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India's CCUS Policy — Budget Rs 20,000 Crore for Carbon Capture in Hard-to-Abate Sectors

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SUBJECTS COVERED

ENVIRONMENT ECONOMY SCIENCE & TECH

CURATED & WRITTEN BY

Bharat Choudhary

UPSC Educator & Content Creator •

linkedin.com/in/epicbharat

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WHY IN NEWS

Union Budget 2026-27 allocated **Rs 20,000 crore over five years** for a Carbon Capture, Utilization and Storage (CCUS) scheme targeting India's five hardest-to-decarbonise industrial sectors — power, steel, cement, refineries, and chemicals — as part of India's roadmap to Net Zero by 2070.

WHAT IS CCUS?

Carbon Capture, Utilization and Storage (CCUS) is a set of technologies that capture carbon dioxide (CO_2) emissions at the point of production, before they enter the atmosphere, and either permanently store them underground or convert them into useful products.

The three-stage process:

Stage 1 — Capture:

- **Post-combustion capture:** CO_2 removed from flue gases after fossil fuel combustion using chemical solvents (monoethanolamine/MEA) or membranes
- **Pre-combustion capture:** Fuel converted to hydrogen + CO_2 before burning; CO_2 captured, hydrogen used as clean fuel
- **Oxyfuel combustion:** Fuel burned in pure oxygen rather than air, producing highly concentrated CO_2 stream for easy capture
- **Direct Air Capture (DAC):** CO_2 extracted directly from ambient air (most expensive; currently used in small-scale facilities in Iceland and USA)

Stage 2 — Transport: CO_2 compressed to liquid/supercritical state and moved via dedicated pipelines (existing oil pipelines can be repurposed), ships, or trucks to storage/utilization sites.

Stage 3A — Utilization (the "U" in CCUS):

- CO_2 used as feedstock in industrial processes: urea fertilizer, methanol, synthetic fuels, concrete curing, beverage carbonation, enhanced oil recovery (EOR)
- **CCU (without storage):** CO_2 recycled but eventually re-emitted — reduces but does not permanently eliminate the carbon

Stage 3B — Storage (the "S" in CCUS): CO_2 injected into geological formations at depths > 800 metres, where pressure and temperature conditions ensure it remains in supercritical state and does not escape. Key storage types:

- **Saline aquifers** (largest global capacity — porous sedimentary rock filled with brine)
- **Depleted oil/gas fields** (India has these in the Cambay Basin, Gujarat and KG Basin, AP/Telangana)
- **Basalt formations** (Iceland and India's Deccan Traps — CO_2 mineralizes into carbonate rock within years; safer than aquifers)
- **Coal seams** (CO_2 adsorbs onto coal; can trigger methane release — coalbed methane)

WHY HARD-TO-ABATE SECTORS NEED CCUS

"Hard-to-abate" sectors are industries where electrification or renewable energy substitution cannot fully eliminate CO_2 emissions because CO_2 is produced as an inherent part of the chemical process — not just from energy use.

Sector	Why CO_2 Emissions Are "Process-Linked"
Steel	Blast furnace converts iron ore (Fe_2O_3) using coke (carbon) → CO_2 is a chemical product of reduction, not just energy
Cement	Calcination of limestone ($CaCO_3 \rightarrow CaO + CO_2$) — CO_2 release is chemically unavoidable
Refineries	Hydrotreating, catalytic cracking, hydrogen production all generate CO_2
Chemicals	Ammonia synthesis (Haber-Bosch) uses natural gas as both energy and feedstock → CO_2 by-product
Power (coal)	While coal can be replaced by renewables, transition will take decades; CCUS bridges the gap

India's steel sector specifically:

- India produced **152 million tonnes** of crude steel in FY 2024-25 — **world's 2nd-largest producer** (after China)
- Steel accounts for **10–12%** of India's total greenhouse gas (GHG) emissions
- **National Steel Policy 2017** targets: 300 MT capacity by FY 2030-31; 500 MT by 2047
- **Green Steel Taxonomy (Ministry of Steel):** Steel rated on stars (1–5) with 3–5 stars for below **2.2 tCO_2e per tonne** of crude steel — CCUS is one pathway to achieve this rating
- India's steel plants predominantly use **blast furnace–basic oxygen furnace (BF-BOF)** route (80%+ output) which is more carbon-intensive than electric arc furnace (EAF) route. Transitioning to EAF requires scrap availability; India has limited scrap today.

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INDIA-SPECIFIC CCUS CHALLENGES

1. Capital intensity and the electricity penalty: CCUS equipment raises power plant capital costs significantly and requires **15–25% extra energy** to run the capture process — meaning power output drops or fuel consumption rises. This raises electricity cost by **60–80%** for retrofitted plants, creating competitiveness concerns for Indian industry.

2. No dedicated CO_2 pipeline network: India lacks the pipeline infrastructure for CO_2 transport. Building it requires new regulatory frameworks (CO_2 is corrosive and requires different materials than natural gas pipelines). The Rs 20,000 crore Budget allocation would need a significant portion for pipeline/transport infrastructure development.

3. Geological assessment gaps: India lacks a comprehensive geological CO_2 storage atlas comparable to what Europe (EU GeoCapacity), USA (DOE storage atlas), or Australia has built. The Deccan Trap basalt formations are promising — CO_2 mineralizes rapidly in basalt — but detailed capacity estimation is incomplete.

4. Regulatory vacuum: No Indian law currently addresses liability for CO_2 leakage from storage sites. Questions remain: Who monitors injection sites for 1,000 years? Who bears liability if CO_2 leaks contaminate groundwater or re-enters atmosphere? These require new legislation.

5. Water consumption: Conventional solvent-based capture is water-intensive — competing with agriculture and industrial water demand in water-stressed regions.

POLICY AND INSTITUTIONAL ECOSYSTEM

Budget 2026-27 provisions:

- **Rs 20,000 crore** allocated as Viability Gap Funding (VGF) over 5 years — covering part of the capital cost premium to make CCUS commercially viable
- **Two National Centres of Excellence in Carbon Capture** to be established (locations to be announced)
- **IIT Bombay** and **JNCASR, Bengaluru** are lead research institutions

Mission Innovation CCUS Challenge (2018): India co-leads this international initiative under the Mission Innovation multilateral clean energy platform, targeting cost reduction of CCUS by 10x.

International comparisons:

- **Norway's Sleipner project** (North Sea, 1996): World's first commercial-scale CO_2 injection into a saline aquifer; stores ~1 MT CO_2/year
- **USA's 45Q Tax Credit:** USD 85 per tonne CO_2 captured for permanent geological storage; USD 60 for utilization — has catalysed over 200 projects

EU Carbon Border Adjustment Mechanism (CBAM): From 2026, EU will charge levies on cement, steel, aluminium, fertilizer imports based on their carbon content — CCUS adoption by Indian exporters reduces CBAM exposure

UPSC RELEVANCE

CCUS (Carbon Capture, Utilization and Storage), hard-to-abate sectors (5: power/steel/cement/refineries/chemicals), Green Steel Taxonomy, National Steel Policy 2017 (300 MT by 2030-31), India's steel rank (2nd largest), CBAM (Carbon Border Adjustment Mechanism, EU), Direct Air Capture, Saline aquifer storage, Basalt carbonation, Deccan Traps, Mission Innovation, 45Q Tax Credit (USA).

Climate change mitigation technologies; industrial decarbonization; India's Net Zero roadmap (2070); green steel and carbon pricing; CBAM implications for Indian exports; role of government in financing clean technology transition (VGF model); Paris Agreement and NDC implementation.

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BUDGET CCUS ALLOCATION:

Budget 2026-27 allocation: **Rs 20,000 crore** over 5 years (Viability Gap Funding)

5 target sectors: Power, Steel, Cement, Refineries, Chemicals

India's Net Zero target: **2070** (committed at COP26, Glasgow)

INDIA STEEL SECTOR:

India crude steel output FY25: **152 million tonnes — world's 2nd largest** (after China)

Steel's share of India's GHG emissions: **10–12%**

National Steel Policy 2017: **300 MT by FY 2030-31**; 500 MT by 2047

Green Steel threshold: below **2.2 tCO_2e per tonne** of crude steel (3-5 stars)

CCUS PROCESS:

Capture methods: Post-combustion (solvents/MEA), Pre-combustion, Oxyfuel, Direct Air Capture (DAC)

Energy penalty: **15–25% extra power** required for capture operations

Cost impact on power: raises electricity cost **60–80%** for retrofitted plants

Storage depth: Geological formations at **>800 metres** depth

STORAGE TYPES:

Saline aquifers (largest global capacity), depleted oil/gas fields, basalt formations, coal seams

Deccan Traps (India): CO_2 mineralizes into carbonate rock within years — fast and permanent

Indian sedimentary basins: Cambay (Gujarat), KG Basin (AP/Telangana)

KEY INSTITUTIONS AND POLICIES:

Mission Innovation CCUS Challenge: Launched **2018**; India co-leads

Two National Centres of Excellence in Carbon Capture (Budget 2026-27)

IIT Bombay + JNCASR Bengaluru: Lead CCUS research institutions

CBAM (EU): Carbon Border Adjustment Mechanism; affects Indian steel/cement/aluminium exporters from 2026

Norway Sleipner: World's first commercial geological CO_2 storage since **1996**; ~1 MT CO_2/year

USA 45Q: USD 85/tonne for permanent geological storage; USD 60 for utilization

Sources: Drishti IAS, AffairsCloud

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