Integrating Circularity Indicators into Life Cycle Assessment: A Framework Based on EPDs in the Building Sector

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The transition to a circular economy (CE) in the building sector requires more than reducing environmental impacts; it calls for integrating material efficiency, reuse, durability, repairability, and recyclability into product design and assessment. Environmental Product Declarations (EPDs), developed according to EN 15804, are widely used to communicate the life cycle environmental impacts of building products. However, their potential to support circularity assessment depend on reporting of CE-related indicators information.

This study investigates how circularity-related information is currently reported in building product EPDs and explores the alignment of life cycle data for EPD with the circularity standard ISO 59020 and ISO 59040. A structured content analysis was conducted on published EPDs across major construction material categories including aluminium, steel, cement, timber, glass, and ceramics to identify the presence, and quality of circularity indicators data.

The completeness of circularity information largely depends on the declared life cycle modules: cradle-to-gate EPDs (A1–A3) often omit use-phase (B) and end-of-life (C, D) data which are critical for circularity assessment. Results show that while indicators such as recycled content, recyclability, and recovery potential are commonly used and reported, others relating to design for reuse, repair, or refurbishment are rarely included in life cycle assessment for developing EPD. Furthermore, many EPDs rely on generic or default assumptions relating to use phase, recycling and recovery rates, limiting comparability across materials.

The study recommends extending module declarations, improving reporting consistency for circularity indicators in line with ISO 59020 and ISO 59040, and introducing circularity scores (e.g., Material Circularity Indicator MCI or Circular Transition Indicator CTI) within EPDs. These improvements would enhance transparency, comparability, and the usefulness of EPDs as tools for supporting circular design and procurement in the building sector.

INTRODUCTION

While Environmental Product Declarations (EPDs) primarily focus on reporting environmental impact indicators such as climate change, acidification, and eutrophication, information related to circular economy (CE) attributes is not fully addressed. Although EN 15804 provides a structured framework for life cycle inventory and life cycle assessment and allows the reporting of end-of-life benefits beyond the system boundary through Module D. Though, module D is not included in all types of EPDs, particularly those based on a cradle-to-gate scope (module A1-A3). Circularity information relevant to the use stage (module B) is also not covered in all types of EPDs. As a result, valuable data on circularity aspects may not be fully represented in an EPD, making it difficult to support circular design or procurement decisions.

While EN 15804 focuses on environmental impact assessment through life cycle inventory data (modules A–D), ISO 59020 and ISO 59040 focus on measuring and reporting circularity performance using product life cycle inventory. This research contributes to addressing circularity data alignment according to ISO 59020 (Circularity Performance – Measuring Circularity) and ISO 59040 (Circularity Data sheet for reporting). By reviewing EPDs from selected product categories such as concrete, steel, timber, aluminium, cement, and ceramics, this study identifies which circularity indicators are currently reported in relation to the declared modules (A–D) and examines how better alignment with the ISO circularity framework could enhance the consistency and comparability of circularity information.

LITERATURE REVIEW

- ISO 59010:2024 Circular economy — Guidelines on business model and value network implementation
- ISO 59020:2024 Circular economy — Measuring and assessing circularity performance
- ISO 59040:2025 Circular economy — Product circularity data sheet
- ISO 59014:2024 Environmental management and circular economy — Sustainability and traceability of the recovery of secondary materials — Principles, requirements and guidance
- Material circularity indicator (MCI) and Circular transition indicator (CTI)

Circularity indicator Category	Circularity indicator
Resource Inflows (Mandatory)	Average reused content
	Average recycled content
	Average renewable content
Resource Outflows (Mandatory)	Percent actual reused products and materials
	Percent actual recycled material
	Percent actual recirculated material in the biological cycle
Resource Outflows (Optional)	Average lifetime of product or material relative to Industry average
Energy and Water (Optional)	Average per cent of energy consumed that is renewable energy
	Per cent water withdrawal from inflow circular sources
	Per cent water discharged in accordance with quality requirements
	Ration (onsite or internal) water reuse or recirculation
Economic (Optional)	Material productivity
	Resource intensity index

(Reference: ISO 59020:2024)

Enhancing Circularity in Construction through EPDs

EPD
(Environmental Product Declaration)

Provides data on recycled content and reuse potential

↓

Includes end-of-life scenarios (recycling, reuse, landfill)

↓

Guides circular design & procurement decisions

↓

Encourages closed-loop material flows

↓

Improved Circularity in Construction

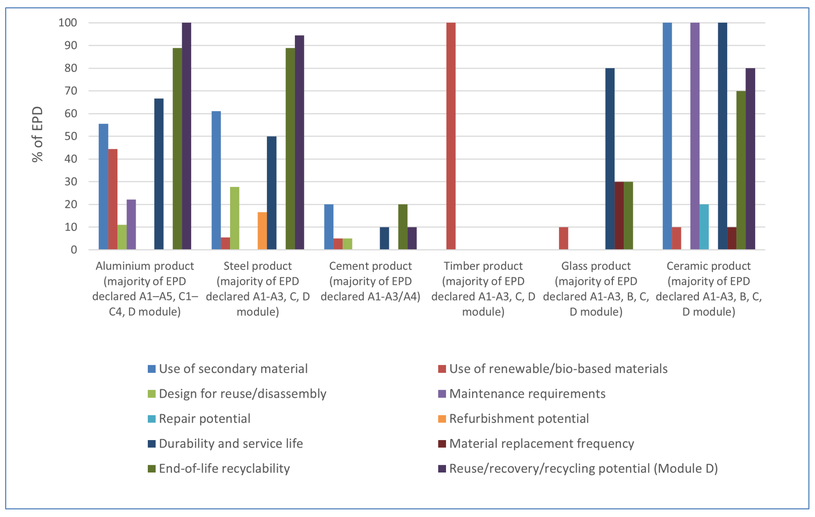
METHODOLOGY

Alignment of life cycle data frameworks between EN 15804 and ISO 59020/59040

ISO 59020 Indicator		ISO 59040 Data Requirement (Reporting & Communication)	Relevant life cycle inventory data, EN 15804 (Environmental Impact Assessment)
Circularity Aspect	(Circularity Measurement)		
Material Inputs	Average reused content	Reused content (%)	Use of secondary material (Modules A1–A3)
	Average recycled content	Recycled material (% pre/post-consumer)	Use of secondary material (Modules A1–A3)
	Average renewable content	Renewable materials (%)	Use of renewable/bio-based materials (Modules A1–A3)
		Material composition (mass fractions)	Material composition (Modules A1–A3)
		Hazardous substances declaration	
Circular Production	% renewable energy	Renewable energy share (%)	Total energy and water inputs (renewable/non-renewable energy and circular source of water use is included) (Modules A1–A3/A4)
	% water from circular sources	Water reuse/recirculation volume	Total energy and water inputs (renewable/non-renewable energy and circular source of water use is included) (Modules A1–A3/A4)
Durability and Lifetime	Average lifetime of product/material relative to industry average	Product lifetime (reliability)	Average product lifetime/durability (B2–B5, Use Phase)
		Maintenance/repair description	Maintenance requirements (B2 Maintenance)
		Repair/upgrade potential	Repair potential (B3 Repair) (B4 Replacement)
		Demounting/disassembly ease	Design for reuse/disassembly (C1 Deconstruction/Demolition)
		Reuse/refurbishing feasibility	(C3 Waste Processing), (B5 Refurbishment)
End of Product Use (Outflows)	% actual reused	Dismantling/remanufacturing	Waste processing for reuse/recovery/recycling (C3 Waste Processing)
	% actual recycled	Recycling fraction recoverable	Waste processing for reuse/recovery/recycling (C3 Waste Processing)
	% actual recirculated in biological cycle	Composting/biodegradability	
	% water discharged in accordance with quality requirements	Product portion released to environment	
	Ratio of (onsite or internal) water reuse or recirculation		
Circularity Benefits		Environmental/resource benefits summary	Recovery/reuse/recycling potential (Module D Benefits beyond system boundary)
Economic Indicators	Material productivity		
	Resource intensity		

ISO 59000:2024 family of circular economy standard and other Circularity tools

Quantitative overview of the circularity indicators in EPD



ANALYSIS

Key observations from the analysis include

- While some indicators, such as use of secondary material, recyclability, and recovery potential, are reported relatively frequently, mainly because the relevant modules are commonly declared, others, such as repair potential, refurbishment potential, and maintenance requirements, are rarely included because module B (use stage) is often not declared. EPDs limited to modules A1–A3 typically lack data on use-phase and end-of-life indicators, whereas those including modules B, C, and D provide more comprehensive circularity-related information.

- Many EPDs rely on default or generic assumptions for use stage inventory, recycling and recovery rates, which may not accurately represent actual product-specific or regional conditions. These Data limitations and reporting inconsistencies reduce the comparability and reliability of circularity-related information within and across product categories.

- The life cycle inventory (LCI) data collected for the life cycle assessment (LCA) used in EPD generation can also support a quantitative assessment of circularity performance (e.g., calculation of a circularity score). However, none of the evaluated EPDs currently provide information on quantitative assessment of circularity performance measurement, which could be incorporated by EPD developers where applicable.

RECOMMENDATIONS

1. Extending Life Cycle Modules to Include Circular Economy Data

- EPD developers can include modules B (use) and C (end-of-life) whenever possible, as these modules provide critical data for assessing circularity. Module B, in particular, can provide valuable data on durability, maintenance, and refurbishment potential, which is important for assessing product circularity.
- Highlight the contribution of module D (benefits beyond the system boundary) for reuse, recycling, and energy recovery. For example, highlight, how circularity contributes to reducing environmental impacts (e.g., avoided resource use, reduced emissions).

2. Increase Reporting of Circularity Indicators

- Circularity indicators be reported consistently across all relevant modules, with clear definitions aligned to ISO 59020 and 59040. Consider including realistic scenarios for Use and End-of-Life
- Many EPDs use default values for use and end-of-life scenarios, which may not reflect actual circular pathways available in practice. For module B and C, including realistic scenarios (e.g., product lifetime, maintenance cycles, recycling rates) can improve the relevance of circularity data with ISO circularity standard.

3. Inclusion of Circularity score:

- EPD developers can calculate and present a circularity score in EPD using recognized methods such as the Material Circularity Indicator (MCI), the Circularity Technical Indicator (CTI), or other approaches described in ISO 59020. Including such a metric would allow for a clear, comparable assessment of product circularity. Including circularity score will also help to meet the ‘Design for Circularity’ credit for Green Star scheme v1.1.

4. Include more circularity information in EPD:

- Where possible, provide more circularity indicator information in EPDs, as it enables users to make informed decisions on material selection, assess product circularity performance, and identify opportunities for reuse, recycling, and resource efficiency.