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ECO-DESIGN OF AN INNOVATIVE ENVIRONMENTAL BIOREFINERY TO PRODUCE ADDED VALUE
CHEMICALS FROM WASTE

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Purpose: In order to face current environmental challenges we need to progressively shift from a global and fossil-based production to a local and bio-based production. Using locally produced organic waste to fuel the production of chemicals represents, then, an attractive option because of high availability and low feedstock costs. The aim of BIORARE project (Investissement d'Avenir ANR-10-BTBR-02) is to evaluate how bioelectrochemical technologies could be combined to existing waste treatment facilities, namely two steps anaerobic digestion processes in order to encourage environmental biorefineries producing “waste-based” chemicals. A strategy for life cycle assessment-based eco-design was elaborated in order to help to refine the biorefinery concept and to identify environmentally sensitive parameters.

Methods: From complete laboratory testing and proof of concept, BIORARE scenario was fully simulated for the production of bioethanol and niche market molecules. Two environmental assessment phases were carried out: a LCA of BES materials and operation to eco-design this core element of the BIORARE scenario and a LCA of BIORARE scenario compared to current bio-based chemical production scenarios.

Results: LCA results and sensitivity analysis showed that BES components could generate high impacts depending on the way they are implemented in the process, especially when BIORARE scenario is compared to alternative current agro-based production scenarios. Moreover, important CO₂ emissions were identified in the BES unit and the waste treatment line. Improvement strategies were thus implemented to recover CO₂ streams in the purpose of allocating lesser environmental impacts and a higher added value to BIORARE.

Conclusions: Lots of strategies and technologies have been developed to recycle at best different types of waste whilst fitting in the concept of circular economy. Environmental biorefineries relying on bioelectrochemical systems are an attractive concept since it aims at producing useful platform chemicals from waste derived outputs (CO₂, organic substrate, electricity and heat). We manage to model various implementation schemes for these biorefineries through a LCA methodology, in order to identify key environmentally sensitive design parameters and to select best potential implementation strategies, thus illustrating how LCA approaches could be used to steer eco-design of innovative processes.