How to measure the environmental sustainability: LCA based benchmarks for buildings and construction products

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RESEARCH OBJECTIVE

which is the research objective?

Analysis of different benchmarking methodologies, in order to set environmental benchmarks related to the Life Cycle Assessment (LCA) of whole-buildings and construction products

why do we do this?

There is the need of new common LCA based benchmarking methodology in the construction sector, in order to set the sustainability level of whole-building and construction materials

what is it analysed ?

Analysis of the LCA benchmarks applied in the **Green Building Rating Systems** (GBRSs)
Analysis of different benchmark typologies - **internal** and **external** benchmarks
Analysis of different benchmarking approaches - **statistical analysis** of a sample and **baseline building** modeling
Analysis of what the practitioners should do to apply LCA and LCA benchmarks

LCA BENCHMARKS IN THE CONSTRUCTION SECTOR

Where the LCA benchmarks are used ? → **Green Building Rating Systems (GBRSs)**
Energy Certifications

BREEAM, DGNB, GPR Software, HQE, ITACA Protocol, Verde, Green Star, HK-BEAM Plus, LEED, EDGE, CASBEE

Which benchmark typologies are used in GBRSs ?

External

Benchmarks fixed through the statistical analisys of a reference sample (it is composed of buildings which belong to a built environment of a specific context)

Internal

Benchmarks fixed through the analysis of a reference building modelled in accordance with the construction standards of a specific context

Which kind of benchmarks are fixed in GBRSs ?

- **Limit** → The lowest acceptable value which sets the sufficient environmental performance
- **Reference** → The average value which sets the average environmental performance
- **Target** → The highest value which sets the better environmental performance

For which building part are they fixed?

- **Construction materials** → i.e. bricks, concrete, gypsum plasterboards, insulation, etc,
- **Building elements** → i.e. structure, floors, roofs, walls, windows, etc.
- **Whole-building** → i.e. residential multi-family building, single-family house, etc.

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LCA BENCHMARKS IN THE GBRSs - analysis criteria

- **LCA criterion** → **Criterion** in which the Life Cycle Assessment is required
- **LCA system boundaries** →
  - **A1-3** Production phase
  - **A4-5** Construction phase
  - **B1-7** Use phase
  - **C1-4** End-of-life phase
- **Construction elements** → The main **building elements included in the LCA** system boundaries i.e. structures, floors, roof, external walls, internal walls, etc.
- **Environmental Impacts** → LCA environmental impact categories (they are not the same in every GBRSs, but they depend on the certification used)
- **LCA benchmarks** → **Limit** value, **Reference** value and **Target** value (internal/external)
- **Practitioner actions** → What the **practitioner** has to do, in order to calculate the LCA impact category results and obtain the criterion score

LCA BENCHMARKS IN THE GBRSs - analysis (example)

	BREEAM (UK)	DGNB (Germany)	LEED (America)
LCA criterion	Mat 01 Life cycle impacts	ENV 1.1 + ENV 2.1 - Life Cycle Impact Assessment	MR 1: Building Life-Cycle Impact Reduction
LCA system boundaries	 A1-3  A4-5  C1-4	 A1-3  B1-6  C3-4	 A1-3  B1-7  C1-4
Construction elements	Ground floors - Upper floors - Separating floors Roofs - External walls - Windows and curtain walls - Internal walls - Separating walls - Insulation - Landscaping	External walls - Roof - Floors - Baseplate Foundations - Interior walls and doors Heating anf Cooling Systems - Building services User equipment	Project's structure - Envelope - Structural floor Ceiling - Roof - Parking structure
Environmental Impacts	GWP - ODP - AP - EP - POCP - ADNP - ADP - HTP - FAETP - TETP - Nuclear waste - Waste treatment	GWP - ODP - AP - EP - POCP - PEI nrn - PEI tot	GWP - ODP - AP - EP - POCP - ADP - PEI nrn
LCA benchmarks	External	External	Internal
	A+ - A - B - C - D - E	Limit value (1 point) GWP = 13.6 kgCO2eq/m2NFA*a Reference value (5 points) GWP = 9.4 kgCO2eq/m2NFA*a Target value (10 points) GWP = 6.58 kgCO2eq/m2NFA*a	Minimum impacts reduction of 10% than a base-line building built follows the national construction standards + no impact category may increase more than 5% compared with the baseline building
Practitioner actions	Use of "BREEAM Green Impact Calculator"	Use of "Okobau.dat" database for LCA	Baseline building modelled through the American standard ASHRAE 90.1-2010 Appendix G"

CONCLUSIONS

some criticalities …

- There is no homogeneity in LCA results, due to the different LCA system boundaries and the different environmental impact categories considered
- It is no possible to compare LCA benchmark values due those differences, the different benchmarking methodologies and the different benchmark expressions used in the GBRSs (letters, numbers, percentage values)

but there are benefits …

- The LCA benchmarks can be useful for several stakeholders in different design process phases
- The LCA benchmarks permit to set threshold values through which the practitioner can make a comparison of similar buildings
- The LCA benchmarks expressed in numerical form can ensure transparent results in the Green Building Rating Systems

… and possible improvement

- The need of a common benchmarking methodology able to fix LCA benchmark values related to a specific context, which permit the comparison of the environmental performances of the buildings
- The need of a common benchmarking methodology able to change the LCA benchmark values over time according to the built environment improvement

THANK YOU FOR THE ATTENTION