

Influence of functional unit selection on environmental impact assessment of structural systems made of reinforced concrete, mass timber, and structural steel

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Summary

Life cycle assessment (LCA) is one of the standardized frameworks widely used for evaluating the environmental impacts of buildings. Despite the guidance of international standards, namely, ISO 14040:2006 and ISO 14044:2006, LCA results remain highly sensitive to functional unit selection – the metric for normalization.

This study evaluates how different functional unit selections influence comparative LCA results for nineteen case studies. Each case study includes multiple functionally equivalent design scenarios for building structural systems composed of reinforced concrete, mass timber, or structural steel. This study applies four different metrics (i.e., functional units) to report the environmental impact assessment results for each structural material option.

Functional units: (i) gross floor area, (ii) net floor area, (iii) gross floor area and service life, and (iv) net floor area and service life.

Environmental impact categories: climate change, ozone depletion, acidification, eutrophication, photochemical ozone formation, and depletion of fossil resources.

Key Takeaways:

- 1. Design scenarios with the highest environmental impacts (Figure 1):** Each material selection can be the highest-impact or lowest-impact alternative for a case study, depending on the environmental impact category and functional unit selection.
- 2. Influence of functional unit selection on LCA results (Figure 2):** Different functional unit selection alters LCA results for structural steel buildings by a maximum of 4%, while for reinforced concrete and mass timber buildings, changes can be up to 15% and 18%, respectively.
- 3. Influence of functional unit formulation on LCA results (Figure 2):** Incorporating service life into the functional unit formulation has a greater influence on LCA results (up to 15%) than incorporating floor area type (a maximum of 3%).
- 4. Drivers of sensitivity to functional unit selection:** Sensitivity of LCA results to functional unit selection is governed by the interplay between the material selection, functional unit formulation, and environmental impact category under analysis. Therefore, structural material selections should be conducted by multi-impact category LCAs and different functional unit selections to provide robust information for decision making.

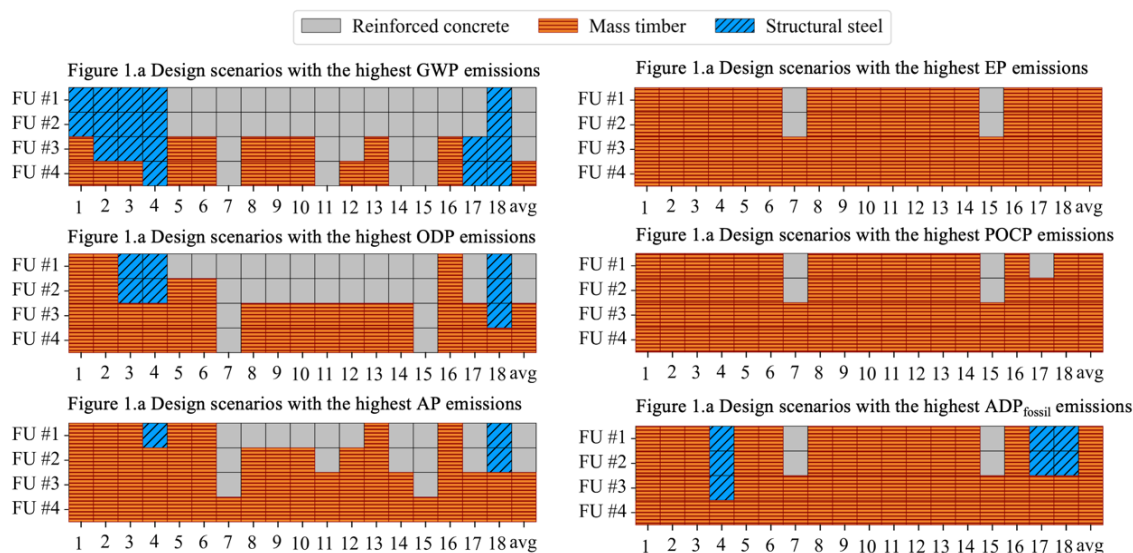


Figure 1. Design scenarios with the highest environmental impacts per case study corresponding to functional unit selection and environmental impact category.

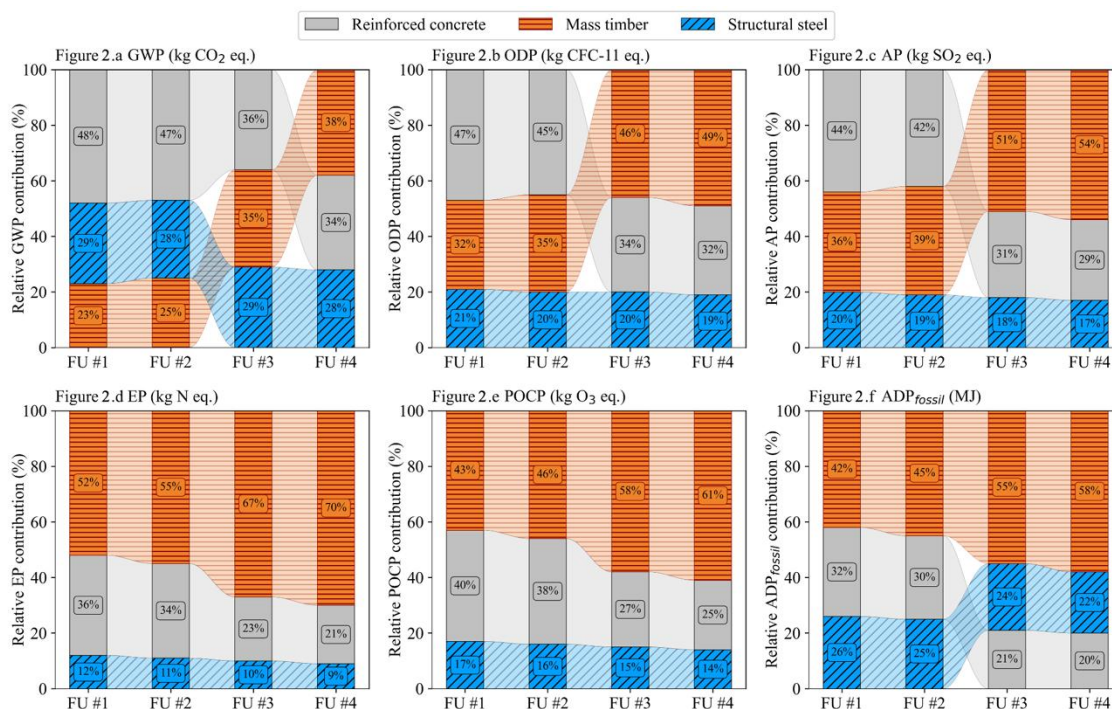


Figure 2. Sensitivity of comparative LCA results to functional unit selection for six environmental impact categories.