportunities in engineering, construction, transport, and storage sectors.
- **Complement to renewable energy** – Provides a base-load alternative where solar and wind are not viable.

Challenges in Implementing CCUS in India

- **High capital cost** – Infrastructure and technology deployment require **large upfront investments**.
- **Technology readiness** – Innovations like **Direct Air Capture (DAC)** are still in early stages.
- **Lack of investment** – The sector is yet to gain momentum from private and institutional investors.
- **Infrastructure constraints** –
    - Need for **specialized pipelines** to transport CO_2.
    - Existing oil/gas pipelines are **unsuitable** due to corrosion risks.
- **Storage challenges** –
    - Limited availability of **safe and suitable geological sites**.
    - Many storage sites are **geographically distant** from emission sources.
- **Policy and regulatory gaps** – No unified national regulation exists to oversee CO_2 capture, transport, utilization, and storage.

What Lies Ahead: India's Approach

- India is preparing to launch a **National CCUS Mission**, focused on:
    - Power
    - Steel
    - Cement industries

- Policy support required includes:
    - **Viability Gap Funding (VGF)**
    - **Production Linked Incentives (PLI)**
    - **Tax credits** for industries and innovators
- Need for a robust **regulatory framework** governing:
    - Site selection
    - Safety standards
    - Monitoring and liability
- Importance of **R&D investment** to:
    - Improve CO_2 capture efficiency
    - Lower costs
    - Develop new utilization technologies
- **Public-private partnerships** will be key to financing and scaling up projects.