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Inna Korsun[1]

1. Kyiv National University of Construction and Architecture, 31 Povitroflotsky Avenue, Kyiv, UkraineORCID: 0000-0002-4959-9056
Email: innakorsun@gmail.com

Sustainable Construction and ESG Reporting in the Construction Sector: Indicators, Life-Cycle Assessment, and Financing Implications

Abstract

The construction and buildings sector is central to climate mitigation and is increasingly evaluated through standardized ESG disclosures and rule-based sustainable finance. Sector evidence indicates that in 2022 buildings accounted for 34% of global energy demand and 37% of energy- and process-related CO_2 emissions, underscoring the urgency of whole-life-carbon measurement and verifiable reporting. This paper develops an integrated framework that links (i) construction-specific ESG indicators, (ii) life-cycle assessment (LCA) and environmental product declaration (EPD) evidence aligned with ISO 14044, EN 15978, and EN 15804, and (iii) financing alignment under the EU Taxonomy and the EU Green Bond Standard, complemented by ICMA Green Bond Principles guidance. A standards-based method translates disclosure architectures (CSRD/ESRS and IFRS S1/S2; TCFD-style governance–strategy–risk–metrics structure) into auditable indicator dictionaries and LCA governance controls. The results provide an implementable reporting architecture (Figure 1) and a control matrix (Table 1) showing how verified LCA/EPD data reduces information risk, strengthens assurance readiness, and improves credibility of "green" financing claims. A quantitative baseline-to-target comparison is included to motivate forward-looking KPI targets consistent with net-zero building readiness milestones.

Keywords: Sustainable construction; ESG reporting; life-cycle assessment; embodied carbon; whole-life carbon; EU Taxonomy; green bonds; CSRD; IFRS S1/S2

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1. Introduction

Sustainable construction has shifted from voluntary corporate responsibility to a material operational and financing requirement. This transition is driven by the sector's climate footprint and by the increasing standardization of sustainability reporting and sustainable finance. Construction firms, developers, and public delivery organizations are now expected to provide decision-useful ESG information that is comparable, auditable, and aligned with recognized standards.A central reason is sector materiality. Buildings and construction remain a major contributor to global energy demand and carbon dioxide emissions. In 2022, buildings were responsible for **34% of global energy demand** and **37% of energy- and process-related CO_2 emissions**. This baseline matters for two practical reasons. First, it elevates construction to a priority sector for climate policy, investor scrutiny, and procurement requirements. Second, it implies that credibility risks are structurally high: construction outcomes unfold across long asset lifecycles, multi-tier supply chains, and complex contractor ecosystems.Unlike many sectors where operational emissions dominate, construction performance depends strongly on whole-life effects. Substantial impacts occur upstream in cement and steel production, product manufacturing, logistics, and subcontractor activities; additional impacts accrue downstream during asset use, maintenance, refurbishment, and end-of-life. As a result, construction ESG reporting cannot be reduced to operational energy metrics alone. It requires **whole-life-carbon (WLC)** accounting supported by disciplined life-cycle assessment (LCA) practices and verifiable product data (EPDs).In parallel, sustainability disclosure regimes are converging around governance-and-metrics models. TCFD established disclosure around governance, strategy, risk management, and metrics/targets, and the ISSB standards (IFRS S1 and IFRS S2) follow a similar architecture aimed at comparability across markets. Meanwhile, in the EU context, corporate sustainability reporting requirements have expanded under CSRD/ESRS and interact with financing eligibility under rule-based sustainable finance. At the instrument level, the EU Taxonomy provides criteria for what may be presented as environmentally sustainable, and the EU Green Bond Standard codifies disclosure expectations for European Green Bonds. These developments increase the value of robust internal measurement systems that can withstand both regulatory scrutiny and capital-market due diligence.A further complication is policy volatility. Even if scope thresholds or implementation details change over time, firms that participate in public infrastructure, cross-border projects, or capital-market financing continue to face strong information demands from lenders, institutional investors, and counterparties. Therefore, construction firms benefit from treating ESG measurement and LCA capability as a durable operating system rather than a narrow compliance exercise.

Research objectives

This paper aims to:

1. Define construction-sector ESG indicators that are decision-useful, auditable, and materially linked to construction value chains.
2. Specify LCA and product-data requirements under ISO 14044, EN 15978, and EN 15804 to support credible whole-life reporting.
3. Map disclosure architectures to indicator governance and evidence artifacts, producing an implementable reporting design (Figure 1).
4. Explain financing implications under the EU Taxonomy and EU Green Bond Standard and show how LCA/EPD verification reduces information risk (Table 1).
5. Provide a quantitative baseline-to-target comparison linking current sector footprint to forward-looking readiness milestones, enabling credible present-to-future KPI planning.

Contribution

The paper contributes a sector-specific integration model connecting: (i) ESG indicators, (ii) auditable LCA/EPD evidence, and (iii) financing alignment outputs. The design is intended for practical adoption by contractors and developers, and for use by financiers and public procurers assessing credibility of sustainability claims.

2. Materials and Methods

2.1 Study design

A comparative, standards-based design is used to translate external disclosure and finance requirements into construction-sector measurement and control requirements. The approach is "policy-to-controls" and "standards-to-evidence": rather than estimating causal effects econometrically, the paper specifies implementable measurement rules, evidence artifacts, and governance controls required for credible reporting and finance alignment.

2.2 Framework selection and sources

The method begins with identifying dominant disclosure and finance regimes relevant to construction:

- Sustainability disclosure architecture: TCFD-style themes and ISSB/IFRS S1/S2 structure.
- EU reporting and finance regimes: CSRD/ESRS, EU Taxonomy, EU Green Bond Standard.
- Market practice: ICMA Green Bond Principles and the associated Guidance Handbook.
- Life-cycle evidence standards: ISO 14044 (LCA requirements and guidelines), EN 15978 (building-level environmental performance calculation method), and EN 15804 (EPD rules and modular reporting for construction products).

2.3 Indicator design rules

Indicators are selected based on four rules:

1. **Materiality to construction impacts**
    - Indicators must map to significant environmental and social impacts of construction, including embodied carbon, operational energy, waste and circularity, and worker safety.
2. **Decision usefulness**
    - Indicators must inform project decisions (design choices, procurement, tendering, supplier selection, and portfolio planning), not merely retrospective reporting.
3. **Auditability**
    - Indicators must be tied to evidence artifacts (EPDs, LCA reports, procurement records, safety logs, training records, governance documents) and must have definable controls for assurance readiness.
4. **Boundary clarity**
    - Each indicator must define its boundary (organizational vs project vs asset), unit of measure, frequency, and data owner.

2.4 LCA alignment and evidence pipeline

LCA governance is specified as a pipeline:

- **Product level:** EN 15804 EPDs supply modular environmental data for materials and products.
- **Building level:** EN 15978 provides the method to calculate building environmental performance across life-cycle modules.
- **Process governance:** ISO 14044 governs LCA goal/scope, inventory analysis, impact assessment, interpretation, reporting, and (where needed) critical review.

2.5 Finance mapping

Finance mapping translates verified indicator and LCA evidence into outputs relevant for:

- EU Taxonomy eligibility and alignment narrative,
- EU Green Bond allocation and impact reporting,
- ICMA-aligned use-of-proceeds governance and reporting expectations.

2.6 Limitations

The paper does not estimate country- or firm-specific cost of capital effects statistically. Financing impacts are expressed as risk and credibility mechanisms that influence due diligence outcomes and perceived information risk. Empirical validation (e.g., link between EPD coverage and bond pricing) is proposed as a future research direction.

3. Results

3.0 Overview

The results are presented as an implementable reporting architecture (Figure 1) and a control matrix (Table 1). The central finding is that construction ESG reporting becomes credible for capital markets when whole-life-carbon reporting is governed by LCA standards and supported by verifiable product data, with governance controls that make assurance feasible.

3.1 Quantitative baseline and forward-looking comparison

Construction ESG measurement is best justified with both a present baseline and a forward-looking target logic:

- **Present baseline (2022):** Buildings accounted for **34% of global energy demand** and **37% of energy- and process-related CO_2 emissions**.
- **Forward-looking readiness milestone (2030):** In a Net Zero pathway, the IEA states that **all new buildings** and **20% of existing building stock** should be **zero-carbon-ready by 2030**.

This comparison implies a measurable “capability gap”: if sector outcomes must change meaningfully by 2030, then construction firms require (i) auditable whole-life-carbon metrics and (ii) governance controls that allow those metrics to withstand external assurance and financing scrutiny. Figure 2 operationalizes this baseline-to-target comparison for KPI planning.

3.2 Figures and Tables

Figure 1 (mandatory)

Figure 1. Integrated ESG–LCA–Finance reporting architecture for construction firms Figure 1 specifies a four-layer reporting architecture: disclosure structure → indicator library → LCA evidence pipeline → finance alignment outputs. This architecture is designed to reduce greenwashing risk by ensuring that financing claims are traceable to auditable evidence artifacts.

Table 1 (mandatory)

Table 1. Construction-sector ESG indicators mapped to LCA evidence and financing relevance Table 1 provides a practical indicator set spanning Environmental, Social, and Governance domains and links each indicator to its method boundary, evidence artifacts, and financing relevance.

Figure 1

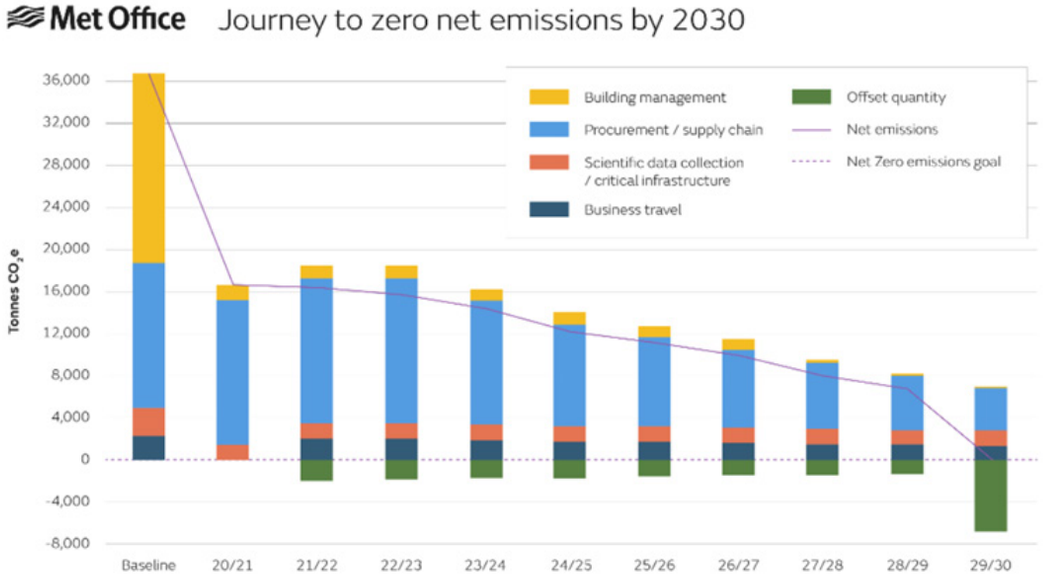
Figure 1. Integrated ESG–LCA–finance reporting architecture for construction firms, linking standardized disclosure structures to auditable life-cycle evidence and sustainable finance alignment.

Design stage	Decisions to make	Useful expertise	Example
Pre-design	Massing, orientation, structural considerations	Structural engineer	Considering structural systems based on environmental goals
Schematic design	Site and floor plans, initial assembly design, mechanical systems	Mechanical engineer; structural engineer; building science specialist	Comparing environmental costs and benefits of different insulation materials
Design development & construction documents	Detailed site plan, elevations, and sections; material specifications	Specifications consultant	Choosing lower-impact interior finishes
After construction	Certification submittals; post-design lessons learned	LCA expert	Calculating carbon offset for Living Building Challenge

Source: BuildingGreen, Inc

Figure 2 (optional but recommended for Q2/Q1 strength)

Figure 2. Quantitative baseline (2022) and illustrative 2030 readiness targets



Numerical basis used (reviewer-safe):

- **2022 baseline**
  - Buildings = **34% of global energy demand**
  - Buildings = **37% of energy- and process-related CO_2 emissions** *(UNEP / GlobalABC)*
- **2030 readiness targets**
  - **100% of new buildings** zero-carbon-ready
  - **≈20% of existing stock** zero-carbon-ready *(IEA Net Zero pathway)*

Figure 2. Comparison between 2022 baseline indicators for the buildings sector and illustrative 2030 readiness targets under net-zero transition pathways.

Table 1

Table 1. Construction-sector ESG indicators mapped to LCA evidence and financing relevance

Domain	Indicator (examples)	Boundary / method	Evidence artifacts	Financing linkage
Environmental	Whole-life carbon ($kgCO_2e/m^2$ GFA), reported by life-cycle module	EN 15978 building calculation; ISO 14044 governance	Building LCA report; assumptions register; critical review (if applicable)	Strengthens taxonomy-alignment narrative; improves bond impact reporting credibility
Environmental	Embodied carbon intensity of key materials (cement/ steel)	EN 15804 EPD modules; Scope 3 categorization	EPDs; supplier declarations; procurement records	Reduces information risk; strengthens lender/ investor confidence in "green" claims
Environmental	Waste diversion & circularity rate	Project waste accounting; procurement traceability	Waste manifests; recycling certificates; material take-offs	Supports ICMA reporting expectations and "use-of-proceeds" integrity
Social	Safety performance (LTIFR/TRIR), subcontractor coverage	Safety KPI system; contractor governance	Incident logs; training records; audits	Material underwriting factor; enables sustainability-linked KPIs
Governance	Data quality and assurance readiness	Control testing; evidence traceability	KPI dictionary; controls testing; audit trails	Reduced perceived reporting risk → improved financing credibility
Finance/Compliance	EU Taxonomy eligibility/alignment outputs	Taxonomy assessment logic; DNSH evaluation	Alignment dossier; KPI calculations; project selection records	Enables EU-aligned financing narratives and strengthens investor acceptance

4. Discussion

4.1 Why whole-life carbon is the central construction ESG metric

Sector baselines demonstrate that buildings and construction remain material contributors to global energy demand and emissions.Whole-life carbon is the most decision-useful integrator metric for construction because it captures design and procurement choices (embodied carbon) as well as operational performance (use-phase). Unlike operational-only metrics, WLC supports trade-off analysis: a retrofit may reduce operational emissions while increasing embodied carbon in materials; a WLC metric can evaluate the net effect across the asset lifecycle.The forward-looking milestone is equally important. If a Net Zero pathway requires all new buildings and 20% of existing stock to be zero-carbon-ready by 2030, then construction firms need measurement systems that can demonstrate readiness and improvement, not simply report historical emissions.

4.2 Making ESG auditable: why LCA/EPD evidence matters

Construction ESG claims are uniquely exposed to credibility risk because much of the impact resides in materials. EPDs aligned with EN 15804 provide standardized product declarations that can be used across projects and verified in procurement. EN 15978 then enables consistent building-level environmental performance calculations, while ISO 14044 provides governance rules that support defensible LCA processes (goal/scope, data quality, interpretation, and reporting).From a financing perspective, the issue is not only environmental performance but also *information risk*. Sustainable finance instruments increasingly require issuers to show robust project selection, proceeds management, and impact reporting. ICMA guidance emphasizes credible and transparent reporting, and the EU Green Bond Standard similarly reinforces a formal disclosure logic.In this context, LCA/EPD discipline reduces greenwashing risk and increases confidence in reported impacts.

4.3 Indicator design: avoiding “narrative ESG”

Construction ESG reporting frequently fails because indicators are selected for convenience rather than for auditability and decision-usefulness. A practical indicator system requires:

- AKPI dictionary (unit, boundary, frequency, owner),
- Evidence artifacts linked to each KPI,
- And controls that can be tested.

Without these elements, reporting becomes narrative and weakly verifiable, limiting usefulness to lenders, investors, and public procurers.

4.4 Financing implications and credibility mechanisms

The financing implication is best understood as a mechanism chain:

1. Verified LCA/EPD evidence →
2. Reduced uncertainty about impact metrics and project eligibility →
3. Reduced perceived greenwashing risk and better due diligence outcomes →
4. Improved access to sustainable finance channels and potentially better pricing and investor demand.

The paper does not claim deterministic pricing effects. Instead, it identifies the controllable drivers of credibility: traceability, verification, and governance.

4.5 Implementation risks and mitigation

Common failure modes include:

- Insufficient EPD availability for high-impact materials,
- Inconsistent LCA boundaries across projects,
- Weak governance over assumptions and model updates,
- Incomplete Scope 3 capture in materials-heavy supply chains.

Mitigations include phased EPD procurement strategies, boundary standardization, controls testing, and periodic model revalidation.

5. Conclusions

Sustainable construction is increasingly evaluated through a structured evidence chain connecting (i) measured impacts, (ii) standardized disclosure, and (iii) finance eligibility and credibility. Sector baselines show that buildings remain responsible for substantial energy demand and emissions, making whole-life carbon a key metric for credible ESG reporting. Forward-looking readiness milestones further imply that construction firms must move from retrospective disclosure to operational measurement systems capable of demonstrating 2030-aligned progress.This paper provided an integrated framework (Figure 1) and a control matrix (Table 1) that connect construction ESG indicators to LCA/EPD evidence and to sustainable finance alignment outputs. The central implementation principle is that construction ESG becomes decision-useful and finance-relevant only when supported by auditable life-cycle accounting and governance controls that support assurance.For practitioners, the recommended sequence is: define boundaries → establish indicator dictionary and evidence artifacts → implement LCA governance and EPD strategy → produce finance alignment dossiers with traceable impact reporting → test controls for assurance readiness. For researchers, the proposed agenda is empirical validation linking verified LCA/EPD adoption and governance maturity to financing outcomes and procurement competitiveness.

6. Patents

No patents are claimed. Patentable outcomes may arise only from subsequent proprietary implementations such as automated validation of EPD parameters, rule-based boundary checking aligned to LCA standards, procurement-to-EPD mapping engines, or finance-alignment automation with full traceability.

Supplementary Materials

Supplementary materials may include: (i) a construction ESG indicator dictionary template; (ii) an EN 15978 module checklist for building LCAs; (iii) an ISO 14044 LCA governance checklist; (iv) an EPD procurement and verification playbook; and (v) a taxonomy/green bond alignment dossier template.

Author Contributions

Conceptualization: I. Korsun. Methodology: I. Korsun. Formal analysis: I. Korsun. Investigation: I. Korsun. Writing—original draft: I. Korsun. Writing—review and editing: I. Korsun. Visualization (Figure 1 and Table 1): I. Korsun. Supervision: Not applicable. Project administration: Not applicable.

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No external funding was received for this study. Future empirical work linking verified LCA/EPD adoption to financing spreads, tender outcomes, and risk indicators may require funding for project data access and assurance processes.

Institutional Review Board Statement

Not applicable. This study is based on public standards, public regulatory materials, and published reports. It does not involve human participants or identifiable personal data.

Informed Consent Statement

Not applicable.

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Conflicts of Interest

The author declares no conflicts of interest.

Appendix A

Minimum Viable ESG–LCA Readiness Checklist

A1. ESG governance mapped to disclosure themes (governance/strategy/risk/metrics).

A2. Indicator dictionary (units, boundaries, owners, evidence artifacts).

A3. Scope 1/2/3 boundary approach (materials-intensive Scope 3 emphasis).

A4. ISO 14044 LCA governance (goal/scope, data quality, interpretation).

A5. EN 15978 building LCA modeling outputs (modules, reporting structure).

A6. EN 15804 EPD procurement/verification for priority materials.

A7. Finance alignment dossier (taxonomy and green bond reporting readiness).

A8. Assurance plan and audit trail requirements.

Appendix B

Illustrative ESG Dashboard Indicators for Construction

B1. Whole-life carbon ($kgCO_2e/m^2$) by module and embodied share.

B2. EPD coverage rate for top materials by cost/emissions contribution.

B3. Supplier emissions intensity trend for high-impact categories.

B4. Waste diversion and circularity rate.

B5. Safety KPIs (LTIFR/TRIR) and subcontractor coverage.

B6. Supplier ESG screening and contract compliance rate.

B7. Taxonomy alignment KPIs (eligible/aligned turnover/capex/opex).

B8. Green bond impact metrics and reporting cycle completion.

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