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Uncertainty and Sensitivity Analysis for Evaluating the Building Element's Replacement in Building LCA

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1 Introduction

When performing an LCA calculation, reliability and consistency issues derive from the uncertainty and variability of the input data, as already discussed in Huijebregts (Huijbregts, 1998). One important parameter, governed by high uncertainty is the service life calculation of the building elements, as already mentioned by different studies and summarized in Grant (Grant, 2010). Furthermore, another uncertainty of the building elements' service life is linked to insufficient information, concerning the material choices, during the early design stages of the building process.

In this study, the service life of building elements is considered stochastically in order to include their uncertainty in the building LCA output. The probability density functions of the service lives of building elements were defined with a consistent way, using input data from an international data collection. Finally, it was examined how the uncertainty of the LCA result can be allocated to the different sources of the input uncertainty (different building elements), using a sensitivity analysis (Saltelli, 2004).

2 Methodology

The general probabilistic framework, followed in the current study, has been already proposed, as for example in Padey (Padey *et al.*, 2013). The probability density functions of the building elements' service lives were defined with a systematic way, based on the DUREE database, which gather service lives for different building elements from the international literature, (Goulouti, *et al.*, 2020). The uncertainty analysis followed and 40'000 Monte Carlo simulations were computed. Finally, a global sensitivity analysis conducted and the Sobol' Indices were calculated, in order to identify the building elements, whose uncertainty mostly influences the LCA uncertainty.

3 Results

The methodology was applied to a building case study that represents a single-family house (SFH) in Switzerland. The building was decomposed in four building elements (technical systems, façade and roof elements and interior layout), according to the functional nomenclature of the Swiss Standard, *i.e.* eBKP-H – SN 506 511 (CRB, 2012). The decomposition corresponded to a screening LCA. The uncertainty analysis was conducted and the probabilistic LCA [$\mu = 23.20\ \mathrm{kg\ CO_{2-eq}}\ /(\mathrm{m^2 y})$, $(\sigma^2 = 5.5^2)$], was calculated for the GHG emissions. The sensitivity analysis followed, by calculating the Sobol' Indices and the results revealed that the uncertainty on the service lives of the façade elements and the interior layout mainly explain the LCA uncertainty. In addition, a detailed LCA was conducted, by decomposing the building in fourteen building elements and the results of the sensitivity analysis confirmed the preliminary results of the screening LCA.

4 Conclusions

The current study presented a systematic way to treat probabilistically the replacement rate of the building elements and quantified the impact of the service lives' uncertainty on the LCA output. Two of the main outcomes of the study are:

- A screening and a detailed LCA was conducted using the DUREE service life database. The results of the sensitivity analyses were similar; the façade elements and the interior layout explain mainly the LCA uncertainty.
- The screening and the detailed LCA revealed that the uncertainty of the technical systems service lives present low impact on the LCA uncertainty. In further probabilistic LCA analysis, the LCA model could be simplified and conventional deterministic values from the standards (SIA 2032, CRB) could be used for the service life of this building element.

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