

EMBODIED CARBON ACCOUNTING IN INDIA'S CEMENT SECTOR: A COST AND MANAGEMENT ACCOUNTING FRAMEWORK

Abstract

Cement is responsible for 47% of embodied emissions of the five key building materials assessed by NITI Aayog in India. The October 2025 GEI target notification covers 186 cement plants. In this article, we examine the carbon-emission profile of India's cement sector and propose a “carbon cost card” with variance analysis, which will enable Cost and Management Accountants to track, control and report carbon costs alongside traditional costs.

Introduction

Buildings and construction are increasingly material- and energy-intensive with Cement and steel being major contributors to embodied emissions, estimated by NITI Aayog, in Scenarios Towards Viksit Bharat and Net Zero (2026) to be 214 MtCO_{2e} from cement and 143 MtCO_{2e} from steel. Between 70-85% of the embodied emissions over the lifecycle of conventional buildings are attributed to five materials: cement, steel, bricks, aluminum and glass.

For CMAs, carbon accounting will integrate emissions into standard costing, variance analysis and project-level costing using cement emission-intensity data and CCTS targets.

The objective of this article is to examine how carbon-emission measurement and embodied-carbon concepts can be integrated into cost and management accounting practices in India's cement sector, with particular reference to carbon costing, compliance, variance analysis and decision support.



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Approach and Basis of Analysis

This article is conceptual and practice-oriented and is based on government and regulatory documents, sectoral studies and professional-accounting literature. Illustrative management-accounting calculations illustrate carbon costing, variance analysis and functional-unit allocation. The article distinguishes between facts that are already known, accounting practices that are being proposed and hypothetical numerical assumptions.

Embodied Carbon: Concept and Accounting Boundary

EN 15978 classifies building carbon by life-cycle stage. A1-A3 are raw materials, transport and manufacturing (cradle-to-gate); A4-A5 are transport and construction; B is use; C is end-of-life. A1–A5 generally represent embodied carbon upfront, and B6 operational energy.

For cement, it is A1–A3 that matter as manufacturing dominates the emissions. As per NITI Aayog, in Roadmap for Cement Sector Decarbonization (2026), 57-60% is from calcination, 27-31% from process heating, 10-13% from electricity and 1-2% from limestone mining. Calcination produces process emissions that cannot be avoided through efficiency alone. So decarbonization needs energy efficiency, less clinker, alternative fuels, cleaner electricity and possibly carbon capture. Such measures can justify treating clinker-related emissions as a separate carbon-cost item.

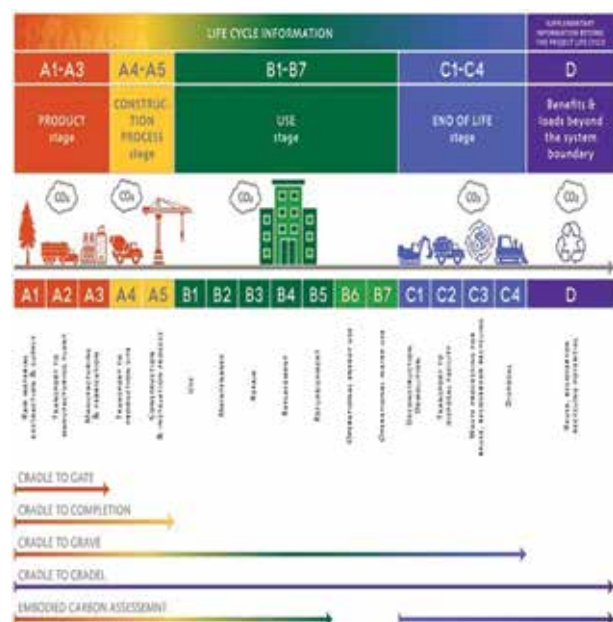


Figure-1: Life-cycle boundary for embodied

carbon assessment, highlighting the A1–A3 product stage relevant to cement manufacturing. (Source: NITI Aayog (2026), Scenarios Towards Viksit Bharat and Net Zero – Sectoral Insights: Buildings)

Quantitative Profile of India's Cement Sector

According to the GCCA India & TERI's (2025), Decarbonization Roadmap for the Indian Cement Industry: Net Zero CO₂ Emissions by 2070, India is the second largest cement producer in the world, accounting for about 8% of the world's installed cement capacity and about 7% of the country's CO₂ emissions. Per capita consumption is around 300 kg compared to 540 kg globally, meaning potential demand growth. As per GCCA India & TERI, the emission intensity was 680 kg CO₂/tonne in 2020, which is set to reduce to 560 kg by 2030 and further to 510 kg by 2047, a reduction of about 18% and 25%, respectively. This emission-intensity pathway is shown in Table 1.

Parameter	2020 (Base)	2030 (Target)	2047 (Target)
Average sector emission intensity (kg CO ₂ /tonne cement)	680	560	510
Approx. reduction over base year	—	~18%	~25%

Table 1: India cement sector – average emission intensity trajectory (Source: GCCA India & TERI)

Through energy efficiency, renewable electricity, alternative fuels and lower clinker factor, CEEW's pathway reduces cement intensity from 0.66 to 0.44 tCO₂e/tonne. There are a number of measures with negative mitigation costs, which is consistent with capital appraisal.

CareEdge ESG's 2026 report on BRSR disclosures of 20 listed cement companies at the company level reports Scope 1 emissions rose from 184 MtCO₂e in FY22 to 215 MtCO₂e in FY24, while combined Scope 1 and Scope 2 emission intensity declined by about 9%. The 2020 intensity benchmark of 680 kg CO₂e/tonne, GCCA India-TERI targets and CCTS intensity requirements can support standards and variance analysis.

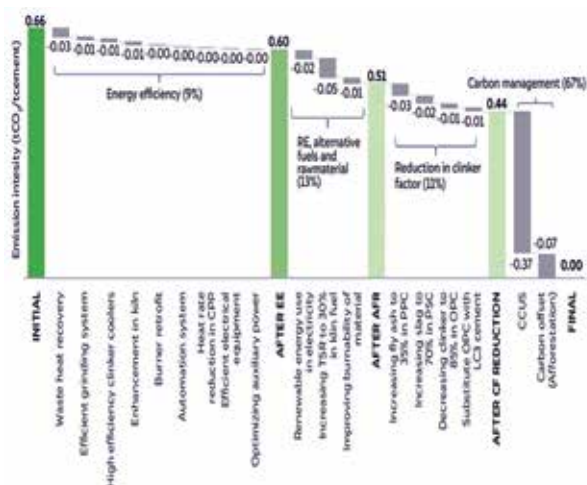


Figure-2:Carbon-management pathway for reducing emission intensity of the Indian cement industry.

Source: CEEW, Evaluating Net-zero for the Indian Cement Industry.

Regulatory Architecture: From PAT to the Carbon Credit Trading Scheme

For designated entities in covered sectors, the PAT framework is being gradually transitioned to the CCTS compliance mechanism, under which entities are subject to GHG emission-intensity targets. MoEFCC notified binding GEI targets in October 2025 for the first four sectors including cement. CCTS requirements are important for cost accountants and internal MIS.

Feature	Detail
Governing framework	Carbon Credit Trading Scheme (CCTS), 2023, administered by BEE/MoEFCC, gradually replacing the PAT scheme for specified sectors and obligated entities
Phase 1 notification	Greenhouse Gas Emission Intensity (GEI) targets were notified in October 2025 for four sectors, covering 282 obligated industrial units, of which 186 were cement units at that stage.
Phase 2 notification	Petroleum refining, petrochemicals, textiles and secondary aluminium added in January 2026, covering 208 further industrial units.

Baseline and target years	FY 2023-24 baseline; binding GEI targets apply for FY 2025-26 and FY 2026-27
Cement-specific reduction range	Approximately 4.7% to 7.6% reduction in emission intensity over the two-year target period, varying by cement sub-sector and plant
Non-compliance consequence	Deficit entities must purchase Carbon Credit Certificates (CCCs) to cover the shortfall; failing this, CPCB levies an Environmental Compensation equal to twice the average CCC price for that compliance year's trading cycle
Market launch	The institutional framework for the Indian Carbon Market is operational, with Grid Controller of India as registry operator and CERC as regulator. As of March 2026, no CCCs had yet been issued to obligated entities.

Table 2: Key design features of the Carbon Credit Trading Scheme as applicable to cement (Source: BEE/MoEFCC notifications; ICAP; industry compliance guides, 2025–26)

For plant controllers, emission intensity has become a KPI along with cost and energy per tonne, with direct P&L implications. By comparing standard and actual emissions, carbon-credit market price and GEI targets will enable systematic efficiency and compliance variance analysis.

A Cost and Management Accounting Framework for Embodied Carbon

Within this framework, plant-level CCTS emission intensity is used as a management-accounting proxy for the carbon intensity of cement production and does not reflect full lifecycle embodied carbon.

1. Carbon as a Costed Element of the Product

Within management accounting, carbon emissions can be incorporated into internal product costing using a compliance price, shadow price or other internally determined carbon valuation, and managed through budgeting, control and variance analysis



Figure 3: Cement composition directly influences carbon emissions, (Source Global Cement and Concrete Association (GCCA), Blended Cement – Green, Durable and Sustainable, 2022.)

2. Standard Costing Extended to Carbon: The Carbon Cost Card

A carbon cost card is an extension of the standard costing which compares the standard GHG emission intensity and carbon price with actual intensity and carbon cost. A hypothetical 40 lakh tonne cement plant is used as an example.

Element of Carbon Cost Card	Standard	Actual
Cement output (tonnes)	40,00,000	40,00,000
Emission intensity (tCO ₂ e / tonne cement)	0.66	0.60
Total carbon emissions (tCO ₂ e)	26,40,000	24,00,000
Illustrative internal Carbon price (₹ / tCO ₂ e)	900	900
Total carbon cost (₹ crore)	237.60	216.00

Table 3: Illustrative Carbon Cost Card, XYZ Cement Ltd, a hypothetical entity constructed for exposition. The 0.66/0.60 intensity figures are scenario values from CEEW's sector abatement pathway analysis; plant size and carbon prices ₹900 are illustrative planning assumptions only and are not presented as actual CCC market prices.

3. Carbon Intensity, Compliance and Efficiency Variance Analysis

The following proposed management-accounting variances extend the logic of traditional usage variance analysis to carbon emission performance:

1. Carbon Efficiency Variance = (Standard

Emission Intensity – Actual Emission Intensity)
× Actual Production

2. Carbon Compliance Variance = (CCTS Target Emission Intensity – Actual Emission Intensity)
× Actual Production

Applying these formulae gives results in Table 4.

Variance	tCO ₂ e	Amount (₹ crore)
Carbon Efficiency Variance	2,40,000 (F)	₹21.6 crore (F)
Carbon Compliance Variance	80,000 (F)	₹7.20 crore (F)

Table 4: Carbon variances, XYZ Cement Ltd (F = Favorable); Hypothetical ref. CCTS target assumed as 0.62 tCO₂e/t cement for illustration. The total improvement from the standard intensity to actual intensity is 2,40,000 tCO₂e is ₹21.60 crore. Of this, 80,000 tCO₂e (₹7.20 crore) represents emissions below the assumed CCTS target, monetary amount is calculated by multiplying the emission variance by the illustrative ₹900 price.

The Favorable compliance variance is 80,000 tCO₂e, reflecting that emissions are below the assumed 0.62 tCO₂e/tonne reference target used solely for this illustration. This value is a hypothetical assumption for demonstrating the variance calculation. An unfavorable variance will indicate excess emissions which may require corrective action. So, variance analysis is the link between traditional cost control, operational efficiency and carbon compliance performance.

4. Allocating Cement-Related Embodied Carbon to a Functional Unit

The bill of materials gives traceability of plant-level cement emission intensity to cement-related embodied carbon at functional units used in construction and green-building assessments. The example assumes M25 concrete with 320 kg cement/m³ and 0.40 m³ concrete/m² built-up area, actual values depend on mix design and structural requirements.

Functional Unit	Standard	Actual
Cement intensity (tCO ₂ e / tonne cement)	0.660	0.600
Cement content assumed in M25 concrete (kg/m ³)	320	320

Embodied carbon per m ³ concrete, cement fraction (tCO ₂ e/m ³)	0.211	0.192
Concrete consumption assumed (m ³ /m ² built-up area, RCC frame)	0.40	0.40
Embodied carbon per m² built-up area, cement fraction (kg CO₂e/m²)	84.5	76.8

Table 5: Illustrative allocation of cement-linked embodied carbon to concrete and built-up area (mix and consumption ratios are indicative planning assumptions and will vary by grade, mix design and structural system)

The calculation connects plant level carbon intensity with project level reporting. Reducing intensity cuts cement-related carbon from 84.5 to 76.8 kgCO₂e/m². This is not the total embodied carbon for the building, as other materials, transportation, construction and life-cycle stages also contribute. The framework also helps CMAs measure carbon performance, identify potential efficiency improvements, assess exposure to CCC and link plant data with project reporting.

Strategic and Disclosure Implications for Cost and Management Accountants

The BRSR and assured sustainability disclosures can be strengthened by considering embodied carbon as a costed item. CEEW recommends internal carbon pricing for NPV, IRR and Payback period appraisal. EU CBAM covers cement under its definitive regime from 1 January 2026, making it reliable embedded-emissions data relevant for Indian cement exports to the EU.. CMAs should develop consistent policies regarding the measurement, recognition and disclosure of CCC.

Recommendations

- Develop a carbon cost card for each notified CCTS-sector plant and update it each compliance cycle against the applicable GEI target.
- Extend existing variance-reporting MIS to include carbon efficiency and compliance variances.
- Implement an internal shadow carbon price for capital appraisal based on entity's realized or forecast carbon-credit exposure.

- Establish policies for recognition, measurement and disclosure of Carbon Credit Certificates.
- Track CBAM-related embedded-carbon figures separately for export volumes and reconcile them with domestic CCTS data.

Conclusion

Embodied carbon is fast becoming a cost and compliance issue in India's cement industry. CCTS framework creates opportunity for management-accounting tools such as standard costing, carbon cost cards, variance analysis and project level reporting. Compliance monitoring, BRSR reporting, capital appraisal and CBAM exposure are underpinned by the separation of emission performance from monetary valuation. Carbon measurement and disclosure can improve decision-making, cost control and performance management. MA

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