Simplified LCA user-friendly tool to eco-design returnable bottles scenarios

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1. Introduction

Returnable bottles are one of the most promising strategies to reduce the environmental impacts of food packaging. Companies usually use the same generic values to justify their development (e.g., -79% GHG emissions compared to single-use (ADEME, 2018)). In addition, they rely on only a few parameters when speaking of optimize the environmental performances (mostly the return rate and the mass of the bottles). We developed a user-friendly tool to help stakeholders evaluate and optimize their returnable bottle systems. Based on simplified parametrized LCA models (Padey et al., 2013, Douziech et al., 2021), it combines the results' simplicity of use and scientific accuracy.

2. Methods

To ensure the tool covers a realistic diversity of existing systems, we built a typology of configurations for returnable bottle strategies, helped by private companies (e.g., the drink producer can do the cleaning or not, which can potentially affect the environmental impacts). In parallel, we developed Python scripts to generate simplified parametrized LCA models from impact equations. This consists of simplifying the impact equations by (1) identifying the input parameters that make the results vary, applying Sobol' method (Sobol, 2001) on Global Sensitivity Analysis, and (2) setting the non-key parameters to the mean value in the equations (figure 1). The simplified models were applied with the stakeholders of H2020 FAIRCHAIN (https://www.fairchain-h2020.eu/) to optimize the implementation of returnable bottles strategies for a new innovative whey-based drink. We developed an interface for small and mid-sized stakeholders to include LCA results when developing local distribution strategies. Facing the difficulty of making decisions, expressed by the stakeholders, including a large number of – obscure – indicators, we also worked on the usability of the results presented in the tool to be used for decisions. This was done by selecting a limited number of indicators to display by looking at the correlations between impact categories when simulating thousands of random systems with simplified models.

3. Results and discussion

3.1 Simplified parametrized LCA models

The simplified models developed show an excellent ability to balance simplicity and robustness. For instance, the first simplified model developed in FAIRCHAIN helps to reduce the required data from 46 to 13, while explaining 90% of the total variability of the results for all impact categories of the EF3.0

method. It is, in addition, possible to discuss with the stakeholders the possibility of setting some other input data (e.g., in the case, it is difficult to collect) considering its impact on the results (as the share of variance due to each of the remaining parameters is known). We experimented with the search for trade-offs with project partners. We generated simplified models for the configurations considered in the research project and provided scripts and protocol to generate more.

3.2 User-friendly tool

We developed an interface that aims to (1) guide the user through the typology to the simplified model corresponding to its system and (2) produce LCA results with a limiting dataset. The expert version of the tool also allows the user to generate its own simplified models. The observation of correlations showed a good potential to reduce the number of indicators (from 16 to 5 for the first simplified model) to consider when comparing scenarios without compromising the whole environmental picture.

4. Conclusions

In the FAIRCHAIN research project, we explored the necessary trade-off between users' requirements ("we need it to be simple") and scientists' positions ("we want it to be robust"), and proposed an answer for the development of returnable bottle strategies: a user-friendly tool based on statistical simplification methods. The tool was developed and tested with future users, involved in the research project, involving practical constraints and ideas for future improvements, and large diffusion of the tool beyond the project.

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6. References

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Figure 1. Protocol used to generate simplified LCA models for a given archetype from the typology of returnable bottles systems. For a given archetype, the protocol is applied independantly to every impact category.