CARBON CAPTURE, UTILIZATION & STORAGE (CCUS)

Strategic Opportunity Landscape for Indian Industry

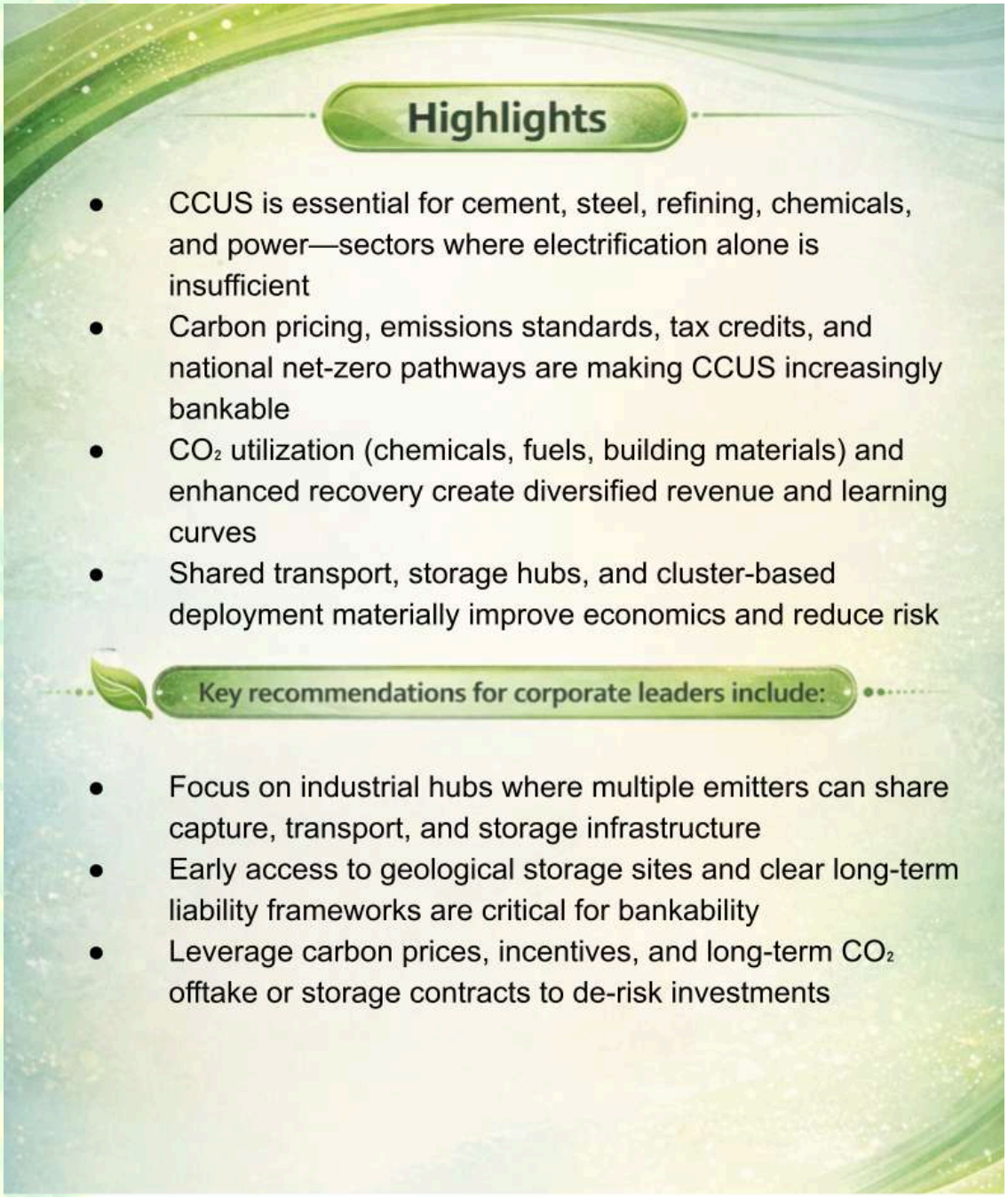
Carbon Management | Industrial Decarbonization | Carbon Infrastructure | Net-Zero Enablement

CEMENT | STEEL | REFINING | CHEMICALS | ENERGY

Prepared for Corporate Leaders & Sustainability Decision Makers

Carbon Management
Opportunity 3 : CCUS

This section provides key inputs on Carbon Capture and Utilization Opportunities for corporate leaders.



Opportunity Snapshot: CCUS (Carbon Capture, Utilization & Storage)

Capture, store and/or valorise CO_2 emissions from industrial sources

Market Signal

- **High relevance** for hard-to-abate sectors (cement, steel, refineries)
- Increasing global investments in CCUS hubs and industrial clusters
- **Annual Market size by 2030:** 1500-2500 ₹ Cr

What Makes or Breaks It?

- **Point-source capture efficiency** (>85–90% CO_2 capture rates)
- **Access to storage/utilization pathways** (geological storage, chemicals)
- **Long-term carbon pricing** or credit support for viability

Why It Matters NOW?

- Essential for decarbonising sectors where **electrification is not viable**
- Carbon pricing/markets improving project economics
- **Global push for carbon removal** and negative emissions

Well Aligned Opportunity for

- **Oil & gas companies and heavy industries**
- **Large infrastructure and EPC players**
- **Chemical and energy companies**

Key Challenges

- **High capture cost** (₹4,000–6,000 per ton CO_2)
- Lack of CO_2 **transport and storage infrastructure**
- **Limited revenue** without strong carbon pricing

Business Model

- Pilot projects in cement, steel, refining clusters
- Develop CO_2 utilization (methanol, chemicals)
- Partner in CCUS hubs with shared infrastructure

Introduction and Business Case

Carbon Capture, Utilization and Storage (CCUS) acts as industrial carbon plumbing, capturing CO_2 from smokestacks, compressing and transporting it and then either putting it to work (fuels, chemicals, construction materials) or locking it underground.

For India, CCUS is vital for hard-to-abate sectors like steel, cement and refineries, where emissions are inherent to processes, not just energy use. It helps industry meet ESG expectations, reduce carbon compliance costs and turn waste carbon into economic value streams such as methanol, soda ash and urea.

While the business opportunities from the CCUS domain are currently in the early stages, companies in relevant industries could find it valuable to initiate efforts and projects that will get them market ready when the opportunity growth accelerates.

Market Potential for CCUS in India

Year	Installed/Expected Capture Capacity ($ktCO_2/yr$)	Cumulative Capex Opportunity (₹ Cr)	What unlocks it
2025	1-3	100-200	Early demos in steel/cement/power; CO_2-to-chemicals pilots
2030	25-50	1500-2500	State incentives, cluster pipelines, offtake contracts for urea/methanol
2040	750-1000	25000-40000	Storage hubs online; blue H_2 + industrial hubs; cross-sector CO_2 networks

Market Segments and Applications

Segment	Applications	Business Model	Key Drivers
Post-Combustion Carbon Capture	Power plants, cement, steel, refining	Capture unit sales + long-term service contracts	Decarbonization of existing assets
Pre-Combustion & Oxy-Fuel Capture	Hydrogen, ammonia, power generation	EPC + licensing + offtake agreements	Blue hydrogen and industrial decarbonization

Industrial CCUS Hubs	Multi-industry clusters	Infrastructure development + storage fees	Shared infrastructure lowers unit costs
CO_2 Transport Infrastructure	Pipelines, shipping, terminals	Regulated transport tariffs	Scaling CCUS beyond single sites
Geological CO_2 Storage	Saline aquifers, depleted oil & gas fields	Storage access fees + long-term liability management	Permanent carbon sequestration demand
Direct Air Capture (DAC)	Corporate carbon removal, net-zero targets	Carbon removal credit offtake contracts	Need for neutralizing residual emissions
Carbon Utilization (CCU)	Fuels, chemicals, materials	Product sales + carbon value premiums	Turning CO_2 into economic feedstock
Hydrogen & Ammonia with CCS	Energy, chemicals, export fuels	Integrated project finance + long-term offtake	Clean hydrogen demand growth
Modular & Small-Scale Capture	Distributed industrial emitters	Equipment leasing + O&M	Addressing mid-size and hard-to-reach emitters
CCUS Advisory, MRV & Project Services	Project design, permitting, monitoring	Project design, permitting, monitoring	Complexity, regulation, and financing needs

Typical Project Capacities & Investments Required in India

Project Type	Typical Capacity	Indicative CapEx (₹ Cr)	Notes
Cement plant post-combustion capture (amine)	0.5-1.0 $MtCO_2/yr$	1,200-3,000	Brownfield integration; heat integration is key.
Steel (BF/DRI) flue-gas capture	0.5-1.5 $MtCO_2/yr$	1,500-3,500	Higher impurities; pre-treatment & solvent management add cost.
Refinery/H_2/Ammonia CO_2 capture (process gas)	0.3-1.0 $MtCO_2/yr$	800-2,200	Higher-purity CO_2 streams → lower capture cost.

Coal power CCUS pilot → scale	0.1-1.0 $MtCO_2/yr$	400-3,500	Energy penalty significant; start with slip-stream pilots.
Cluster transport & storage hub (pipeline + saline aquifer)	5-10 $MtCO_2/yr$ throughput	3,000-8,000	Shared T&S infra; excludes capture units at sources.
CO_2 mineralisation / carbon-cured concrete	0.05-0.2 $MtCO_2/yr$	100-300	Near-site use with ready-mix/blocks; fast-trackable.
CO_2-to-methanol/e-fuels (with green H_2)	0.1-0.5 $MtCO_2/yr$ utilisation	1,500-5,000	H_2 capex dominates; colocate with RE/H_2 hubs.
BECCS (bioenergy + capture)	0.05-0.2 $MtCO_2/yr$	150-500	Delivers durable "carbon-removal" credits.

Underlying Technologies & Processes

A) Capture

Element	Options	Key traits
Process route	Post-combustion (amines, advanced solvents)	Retrofit-friendly; 85-95% capture; heat integration critical (steam demand).
	Pre-combustion (shift + separation for blue H_2)	High-purity CO_2 streams; pairs with H_2 production in refineries/fertiliser.
	Oxy-fuel combustion	High CO_2 flue gas reduces separation load; boiler/kiln redesign.
	Emerging: membranes, cryogenic, calcium looping	Smaller plots/special niches; improving but less mature at scale.

B) Conditioning and Transport

Element	Options	Key traits
State of CO_2	Gas/liquid/supercritical	Compression to >73 bar for dense-phase pipeline/shipping.
Transport	Pipeline (onshore/offshore), ship, truck/rail (short hop)	Pipelines dominate at scale; clusters reduce ₹/t; shipping viable coastal.

Hubs	Single-source vs. multi-source networks	Shared dehydration/compression lowers unit cost and accelerates FIDs.

C) Utilization

Route	End-product
Urea / fertilisers	Urea, ammonium bicarbonate
Methanol / synfuels	Methanol, SAF (with H_2)
Mineralisation	Carbonated aggregates / cement curing
Chemicals	Soda ash, polycarbonates

D) Storage

Formation	Examples
Saline aquifers	Krishna-Godavari, Cambay, Cauvery basins
Depleted oil & gas fields	West coast offshore, onshore fields
Basalt mineralisation	Deccan Traps

Key Challenges

Challenge Area	Key Issues	Business Impact	India Specific	Strategic Implications
High Capital Intensity & Uncertain Monetization	Capture, transport, and storage infrastructure requires significant upfront investment	Slow project development and financing challenges	Limited carbon pricing signals; early-stage incentive frameworks	Need blended finance, policy support, and long-term contracts
Policy & Regulatory Framework Maturity	Lack of fully established regulatory clarity around storage liability and CO_2	Investment uncertainty and project delays	Emerging policy landscape for CCUS in India	Early regulatory engagement and flexible project design essential

	transport			
Storage Infrastructure & Geological Readiness	Identification and certification of suitable storage sites	Limits scalability and bankability	Limited mapped storage infrastructure; regulatory approval processes evolving	Focus on cluster-based industrial hubs and shared infrastructure
Offtaker Demand & Commercial Value Chains	Limited domestic markets for CO_2 utilization and low-carbon product premiums	Revenue diversification challenges	Early-stage demand for green materials and carbon-neutral products	Integrate CCUS with hydrogen, chemicals, and low-carbon materials markets
Technology & Supply Chain Dependencies	Reliance on advanced capture technologies and specialized equipment	Cost volatility and implementation risks	Import dependency; evolving technology standards	Partnerships with technology providers and modular deployment strategies

Prominent Players in the Indian Market

Company / Entity	Project Details
Tata Steel	Jamshedpur — 5 TPD CO_2 capture from blast furnace gas, pilot with Carbon Clean.
Dalmia Cement	Roadmap for carbon-negative cement; evaluating CCUS pilots at kiln sites.
UltraTech Cement / ACC / Ambuja	Feasibility studies for kiln flue gas capture; exploring utilisation pathways.
NTPC Ltd.	Vindhyachal — 10 TPD CO_2-to-methanol pilot; evaluating scale-up at other plants.
IOCL (Indian Oil)	Research on blue hydrogen with CCUS at refineries; CO_2 capture + utilisation projects.
Tuticorin Alkali Chemicals	CO_2-to-soda ash commercial plant (60 TPD capture), first industrial CCU example in India.
ONGC / Oil India Ltd.	Exploring EOR/EGR projects using captured CO_2 in depleted fields.

CarbonOro, Carbon Clean	CarbonOrO delivers carbon capture solutions to industrial CO2 emitters across hard-to-abate sectors to accelerate the Net Zero transition.
Carbon Clean	Leading the race in carbon capture technology. Unrivaled solutions for hard-to-abate industries to achieve their 'net zero' goals.
Mati Carbon	Focuses on farmer-centric carbon removal through soil remineralization
Core Carbon X Solutions	A climate and sustainability consulting firm that emphasizes climate change mitigation, making it relevant to the topic of carbon capture
Green Carbon Hub	Helping businesses and residential communities achieve Net-Zero emissions for business & communities
Carbon Credits	Their platform provides valuable insights into carbon pricing and investment opportunities, making it a key resource for those interested in carbon capture and related initiatives.
Catalyst Environment Technology Solutions	Specializes in innovative carbon capture technology solutions, highlighting their HiGee system that can capture up to 85% of CO2 from flue gas
Abhitech Energycon Limited	Their products specifically address the challenges of combustion, contributing to sustainable carbon capture and offering potential revenue opportunities while mitigating carbon pricing and taxes.
Carbon Minus	Offering solutions that help businesses achieve their net-zero goals through efficient energy data management
Furgo	Supporting the first major CCS project in Visakhapatnam with geological expertise.

Innovation Perspectives

Innovation	**Business Opportunity**	**For Senior Management**
CCUS Hubs as Infrastructure Platforms	Own regional CO_2 infrastructure	Infrastructure earns returns independent of CO_2 price volatility
Low-Cost, Modular Capture	Capture-as-a-service for mid-size emitters	Unlocks the long tail of industrial emissions
CO_2 Storage as a Strategic Asset	Long-term storage access monopolies	Storage scarcity creates pricing power
Hydrogen & Ammonia + CCS Integration	World-scale clean fuel projects	Positions CCUS as enabler of new energy markets
Direct Air Capture with	Premium carbon removal	Addresses residual emissions

Guaranteed Storage	offtakes	no alternative can
CO_2 Transport Innovation	Asset-light transport models	Accelerates cross-border CCUS scaling
Carbon Utilization at Industrial Scale	Product-linked CO_2 monetization	Creates revenue, not just cost avoidance
Digital MRV & Liability Management	MRV-as-a-service platforms	Trust and compliance become monetizable
Policy-Anchored Business Models	De-risked project finance	Converts policy into bankable returns
End-to-End CCUS Orchestration	One-stop CCUS solution provider	Simplifies adoption for industrial customers

Concentric & Satellite Opportunities

- Capture technology providers & EPC integrators: Firms engineering post-combustion and industrial CO_2 capture systems tailored for cement, steel and refineries.
- CO_2 transport & pipeline infrastructure developers: Concentric utilities building shared CO_2 corridors connecting emission clusters to storage hubs.
- Geological storage & monitoring services: Subsurface specialists mapping saline aquifers, conducting injectivity tests and ensuring long-term containment.
- CO_2 mineralisation & concrete curing plants: Industrial users turning captured CO_2 into carbonates, aggregates and construction materials.
- Synthetic fuel & chemical producers: Satellite ventures using captured CO_2 with green hydrogen to make e-methanol, e-kerosene and carbon-neutral feedstocks.
- Equipment and solvent manufacturers: Local production of absorbers, compressors, membranes and advanced amine blends suited to Indian conditions.

Key Takeaway for Senior Management

Takeaway	**Details**
CCUS is becoming essential industrial climate infrastructure, not a niche abatement tool	• For cement, steel, chemicals, refining, and fossil-based power, CCUS is often the only pathway to deep decarbonization • ***Examples****:* capture from cement kilns, refineries, ammonia plants; blue hydrogen with CCS • **Competitive advantage for end use sectors:** license-to-operate and regulatory resilience in hard-to-abate sectors

Cluster-based deployment fundamentally changes economics	• Shared transport and storage infrastructure reduces capex and risk for individual emitters • ***Sub-components****:* industrial hubs, shared pipelines, common storage reservoirs, CO_2 hubs • **Recommended innovation focus:** CCUS-as-a-service platforms and shared infrastructure • **Competitive advantage:** lower unit costs and faster scale versus standalone projects
Capture technology must be source-specific and modular	• No single capture solution fits all emission streams • ***Examples****:* post-combustion amines for cement, oxy-fuel for power, pre-combustion for hydrogen • **Recommended innovation focus:** modular, source-optimized capture systems
Long-term storage access and liability clarity drive bankability	• Storage availability and post-closure liability are decisive investor concerns, though this activity - and thus concern - is at a nascent stage India • ***Sub-components****:* saline aquifers, depleted oil & gas fields, monitoring & verification regimes • **Innovation focus:** storage site development, monitoring, and liability management frameworks
Carbon value stacking improves project economics	• Pure storage economics are often insufficient without incentives or utilization • ***Examples****:* carbon pricing, tax credits, utilization into fuels/materials, low-carbon product premiums

Next Steps for Corporate Leaders

CCUS is gaining strategic importance as climate commitments tighten and hard-to-abate sectors face increasing decarbonization pressure for the Indian industry. While the market is still in an early commercial phase, technology maturity, carbon pricing trends, and emerging policy support indicate a widening opportunity space.

This could be an attractive climate tech opportunity for industries and firms in specific sectors and industries keen on catering to this market.

Connect with Team EAI to know more about this opportunity and take your corporate's initial steps. Send a note to consult@eai.in or talk to Muthukrishnan - 9952910083