Addressing high variability in LCA with Global Sensitivity Assessment: from a single parameterized model to multi-parameterized clustered models

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The application of Life Cycle Assessment (LCA) has been traditionally based on deterministic models that provide estimates of the environmental impacts of complex processes through sets of single-value parameters. Too often, this approach neglects to provide the potential distributionof the response of specific systems linked either orboth to uncertainty (due to lack of knowledge in parameters, models and practitioner's decisions) and to variability (caused by inherent differences between locations, technologies and temporal frames for example).

Global sensitivity analysis (GSA)is an efficient method to quantify the impact of both causes of LCA results variance from each input's variationandto support LCA model simplification. However, uncertainty and variability have different implicationswhen refining LCA parameterized models to enhance their quality, so the identification of the main cause of variationis an essential step.

If uncertainty is the major source of variation, the improvement of the LCA model may be obtained by collecting additional information of the system that allows:i) a deeper knowledge of the model parameters, ii) the development of a more detailed and relevant model or iii) a change in arbitrary decisions affecting LCA results.On the contrary, the predominance of variability reveals the existence of potential significantly different alternatives of the modeled process. Consequently better qualified estimates of the environmental impacts cannot be obtained by acquiring more precise input data.

In this work, we propose a method to improve thequality of LCA results linked to variability-based variation in complex models by

1) Identifying whether variability is actually the main cause of variation or not,
2) Grouping the different alternatives into a relevant set of system typologies.Such clustering step does reduce the range of LCA results for each typology,

3) For each cluster, setting a simplified parametrized model based on key parameters responsible for most of the cluster'svariability.

We apply this approach to the quantification of the greenhouse gas (GHG) emissions from the building sector by taking as an example the residential building stock of a representativetown in Luxembourg. The methodreduces the GHG estimates variabilityinduced by agenericsingle parameterized LCA model for all existing types of buildings by establishing multi parameterizedclustered modelsbased onbuilding type-specific key parameters.