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Combining LCA with circular performance for environmental building product assessment

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Objectives

- A conceptual proposal for combining environmental and circular performance indicators for building products
- A visual labelling of indicators as guidance for decision making by practitioners

Environmental targets

The building sector is consuming considerable amounts of energy and raw materials compared with other economic sectors. Building operational energy accounts for about 40% of the energy consumption and 36% of the greenhouse gas emissions in the EU [1]. Furthermore, the construction sector is generating 38% of waste [2] and consuming 32% of material resources in the EU [3].

These challenges correspond to two of the United Nations Sustainable Development goals. Goal no. 12 on Climate Action includes the target of mitigating climate change, while goal no. 13 on Responsible Consumption and Production specifies two 2030 targets: Achieving a sustainable management and efficient use of natural resources and substantially reducing waste generation through prevention, reduction, recycling and reuse.

Problem formulation

One of the puzzle pieces for increased resource efficiency is available knowledge on the environmental performance of building products, which guides practitioners in making greener decisions. Presently, there applicable information on environmental impacts and circular economy potential of building products is often not sufficient and product labels and certification schemes use different methods. At the same time, the circular economy (CE) movement has initiated experimental building and product innovations beyond established approval procedures and supply chains.

Life cycle assessment (LCA) is an internationally standardised [4, 5] and widely adopted approach for building environmental assessment. However, the method is not fully developed regarding circular processes and multiple life cycles in the building sector. Furthermore, circular aspects in building and product cycles are too complex to communicate in a way supporting practitioner decisions. If the circular potential of building products is to become an influential parameter for building design, easy to understand and reliable guidance, comparable with the U-value, is needed [4].

A number of circularity metrics exist in the research community, however, often lacking the integration of environmental impact assessment methods or using alternative approaches [7]. The organisations behind major initiatives on circular material flows, cradle-to-cradle [8] and circular economy [8], have recently extended their conceptual approach with performance indicators for practical purposes [10, 11]. These schemes base the environmental assessment on the LCA-method aside more specific circularity criteria. Another approach, The Material-Cycle-Status [12] is a visual multiple-criteria indicator developed for building practitioners. It rates the circular potential, End of Life (EoL) scenarios, actual versus potential recycling content and the biotic closed-loop potential.

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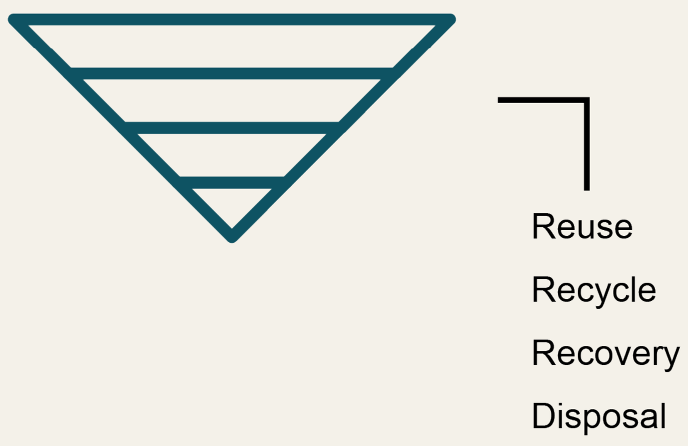
Product performance indicators

The scope should support decision making regarding environmental impacts, resource use and circular economy potential as well as helping the practitioner evaluating the risk of novel solutions. The proposed four indicators combine LCA with circularity for accommodating two types of interest: Product-level environmental performance based on LCA and a circular performance on the product as well as systemic level. Finally, a risk evaluation supplements the indicators. Since circular building solutions often lack precedence, performance can hardly been evaluated ignoring technical and functional reliability.

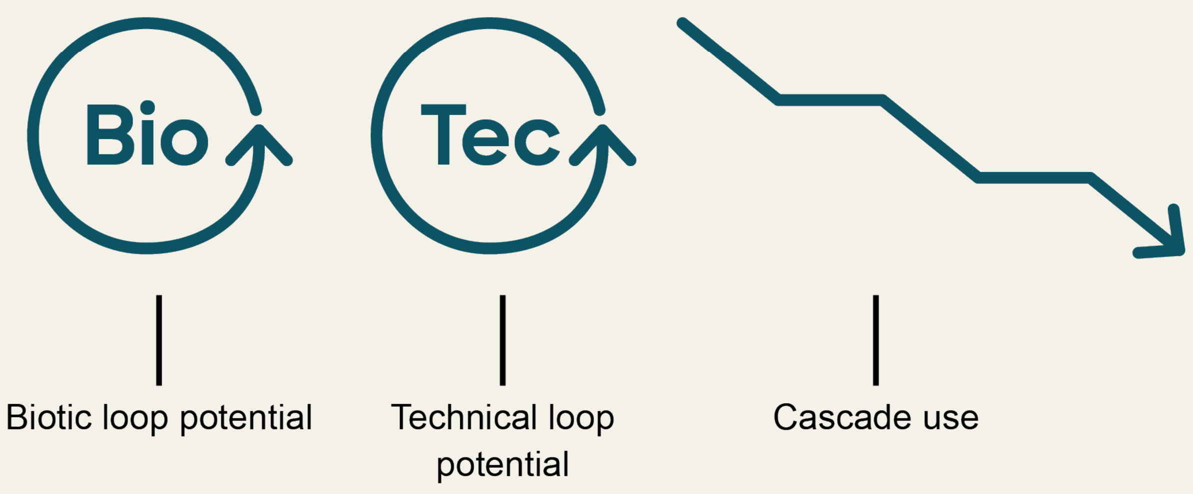
Circularity demand

Products with secondary material content demand existing buildings as material banks. Since the building product phase happens at the beginning of a building cycle, the immediate environmental effect is indicated and can be influenced by material choice. Two assessment criteria apply: The percentage of secondary materials related to virgin material use and the circular value of the secondary materials.



The circular value aligns to the EU waste hierarchy [13] including the relevant steps reuse, recycling, recovery and disposal in the order of priority. Material combinations may be represented by each flow separately.

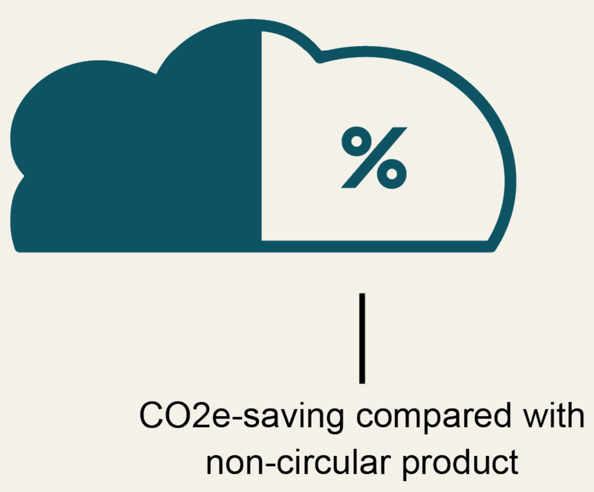
Circularity supply



The supply side of circularity is the potential supply as material source for future product cycles. The circular value is indicated by one of the three symbols (biotic loop, technical loop, cascade use) or a combination of them. It includes both the EoL scenario and supporting material loops or cascades in an infinite circular economy perspective. For both scenarios apply two variants: A business-as-usual scenario based on current average technology and practice and a technically optimised scenario based on present cutting edge technology. The concept for multiple future cycles resemble the logic of replacements in in the conventional LCA framework, however without defined study period. A long-term stable circular value across subsequent cycles can be compared to a long service life in the context of replacements.

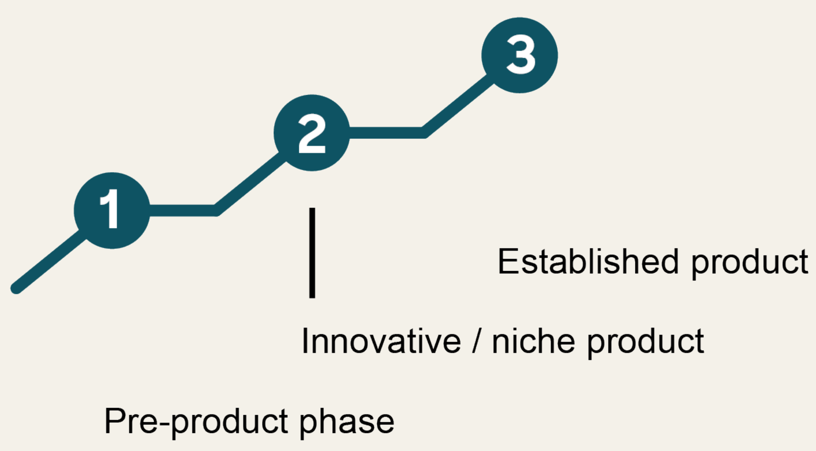
Environmental footprint

This indicator represents the environmental performance of the respective product cycle based on LCA [5, 6]. Scenarios and preconditions are based on the two circularity indicators. The assessment of secondary material sources must follow the latest standardisation [6] and guidelines [14]. The Global Warming Potential, given as CO2 equivalent (CO2e) is selected for demonstration reasons and represents any relevant impact or resource category.



Maturity

This indicator is independent from the environmental and circularity assessment. Allocating risk among parties is particularly relevant when substituting proven solutions with non-standard products. The assessment results in a maturity level on a 3-step scale from the state of experimental to approved products. The result is a function of the assessment criteria technical level of development and market uptake.



The first criterion evaluates the documented technical performance compared with a conventional product. The other criterion reflects, how established the product is on the marked, evaluated by market share and the duration of being on the market.

Conclusion

A draft for four indicators, which combine life cycle environmental assessment and circular potentials, has been presented. Particular weight was laid on the current situation, where more and more circular solutions are being tested meeting the demand for innovations in light of public sustainability goals. By assessing environmental, circular and feasibility aspects, these indicators are targeted to building practitioners making design decisions. Thus, a visual communication of the indicators is proposed, inspired by product label information design.

The LCA-based method used for environmental footprinting has been published elsewhere [15]. The development of assessment criteria underlying the other three indicators is a draft proposal and requires further development and testing.

Acknowledgements

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