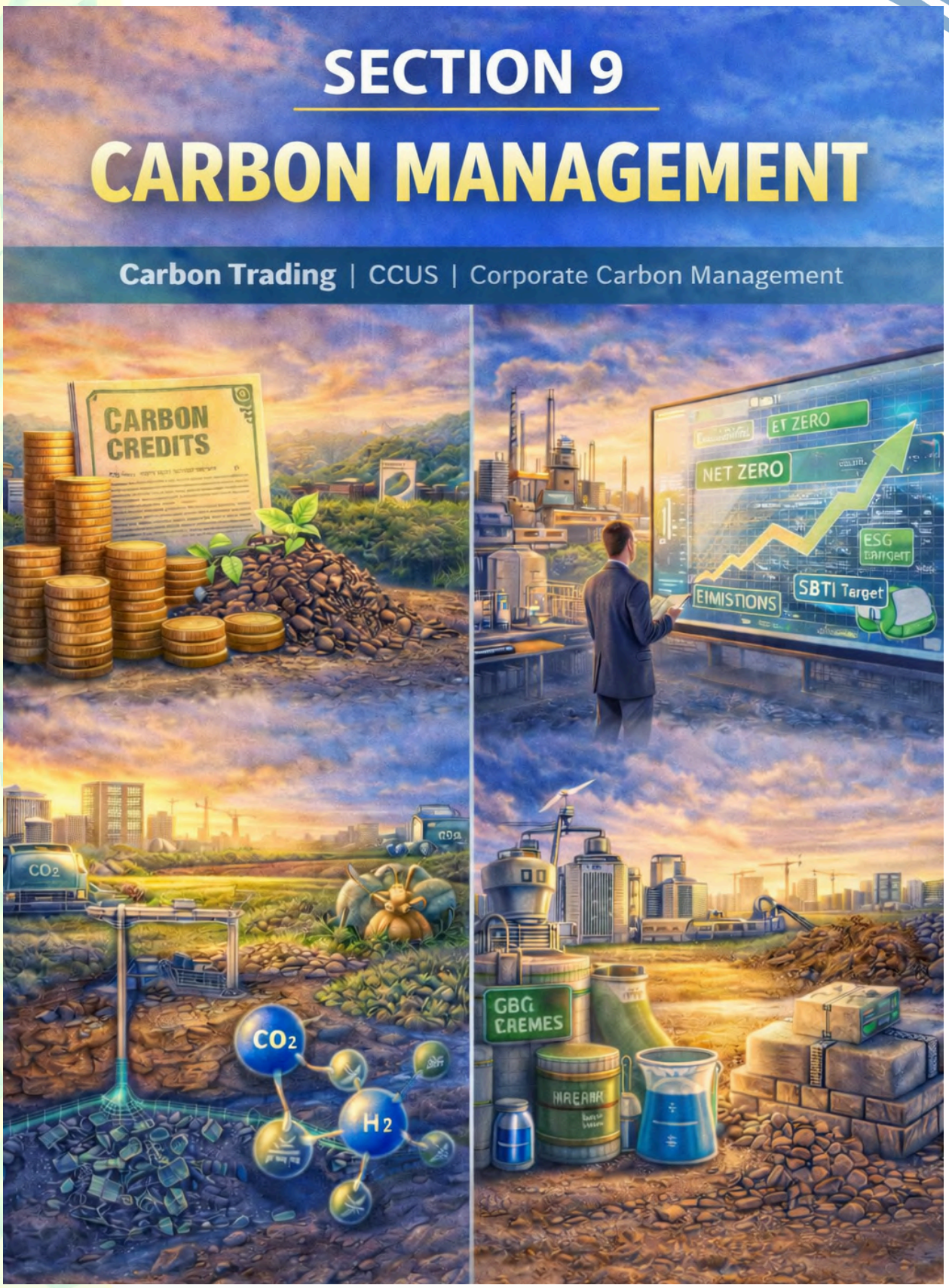

SECTION 9
CARBON MANAGEMENT
Carbon Trading | CCUS | Corporate Carbon Management
CARBON CREDITS
NET ZERO
ESG
SBTI Target
EIMISTIONS
CO2
CO2
H2

Section 9

Carbon Management

Carbon markets, carbon management and CCUS (Carbon Capture,Utilisation and Storage) form the enabling layer of India's decarbonisation ecosystem, translating emissions reduction into economic value, compliance, and competitiveness.

Market Scale & Direction:

India is in the process of operationalising a domestic carbon market with formal trading to begin by mid 2026, while voluntary carbon markets are growing alongside corporate net-zero commitments.

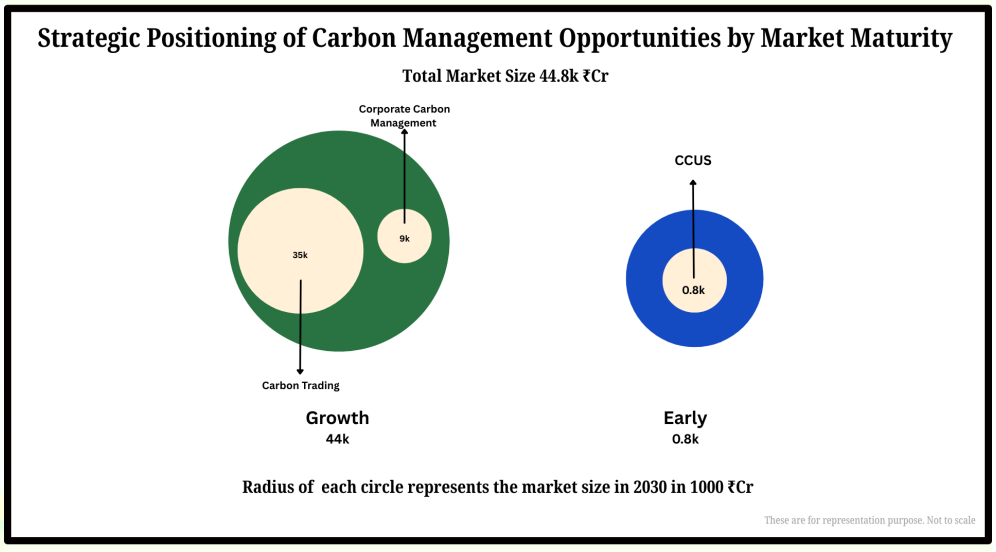
Hard-to-abate sectors (cement, steel, refining) account for ~45% of industrial CO_2 emissions, making CCUS strategically relevant.

Key Segments:

- **Carbon Trading**: Compliance and voluntary carbon credits
- **Carbon Management**: MRV, abatement planning, offsetting, reporting
- **CCUS**: Capture, utilisation, and storage of CO_2

Growth Drivers:

- CBAM and global carbon regulations
- ESG and science-based targets
- Future carbon pricing and compliance costs
- Need for residual emissions management

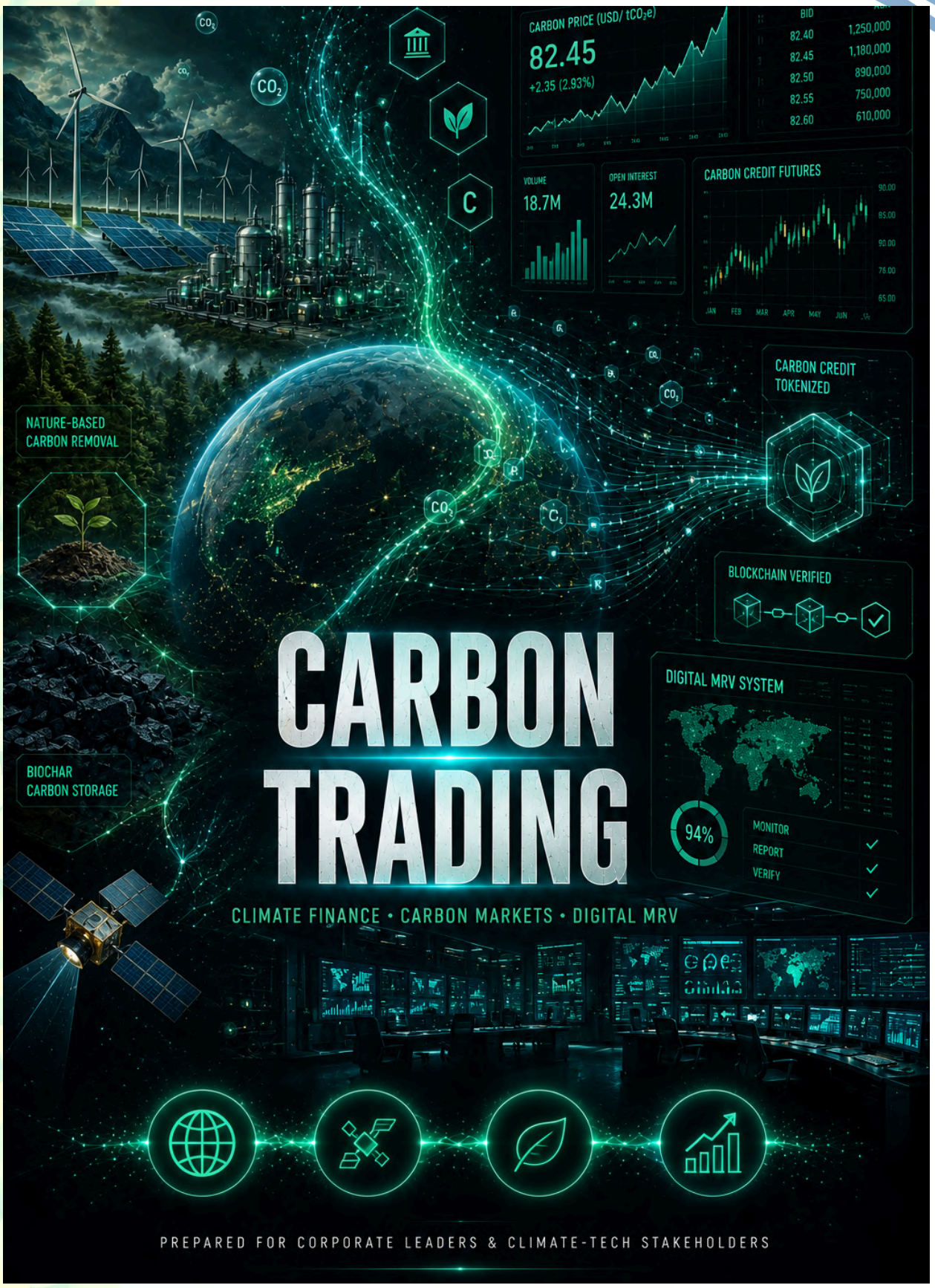


Strategic Trends:

- Shift from offsets to high-integrity, India-based credits
- CCUS integration with chemicals, fuels, and materials
- Digital MRV platforms becoming mandatory

Executive takeaway:

Carbon trading, carbon management and CCUS convert decarbonisation into a strategic asset—protecting exports, monetising emissions reduction, and enabling India's net-zero transition. For investors and corporates, they represent a risk-mitigation and value-creation opportunity, enabling industries to navigate global carbon rules, monetise verified emission reductions, and build scalable carbon-management platforms.


CARBON PRICE (USD/ tCO2e)
82.45
+2.35 (2.93%)
BID
82.40 1,250,000
82.45 1,180,000
82.50 890,000
82.55 750,000
82.60 610,000
VOLUME
18.7M
OPEN INTEREST
24.3M
CARBON CREDIT FUTURES
CARBON CREDIT TOKENIZED
NATURE-BASED CARBON REMOVAL
BLOCKCHAIN VERIFIED
CARBON TRADING
DIGITAL MRV SYSTEM
94%
MONITOR
REPORT
VERIFY
BIOCHAR CARBON STORAGE
CLIMATE FINANCE • CARBON MARKETS • DIGITAL MRV
PREPARED FOR CORPORATE LEADERS & CLIMATE-TECH STAKEHOLDERS

Carbon Management
Carbon Trading

This section provides key inputs on Carbon Trading Opportunities for corporate leaders.

Opportunity Snapshot: Carbon Trading

Enable buying and selling of carbon credits to offset emissions

Market Signals

- Strong demand from corporates with net-zero/ESG commitments
- Growth in voluntary carbon markets (VCM) and international trading
- Annual Market size by 2030: ₹ 15,000 - 17,000 Cr

What Makes or Breaks It?

- Access to high-quality credits (verified, additional, permanent)
- Robust MRV and certification (Verra, Gold Standard)
- Strong buyer network (corporates, global markets)

Why It Matters NOW?

- Mandatory ESG disclosures increasing carbon accounting and offset demand
- Companies seeking cost-effective ways to meet emission targets
- Expansion of carbon credit supply from renewables, bioenergy, nature-based solutions

Well Aligned Opportunity for

- Carbon credit project solution providers and project owners
- Trading platforms and exchanges
- Consulting and ESG advisory firms

Key Challenges

- Price volatility in carbon credit values
- Regulatory uncertainty in domestic markets

Business Models

- Develop projects (renewables, biochar, -afforestation) to generate credits
- Build trading platforms or brokerage networks
- Offer integrated carbon strategy, offset sourcing and reporting solutions for corporates

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Introduction and Business Case

Carbon trading transforms emissions into a market commodity, rewarding reductions and penalising excess. For India, it offers dual benefits: compliance with the emerging Carbon Credit Trading Scheme (CCTS) and participation in growing voluntary markets. It allows industries to monetise carbon savings, hedge against future carbon costs and attract ESG-focused capital.

As India targets Net Zero 2070, carbon markets will be a critical financial lever for decarbonization, thus gaining the interest of a large number of end user stakeholders and presenting significant opportunities to solution providers.

Market Potential for Carbon Trading in India

Year	Market Size (₹ Cr)	Drivers
2025	7,000-8,000	Early CCTS pilots; voluntary offsets from corporates and exporters.
2030	15,000-17,000	National carbon market operational; compliance demand from energy-intensive sectors.
2040	40,000-45,000	Integration with global carbon markets; deep sectoral caps drive liquidity.

Market Segments and Applications

Segment	Applications	Business Model	Key Drivers
Compliance Carbon Markets (ETS)	Power, industry, aviation	Exchange trading + clearing & settlement fees	Government-mandated emissions caps and pricing
Voluntary Carbon Markets (VCM)	Corporate net-zero and neutrality goals	Credit trading + brokerage margins	Corporate climate commitments beyond regulation
Carbon Registries & Standards	Credit issuance, verification, retirement	Registration + verification fees	Need for credibility, transparency, and trust
Carbon Project Development	Nature-based and technology-based projects	Project origination + credit sales	Supply of new, high-quality carbon credits

Carbon Marketplaces & Exchanges	Spot and futures trading	Transaction fees + data subscriptions	Liquidity, price discovery, and scale
Carbon Advisory & Portfolio Management	Corporate carbon strategy and hedging	Advisory fees + asset management	Complexity of carbon regulations and markets
High-Integrity / Premium Credits	Scope 3 mitigation, nature & removals	Premium pricing + long-term offtake	Demand for quality and reputational safety
Digital MRV & Carbon Data Platforms	Emissions tracking and reporting	SaaS subscriptions + analytics	Regulatory reporting and audit requirements
Carbon Derivatives & Risk Products	Futures, options, structured products	Trading & clearing fees	Volatility and financialization of carbon prices

Underlying Technologies & Processes

Element	Options	Key Traits
Measurement	Smart meters, IoT sensors, MRV software	Accurate data capture for emissions baselines.
Verification	Third-party auditors, blockchain registries	Ensures credibility, prevents double-counting.
Trading Platforms	IEX, PXIL, digital carbon exchanges	Provide liquidity, price discovery and compliance tracking.
Credit Types	Renewable energy credits, energy efficiency, afforestation, CCUS, biochar	Diverse supply; sector-specific valuation.
Integration	Linkage with global voluntary & compliance markets	Expands demand pool; supports export competitiveness.

Key Challenges

Challenge Area	Key Issues	Business Impact	India Specific	Strategic Implications
Policy & Regulatory Uncertainty (Transition to Compliance	Shift from voluntary markets to regulated carbon market still evolving	Investment hesitation and pricing uncertainty	India's Carbon Credit Trading Scheme (CCTS) still under development;	Build flexible portfolios aligned with future compliance frameworks

Market)			evolving rules	
Credit Integrity, MRV & Standardization Challenges	Ensuring additionality, permanence, and verifiable emissions reductions	Buyer trust and pricing depend on credit quality	Limited standardized MRV infrastructure across sectors	Invest in digital MRV systems and high-integrity methodologies
Market Liquidity & Price Discovery Risk	Carbon markets still immature with limited liquidity	Revenue volatility and uncertain returns	Early-stage domestic market; reliance on international voluntary markets	Diversify across credit types and geographies
Demand & Offtaker Readiness	Corporates still developing internal carbon strategies	Slower demand scaling compared to supply pipelines	ESG adoption varies by sector; price sensitivity among Indian corporates	Educate buyers and develop long-term offtake agreements
Geopolitical & Global Policy Dependencies	Carbon border adjustments, international standards, and global carbon pricing influence markets	Strategic risk for export-oriented projects	EU CBAM, international market linkage, evolving cross-border standards	Maintain regulatory intelligence and diversified market access

Prominent Players in the Indian Market

Company / Entity	Role / Project Details
Indian Energy Exchange (IEX)	Developing trading platform for India's Carbon Credit Trading Scheme.
Power Exchange India Ltd. (PXIL)	Exploring carbon credit spot & futures contracts.
Eki Energy Services	India's leading carbon credit developer & trader in voluntary markets.
Emergent Ventures India (EVI)	A significant player in climate finance, CDM, and carbon markets.
Varaha	Climate-tech company developing nature-based carbon removal projects and supplying verified carbon credits to corporates.

Innovation Perspectives

Innovation	Business Opportunity	For Senior Management
Carbon Market Infrastructure Platforms	Become core infrastructure for carbon markets	Infrastructure captures value regardless of price direction
High-Integrity Credit Curation	Premium credit portfolios	Pricing power in a trust-constrained market
Carbon as a Risk-Managed Asset Class	Carbon asset management	Elevates carbon from compliance cost to strategic asset
Digital MRV & Transparency Layers	MRV-as-a-service platforms	Solves the credibility bottleneck limiting market growth
Long-Term Carbon Offtake Platforms	Structured offtake contracts	De-risks buyers and unlocks project supply
Carbon + Nature Credit Stacking	Multi-attribute credit markets	Expands revenue per hectare/project
Corporate Carbon Portfolio Orchestration	SaaS-led carbon management	Sticky enterprise customers
Regional & Emerging-Market Marketplaces	First-mover regional dominance	Captures growth where regulation is forming
Integration with Energy & Commodity Trading	Multi-commodity trading strategies	Leverages existing trading capabilities
Regulation-Shaping Market Design	Advisory + platform deployment	Locks in long-term relevance and standards influence

Concentric & Satellite Opportunities

- Carbon project developers & aggregators: Firms structuring renewable, efficiency and nature-based projects into bankable, credit-generating assets.
- MRV & verification technology providers: Digital platforms using IoT, satellite and blockchain tools for transparent, low-cost emissions tracking.
- Carbon exchanges & brokerage platforms: Domestic and cross-border marketplaces facilitating trading under India's Carbon Market and ICM framework.
- Advisory & compliance services: Concentric consultancies guiding corporates on carbon accounting, credit registration and offset procurement.

- Carbon finance & insurance products: Green funds, credit guarantees and floor-price insurance enabling long-term project viability.
- Corporate decarbonisation partnerships: Buyers-suppliers coalitions creating insetting and internal trading programs across value chains.
- Climate data analytics & ratings agencies: Satellite ventures assessing credit integrity, climate risk and ESG-linked investment performance.

Key Takeaway for Senior Management

Takeaway	Details
Carbon trading is evolving into regulated market infrastructure, not a niche ESG tool	• Markets are shifting from voluntary offsets toward compliance-led systems with tighter rules and price signals • ***Examples:*** transition from voluntary credits to compliance markets; sectoral baselines and cap-and-trade mechanisms • **Competitive advantage:** early positioning ahead of regulation-driven demand spikes
Integrity and Monitoring, Reporting Validation (MRV) quality define value, not volume of credits	• Low-quality credits face pricing discounts and reputational risk • ***Sub-components:*** additionality, permanence, leakage controls, digital MRV, third-party verification
Value pools extend beyond credit generation to platforms and services	• Trading, aggregation, advisory, and risk management often outperform standalone project economics • ***Examples:*** carbon portfolio management, carbon-as-a-service, internal carbon pricing tools • **Recommended innovation focus:** platform and service-layer business models • **Competitive advantage:** diversified revenues and lower exposure to price volatility
Corporate participation is shifting from offsets to portfolio strategies	• Companies increasingly combine internal abatement, credit procurement, and trading strategies • ***Examples****:* internal carbon budgets, long-term offtake agreements, hybrid voluntary–compliance exposure • **Recommended innovation focus:** design and develop integrated carbon portfolios
Regulatory intelligence and market access are strategic moats	• Rules, registries, and methodologies evolve faster than many corporates can track • ***Examples****:* registry integration, methodology approvals, jurisdiction-specific eligibility rules • **Recommended innovation focus:** regulatory and market intelligence embedded in operations

Next Steps for Corporate Leaders

Carbon trading is entering a pivotal phase as India transitions from voluntary mechanisms toward a regulated compliance market. Industries with abatement potential, offset generation capability, or surplus credits will be strategically positioned as policies, market rules, and price signals evolve.

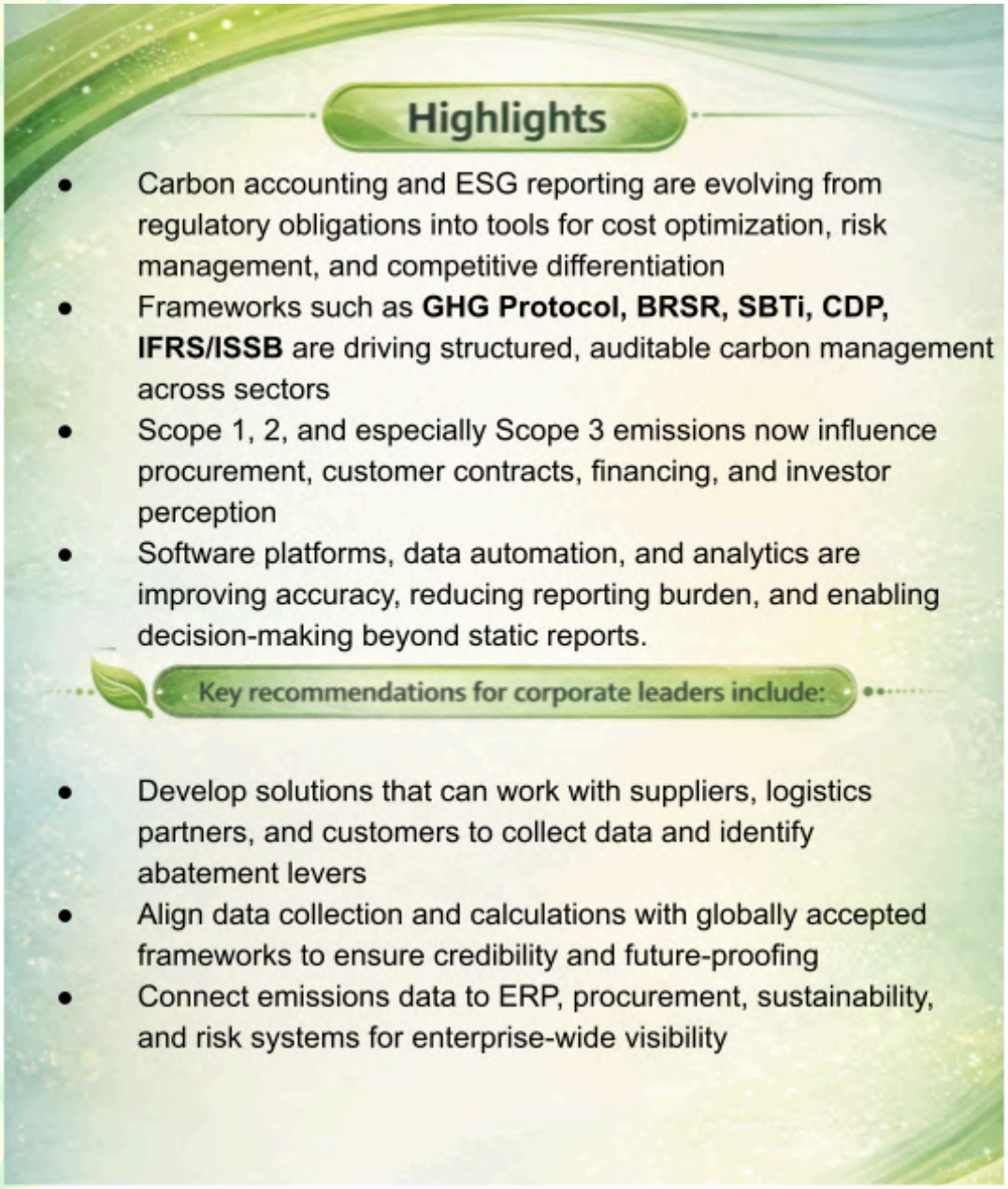
This could be an attractive climate tech opportunity for industries and firms in specific sectors and industries keen on catering to this market.


CORPORATE
CARBON
MANAGEMENT
ESG • CARBON ACCOUNTING • NET ZERO STRATEGY
TOTAL EMISSIONS
tCO2e
125,430
▼ 18.6% vs PY
Year to Date
2023
2024
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
EMISSIONS BY SCOPE
125,430
tCO2e
SCOPE 1 28%
SCOPE 2 37%
SCOPE 3 35%
ESG SCORE
A
86 /100
Strong Performance
ESG PERFORMANCE
ENVIRONMENT
78/100
SOCIAL
82/100
GOVERNANCE
88/100
AI INSIGHTS
You are on track to reduce emissions by
23% by 2030
vs. 2022 baseline
REDUCTION PATHWAY
Net Zero Target
2050
2030
-50%
Net Zero
2050
CO2
↓18.6%
vs PY
Turning Carbon Data into Strategic Advantage
ESG INTELLIGENCE
SCOPE 1–3 TRACKING
NET ZERO STRATEGY
SUPPLY CHAIN DECARBONIZATION
Prepared for Corporate Leaders & Climate-Tech Stakeholders

Carbon Management

Corporate Carbon Management (ESG, Carbon Footprint Analyses)

This section provides key inputs on Corporate Carbon Management Opportunities for corporate leaders.



Opportunity Snapshot: Corporate Carbon Management

Measure, manage, and reduce corporate emissions via carbon accounting, reporting, and reduction strategies

Market Signals

- Rising demand for Scope 3 tracking across supply chains
- Growth in carbon management SaaS platforms & consulting services
- Annual Market size by 2030: ₹ 4,000-5,000 Cr

What Makes or Breaks It?

- Accurate carbon accounting aligned with GHG Protocol/SBTi
- Ability to deliver actionable reduction pathways (not just reporting)

Why It Matters NOW?

- Mandatory ESG disclosures (BRSR in India) driving carbon reporting adoption
- Companies setting net-zero and science-based targets (SBTi)
- Need for data-driven emission visibility and reduction planning

Well Aligned Opportunity for

- SaaS/AI platforms (carbon accounting tools)
- Consulting firms and ESG advisors
- Enterprise software players (ERP/analytics providers)

Key Challenges

- Scope 3 data gaps across suppliers (low visibility, poor data quality)
- Integration with existing enterprise systems (ERP, operations data)

Business Models

- Offer integrated decarbonization strategy, offset sourcing and reporting solutions for corporates
- Pureplay consulting for net-zero strategy and Scope 3 tracking
- Provide seamless integration with enterprise systems

Introduction and Business Case

As investors, regulators and customers demand accountability, corporate carbon management has become a boardroom priority. ESG reporting and carbon footprint analyses enable firms to measure, disclose and reduce emissions across Scope 1-3, aligning with India's Net Zero 2070 roadmap and global frameworks like TCFD, CDP and GRI. Beyond compliance, strong ESG performance reduces financing costs, secures global supply chain access and enhances brand reputation.

For Indian corporates, this is becoming a license to operate in global markets. And for reporting & analytics solution providers, a sizable opportunity.

Market Potential for Corporate Carbon Management in India

Year	Market Size (₹ Cr)	Drivers
2025	1,000-1,200	SEBI's BRSR mandate for top 1,000 listed companies; voluntary ESG disclosures by corporates & startups.
2030	4,000-5,000	Expansion to mid-cap firms, export-linked SMEs; integration of carbon pricing.
2040	8,000-10,000	Full-sector participation; mandatory Scope 3 disclosures; alignment with global carbon markets.

Market Segments and Applications

Segment	Applications	Business Model	Key Drivers
Enterprise Carbon Accounting	Scope 1, 2, 3 footprinting and reporting	SaaS subscriptions (tiered by size/complexity)	Regulatory disclosure
Supply-Chain (Scope 3) Emissions Management	Supplier data collection, engagement, reduction planning	SaaS + supplier onboarding fees	Scope 3 dominates corporate emissions
ESG Data Management & Reporting	Multi-metric ESG disclosures and dashboards	Enterprise software licensing	Investor and regulatory scrutiny
Life-Cycle Assessment (LCA)	Product carbon footprints, eco-design	Project-based + software hybrid	Product-level emissions transparency

Target Setting & Transition Planning	Net-zero roadmaps, SBTi alignment	Advisory + recurring platform use	Credible climate commitments
Audit, Assurance & Verification	Carbon data validation and controls	Professional services fees	Need for audit-grade credibility
Carbon Reduction Analytics	Abatement modeling and prioritization	SaaS + analytics modules	Shift from reporting to action
Carbon Offsetting & Procurement Support	Credit sourcing and portfolio management	Advisory + transaction fees	Residual emissions management
Digital MRV & Data Integration	Automated data ingestion from ERP/IoT	Platform + integration fees	Data accuracy and automation needs
ESG Ratings & Benchmarking	Peer comparison, supplier scoring	Subscription access to ratings	Reputation and procurement pressure

Underlying Technologies & Processes

Element	Options	Key Traits
Carbon accounting frameworks	GHG Protocol, ISO 14064, CDP, TCFD, BRSR	Provide structure for measuring & disclosing emissions.
Digital tools	ESG dashboards, AI/IoT sensors, blockchain registries	Automate data collection, improve accuracy, enable traceability.
Footprint analyses	Scope 1-3 emissions mapping, Life Cycle Assessment (LCA)	Identifies hotspots and reduction pathways.
Assurance & reporting	SEBI BRSR, GRI, SASB, ISSB	Compliance with investor & regulator requirements.
Decarbonization roadmaps	Science-based targets, internal carbon pricing	Converts disclosures into actionable strategies.

Key Challenges

Challenge Area	Key Issues	Business Impact	India Specific	Strategic Implications
Data Availability, Quality &	Fragmented emissions data	Limits accurate carbon	Legacy systems, manual data	Investment in digital carbon data

Integration Complexity	across operations and supply chains	accounting and decision-making	collection, inconsistent reporting standards	infrastructure and automation essential
Scope 3 Supply Chain Engagement Challenges	Difficulty collecting reliable data from suppliers and logistics partners	Incomplete carbon footprint and reduced ESG credibility	Large MSME supplier base with low reporting capability	Supplier onboarding programs and standardized reporting tools required
Regulatory Evolution & Compliance Uncertainty	Rapidly evolving ESG disclosure frameworks and carbon regulations	Compliance risk and increased administrative burden	BRSR, global reporting standards, emerging carbon market rules	Build flexible reporting systems aligned with multiple frameworks
Monetization & ROI Clarity	Difficulty linking carbon management to direct financial outcomes	Slower executive buy-in and investment prioritization	ESG often viewed as compliance rather than value driver	Integrate carbon strategy with cost savings, financing, and market access benefits
Organizational Capability & Change Management	Need for cross-functional alignment across sustainability, finance, operations	Implementation delays and inconsistent execution	Limited in-house expertise; skills gap in carbon analytics	Develop internal governance structures and partner ecosystems

Prominent Players in the Indian Market

Company / Entity	Project Details
E&Y, KPMG, PwC, Deloitte	Leading ESG & sustainability consultants; carbon accounting, assurance and strategy.
Tata Consultancy Services (TCS)	Providing digital ESG platforms and analytics for corporates.
Infosys / Wipro	Net Zero corporates; offering carbon accounting services to clients.
Consultivo	ESG, Sustainability, Business Excellence & Risk Management – both in strategic and operational levels
Green Sutra	ESG, Sustainability, Carbon Footprint Solutions, Life Cycle Assessment (LCA) etc.

EKI Energy Services	Carbon Credit Developer & Supplier, Sustainability and Net Zero services
Sambodhi	ESG Consultants - Data-driven ESG Solutions

Innovation Perspectives

Innovation	Business Opportunity	For Senior Management
Carbon Management as a Financial System	Finance-grade carbon operating platforms	Makes carbon capital-allocation relevant, not just ESG
Scope 3 Orchestration Platforms	Control the hardest 70–90% of emissions	Creates enterprise lock-in and high switching costs
Decision-Grade Abatement Intelligence	What to cut next engines	Shifts market from reporting → value creation
Carbon Risk & Scenario Analytics	Carbon as enterprise risk management	Appeals directly to CFOs and boards
Embedded Carbon in ERP & Procurement	Default carbon-aware enterprise workflows	Carbon decisions happen by default, not exception
Audit-Ready Carbon Controls	Carbon SOX-like compliance platforms	Regulatory defensibility becomes monetizable
Automated MRV & Data Pipelines	Near-real-time carbon accounting	Eliminates manual reporting friction
Carbon Portfolio & Offset Optimization	Carbon asset management services	Treats carbon like a managed asset class
Supplier & Customer Carbon Monetization	Carbon-linked commercial models	Aligns emissions reduction with business outcomes
Regulation-First Carbon Platforms	Compliance-by-design software	Converts regulation into first-mover advantage

Concentric & Satellite Opportunities

- Carbon accounting & assurance firms: Concentric consultancies offering Scope 1-3 inventories, audits and BRSR/GRI/CDP-aligned disclosures.
- Digital MRV & data automation platforms: SaaS solutions integrating ERP, IoT and utility data for real-time carbon tracking and analytics.
- ESG rating & benchmarking agencies: Market players providing verified performance indices for investors and lenders.

- Decarbonisation strategy & offset advisory: Firms designing abatement roadmaps, MACC curves and insetting projects across value chains.
- Supplier engagement & training ecosystems: Programs enabling MSMEs to measure, report and reduce emissions under buyer mandates.
- Carbon finance & green bonds platforms: Satellite fintechs linking verified reductions with sustainability-linked loans and capital markets.
- Product LCA & EPD certification services: Specialists certifying low-carbon products for export and procurement advantages.
- AI-driven compliance & risk intelligence tools: Emerging systems predicting ESG controversies and automating disclosure readiness for enterprises.

Key Takeaway for Senior Management

Takeaway	Details
Carbon management is becoming enterprise decision intelligence, not a reporting exercise	• Leading firms use emissions data to guide capex, procurement, pricing, and product strategy—not just disclosures • ***Examples:*** choosing electrification vs. RE PPAs based on marginal abatement cost curves; supplier switching using emissions intensity • **Recommended innovation focus:** carbon analytics embedded into core planning systems
Scope 3 is the real value (and risk) frontier	• Scope 3 is the real value (and risk) frontier • ***Sub-components****:* supplier data capture, category-based estimates, primary data programs, engagement incentives • **Recommended innovation focus:** scalable Scope 3 data models and supplier enablement • **Competitive advantage:** solutions provide significant benefits such as supply-chain resilience, preferred-customer status, and reduced regulatory exposure
Data quality, auditability, and standard alignment define credibility	• As disclosures tighten, low-quality estimates create financial and reputational risk • ***Examples:*** alignment with GHG Protocol, BRSR, SBTi, CDP, ISSB; audit trails and controls • **Recommended innovation focus:** automation, controls, use of AI tools for validation and audit-ready data pipelines
Carbon data is becoming a financial variable	• Emissions increasingly influence cost of capital, insurance, contracts, and valuations • ***Sub-components:*** internal carbon pricing, scenario analysis, climate risk modelling • **Recommended innovation focus:** linking emissions to P&L, capex, and financing decisions • **Competitive advantage:** access to green finance, lower WACC, and improved deal outcomes

Next Steps for Corporate Leaders

Corporate carbon management is now a strategic requirement as investors, customers, and regulators expect credible ESG disclosures and measurable emissions reductions. The opportunity for differentiation is real, but the landscape remains fluid and complex.

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

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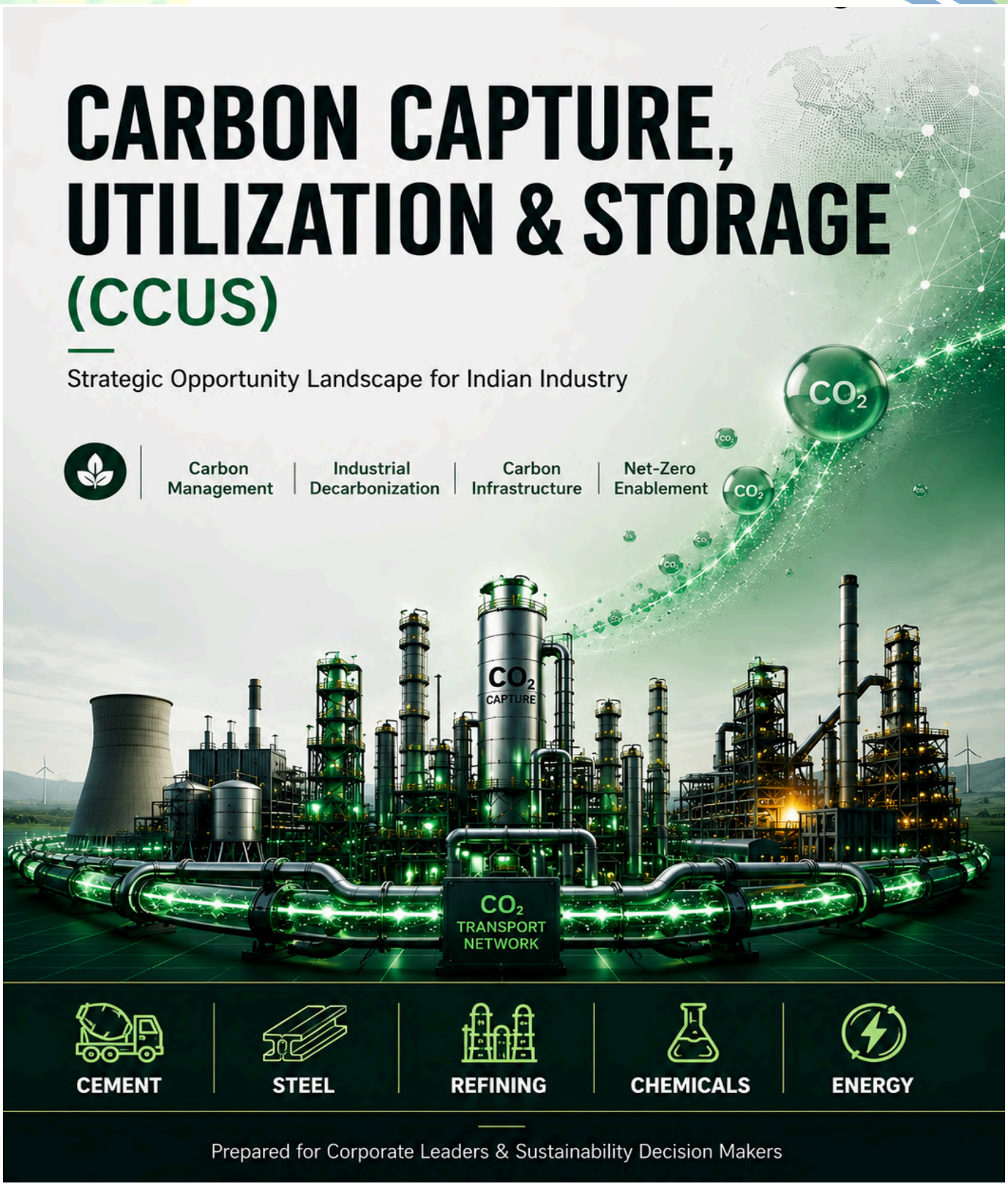
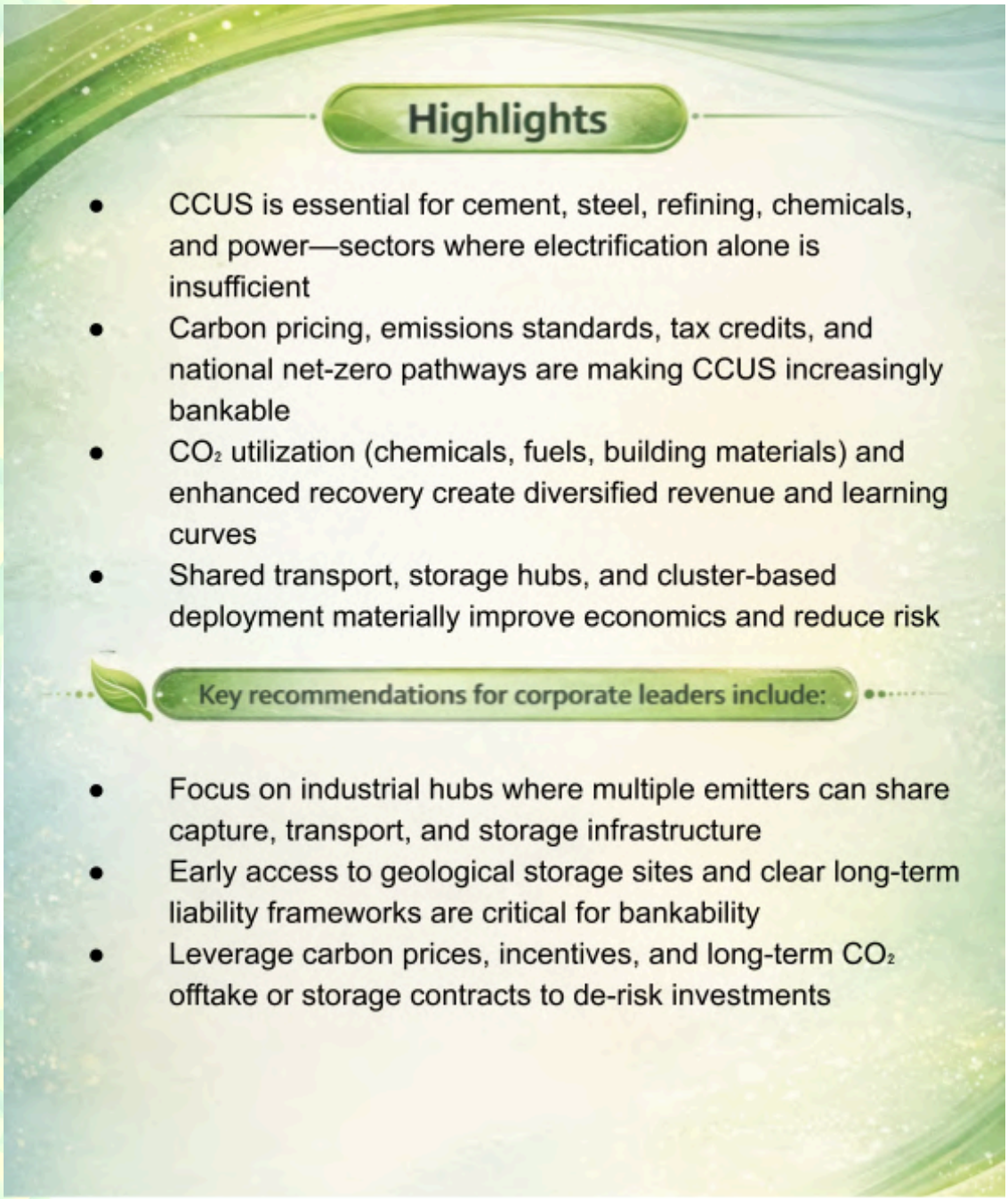

CARBON CAPTURE, UTILIZATION & STORAGE
(CCUS)
Strategic Opportunity Landscape for Indian Industry
Carbon Management
Industrial Decarbonization
Carbon Infrastructure
Net-Zero Enablement
CO2
CO2 CAPTURE
CO2 TRANSPORT NETWORK
CEMENT
STEEL
REFINING
CHEMICALS
ENERGY
Prepared for Corporate Leaders & Sustainability Decision Makers

Carbon Management
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 Signals

- Enhanced interest from 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
- Lack of CO_2 transport and storage infrastructure
- Limited revenue without strong carbon pricing

Business Models

- Focus on pilot projects in cement, steel, refining clusters
- Develop CO_2 utilization (methanol, chemicals) pathways
- Be a partner in CCUS hubs with shared infrastructure

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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.