

The importance of Life Cycle Inventory accuracy in the ecodesign of an innovative PHA production biorefinery

Martina Pelliconi^{1,2}, Serena Righi^{1,2}

NOTA: come da mail inviata al comitato organizzativo, il seguente abstract viene sottomesso alla valutazione del comitato scientifico per una short-presentaton.

Abstract:

To meet European Commission's Green Deal ambitious goal of reaching carbon neutrality within 2050 (European Commission, 2019), a switch towards circular economy appears decisive. In recent years, stringent norms and design standards acquired more and more importance in promoting this shift (Hartley et al., 2020). One of the most significant policies on the matter is the Ecodesign Directives (2005/32/EC; 2009/125/EC) which aim to minimize environmental impacts by considering them since the first stages of product development, thus, anticipating and preventing them. While the Ecodesign Directives focused on energy-related products, their principles and scope can be expanded (Barkhausen et al., 2023). This trend is noticeable in Europe's 2020 Circular Economy Action Plan, which announces the will to bring the ecodesign standards beyond the energy-related products (European Commission, COM(2020)98) and in the ongoing work on the Proposal for Ecodesign for Sustainable Products Regulation, which "is the cornerstone of the Commission's approach to more environmentally sustainable and circular products" (European Commission, <https://commission.europa.eu/>). When talking about innovative processes and products, the aforementioned principles should be incorporated from the earlier stages of research and development, as there is more flexibility in process design, lower costs for change, and more room for improvement (Cucurachi et al., 2018; Moni et al., 2020). Environmental Life Cycle Assessment (LCA) appears as one of the most valuable available tools to implement sustainability. Therefore, ecodesign principles and LCA should be coupled since early-stages of product development.

In this context fits the Horizon Europe-funded BioLaMer project, of which University of Bologna is leading the environmental sustainability work package. The general aim of the project is to demonstrate a proof-of-principle innovative biorefinery for the production of two biopolymers, polyhydroxyalkanoates (PHA) and chitosan, from food waste. PHAs are biopolymers with properties that resemble those of conventional plastics, of which are seen as a more sustainable alternative. However, their high production cost hinder their market penetration (Cristóbal et al., 2016), therefore more cost-effective production lines are sought, while granting the environmental sustainability of the process. To accomplish this, BioLaMer focuses its attention on the feedstock, whose choice and treatment can greatly vary PHA production environmental impact (Dietrich et al., 2017). This applies also to PHAs produced at industrial scale, which often use agricultural feedstock that has been related to elevated impact on several environmental categories (Kendall, 2012). Biolamer element of innovation stands in a high-impact, low-cost feedstock for biopolymer production: the food eating black soldier fly larvae (*Hermetia illucens*). The use of this larvae can lead not only to a more efficient PHA production route, but also to a mitigation of food waste disposal in an upcycling and circular vision. The process is currently advancing, testing various PHA production solutions. LCA is performed simultaneously. At the moment, a first-instance Life Cycle Inventory (LCI) is under development.

Here, we would like to focus the attention on how aiming to apply ecodesign principles can have implications since these early stages of LCA. When working with innovative processes there is an inconsistency between the scale at which LCA is directly performed, usually a laboratory one, and the ecodesign framework, which aim to minimize environmental burdens also at pilot or industrial level. This gap can be closed by scale-up modelling, which is however not always easy and straightforward. To avoid inaccuracies in the scaled-up impact assessment, a precise Life Cycle Inventory (LCI) appears

¹ Affiliazione: Università di Bologna, Centro Interdipartimentale di Ricerca per le Scienze Ambientali, Via S.Alberto, n. 163, Ravenna, Italia

² Affiliazione: Università di Bologna, Dipartimento di Fisica e Astronomia "Augusto Righi", Viale Berti Pichat, n.6/2, 40127, Bologna, Italia

essential. A LCI based as much as possible on single-operation unit processes permit to follow the frequent variations occurring as the process itself is optimized. Moreover, it allows an accurate representation of the production process, leading to less imprecisions in the scale-up procedures. In this way it is possible to have a better understanding of the expected impacts at higher technology readiness levels, which is strictly connected to ecodesign principles. This applies also to the BioLaMer case where the circularity of the process is assumed by the idea itself – by being based on waste upcycling – but strong and decisive conclusions on its sustainability in a pilot scale is based on accurate scaled-up impact assessment, which find its roots in the lab-scale LCI.

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