Carbon Capture Usage Storage (CCUS)

Mains Syllabus: GS III - Environmental Pollution and Degradation

Why in the News?

India has introduced several initiatives to achieve net-zero emissions by 2070 - one of which is the emphasis on harnessing Carbon Capture Usage Storage (CCUS) technology.

What is Carbon Capture Usage Storage (CCUS)?

- **CCUS** – It refers to an array of technologies designed to capture carbon dioxide (CO_2) emissions from large point sources such as thermal plants, oil refineries, and the steel and cement industries.
- The captured CO_2 is either transferred into the earth or reused for industrial applications in various forms.

CCUS (Carbon Capture, Utilization, and Storage) was a prominent topic at COP28, the UN Climate Change Conference held in Dubai in 2023.

- **Stages of CCUS** - CCUS technology comprises three stages of capture, utilisation and storage.
- **First stage (Capture)** - There are different types of carbon capture technologies, and their use is determined by the nature of the gas stream and the intended application.
    - Chemical-solvent based - It is used when the gas streams contain lower concentrations of CO_2.
    - Physical solvent methods – It is preferred for gas streams with relatively higher concentrations of CO_2.
    - Adsorption techniques – This is used to capture carbon when gas streams contain moderate CO_2 concentrations such as Steam Methane Reforming (SMR) flue gas.
- **Second Stage (Utilization)** – In this stage, the captured carbon is converted into value-added products such as green urea, dry ice, carbonated drinks, building materials and chemicals.
- **Third stage (Storage)** – It entails storing the CO_2 in saline aquifers, depleted oil and gas fields, and other similar geological formations.

What are the potentials of CCUS?

- **Direct Emissions Reduction** - CCUS captures CO_2 at the source—before it enters the atmosphere.
- **Decarbonisation of Industrial Sector** - CCUS has tremendous potential for reducing

emissions in hard-to-abate sectors such as coal, steel, cement, oil refineries, which form the backbone of Indian industry.
- **Access to Renewable Fuels** - The captured CO_2 can be converted into green fuels such as hydrogen, green ammonia, methane, etc.
- **Transition to Cleaner Energy** - CCUS also plays an important role in facilitating the transition to cleaner energy sources and complementing options like solar and wind power.
- **Climate Change Mitigation** - By reducing the amount of greenhouse gases released, CCUS helps slow the pace of global warming.
- **Job Creation** - The deployment and operation of CCUS facilities can generate significant employment opportunities in construction, operation, and the broader supply chain.

What are the challenges in CCUS?

- **High Costs** - CCUS requires substantial upfront investment for capture equipment, transportation infrastructure (like pipelines), and secure storage facilities.
- **Technical Challenge** - Direct Air Capture (DAC), a method that captures carbon directly from the air regardless of the source or concentration – is in its nascent phase.
- **Not enough Investment** - Since CCUS technology remains a niche area, it has yet to attract significant businesses and investors.
- **Infrastructure Challenges** - Transporting CO_2 safely requires specialized pipelines, which are expensive to build and maintain.
- Existing oil and gas pipelines are generally unsuitable, and impurities in CO_2 can cause pipeline damage.
- **Storage Challenge** - Identifying suitable geological storage sites is complex, time-consuming, and costly.
- Not all regions have adequate storage capacity, and some sites may be remote from emission sources, increasing transport costs.

What lies ahead?

- India is preparing to launch a national CCUS mission to decarbonize hard-to-abate sectors like power, steel, and cement.
- Viability gap funding (VGF), production-linked incentives (PLI), tax credits are needed to encourage investment in the sector.
- Clear regulations for CO_2 capture, transport, utilization, and long-term storage are needed.
- R&D Support to advance CCUS technologies, improve capture efficiency, reduce costs, and develop innovative CO_2 utilization pathways is needed.

Reference

Indian Express | Carbon Capture Usage Storage Technology

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