Packaging re-use in the circular economy: an LCA evaluation

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The transition towards a circular economy, where the value of products, materials, and resources is maintained for as long as possible, and the generation of waste minimized, is an essential contribution to the European Union's efforts to develop a sustainable, low carbon, resource efficient, and competitive economy (European Commission, 2015). Re-use plays a central role in the circular economy, as a waste prevention activity. Re-use means any operation by which products or components are used again for the same purpose for which they were conceived (European Commission, 2008).

Because of their purpose to contain consumable goods, packaging items are particularly prone to re-use. The aim of this study is to assess the environmental impacts associated with the life cycle of some reusable packaging identified in the Italian context (Rigamonti et al., 2019), i.e. Intermediate Bulk Containers (IBCs), steel drums, and Reusable Plastic collapsible Crates (RPCs). The IBCs are reusable industrial containers designed for the transport and storage of bulk liquid and granulated substances, such as chemicals, food ingredients, solvents, pharmaceuticals, etc. Steel drums are used for carrying chemical and petrochemical products, whereas RPCs are usually used in the fruit and vegetables distribution system. Life Cycle Assessment (LCA) was used to assess the impacts of re-use as a function of the number of uses (the so-called "rotations"), and to quantify the contribution of the reconditioning process to the total impacts of the life cycle, in order to understand if a system based on re-use performs better than a system based on single-use.

The function of the analyzed system is to provide ready-to-be-used reusable packages. The functional unit was assumed as 100 packages (IBCs or steel drums or RPCs) ready for the n^{th} use, with *n* included between 1 and 5 for IBCs, 1 and 10 for steel drums, and 1 and 125 for RPCs (Figure 1). The system boundaries include:

- the packages production;
- the reconditioning process;
- the end of life of the packages (after *n* uses and after being discarded in the reconditioning process);
- the end of life of all the residues generated during the reconditioning process;
- the transport of the packages to the reconditioning plant and that of the wastes to the disposal/recycling plants.

Some plants situated in the North of Italy were surveyed in order to gather primary information on the reconditioning process. Based on these data, the layout and the mass balance of an average reconditioning plant for the three different packages were defined.

For IBCs and steel drums, the results of the LCA show that the impacts of the life cycle of the package mainly come from its manufacturing step, whereas the reconditioning process accounts for less than 20% of the overall impacts for most of the considered indicators. The main burdens of the reconditioning process are associated with the transport from the users to the plant, with the disposal of the solid residues contained in the IBCs bottles and in the drums, and with the disposal of the non-recoverable bottoms (only for IBCs system). It is thus important the behaviour of the users, which should remove any solid/chemical residues from the packages before sending them to reconditioning. Moreover, a widespread distribution of the reconditioning plants in the national territory could reduce the burdens associated with the transports. When comparing reconditioning vs. single-use, the system where IBCs/drums are reconditioned and re-used has better environmental performance than the system where the same IBCs/drums are used only once and then sent to recycling/disposal. The advantages of such a system increase with the number of rotations (Biganzoli et al., 2018 and 2019). For example, considering the steel drums, in case just two rotations take place the environmental impacts of a system based on re-use are on average about 74% of those of a single-use system, and drop to 53% if the number of uses increases to 10 (Biganzoli et al., 2019).

Unlike the previous typologies of package, the reconditioning process of the RPCs shows a non-negligible contribution to the impacts of the overall life cycle when increasing the number of uses. For example, if a crate is used only for 5 times, the reconditioning process accounts for less than 15%, but in case of more than 100 uses, the contribution of the same process can reach 70% of the whole impact, depending on the analysed indicator. The main burdens are associated with the transport of the crates from the users to the reconditioning plant, with the consumption of electrical energy by the reconditioning process, and with the washing step. Nevertheless, after 2 uses, the system where crates are reconditioned and re-used shows better environmental performance than the single-use system where crates of the same capacity (with a 60% lower average weight) are used only once and then sent to recycling/disposal.

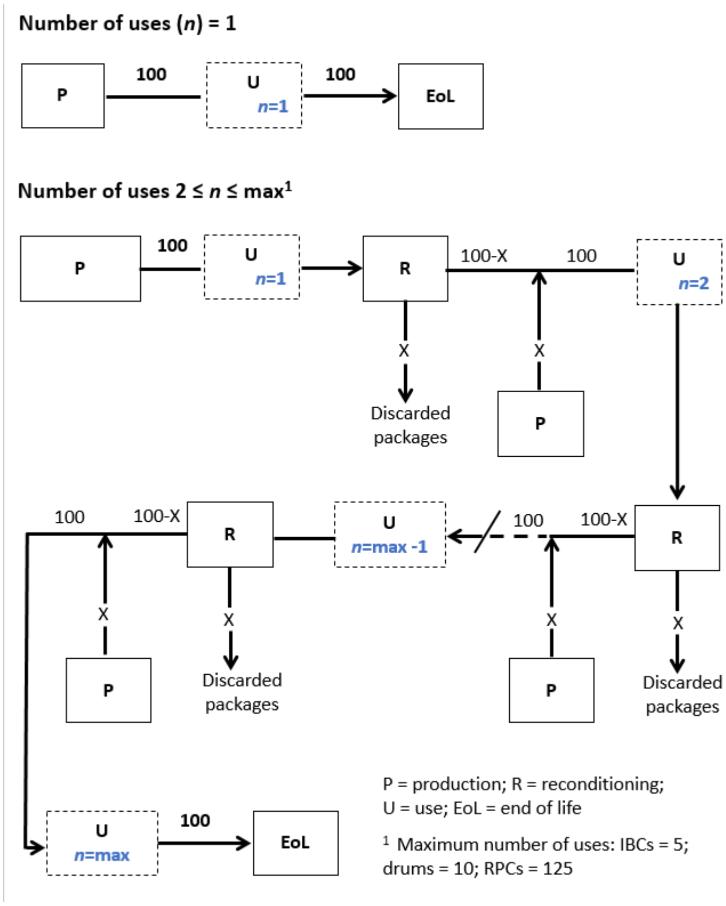

Figure 1. Simplified chart of the life cycle of 100 packages as the number of rotation changes.

References

Biganzoli L., Rigamonti L., Grosso M. (2018). *"Intermediate bulk containers re-use in the circular economy: an LCA evaluation"*. Procedia CIRP 69, 827-832. 25th CIRP Life Cycle Engineering (LCE) Conference, 30 April – 2 May 2018, Copenhagen, Denmark.

Biganzoli L., Rigamonti L., Grosso M. (2019). *"LCA evaluation of packaging re-use: the steel drums case study"*. Journal of Material Cycles and Waste Management, 21, 67-78.

European Commission. COM (2015) 614/2 Communication from the Commision to the European Parliament, the Council, the Eruopean Economic and Social Committee of the Regions: Closing the loop – An EU action plan for the Circular Economy; 2015.

European Commission. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives. Official Journal of the Euopean Union, 22.22.2008, L 312

Rigamonti L., Biganzoli L., Grosso M. (2019). *"Packaging re-use: a starting point for its quantification"*. Journal of Material Cycles and Waste Management, 21, 35-43.

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