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Life Cycle Sustainability Assessment of a Biorefinery for the Valorisation of Brewer's Spent Grain

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Introduction

Today agricultural residues and side streams are not valorised and still considered as a waste instead of a valuable resource. If the potential of these residues and side streams is recognised, products with a high value added can be produced with a biorefinery approach. A high potential for residue and side-stream usage lies in beer production: in Europe, 34 billion litres of beer were produced in 2021 and each cubic metre of beer produces 0.2 ton of the side-product bagasse.

Within the European Project "CHEERS", the side streams of beer production are transformed to five competitive and innovative bio-based products in a biorefinery. One output of this biorefinery involves utilizing brewer's spent grain as feed for mealworms (Tenebrio molitor larvae) to produce protein flour. This protein flour can subsequently be utilized in the production of protein-rich shakes, catering to consumers seeking a nutritious dietary option.

The other four products are created by microbiological processes. They use carbon dioxide from the beer fermentation as input for their processes instead of releasing it to the atmosphere. Together with methane from the anaerobic digestion of wastewater, the following products are created: single cell protein and volatile fatty acids as ingredients for pet food, chlorine to be used in disinfectants, and ectoine for use in cosmetic products (Figure 1).

This research describes the methodological approach for a comprehensive Life Cycle Sustainability Assessment (LCSA) quantifying environmental, social, and economic impacts of this biorefinery, namely the impact on climate change, resource depletion, biodiversity, and primary energy demand. The impact of the high value-added products produced by the biorefinery will be compared to both other ways of using and treating brewer's spent grain and to the conventional production of the products produced by the biorefinery.

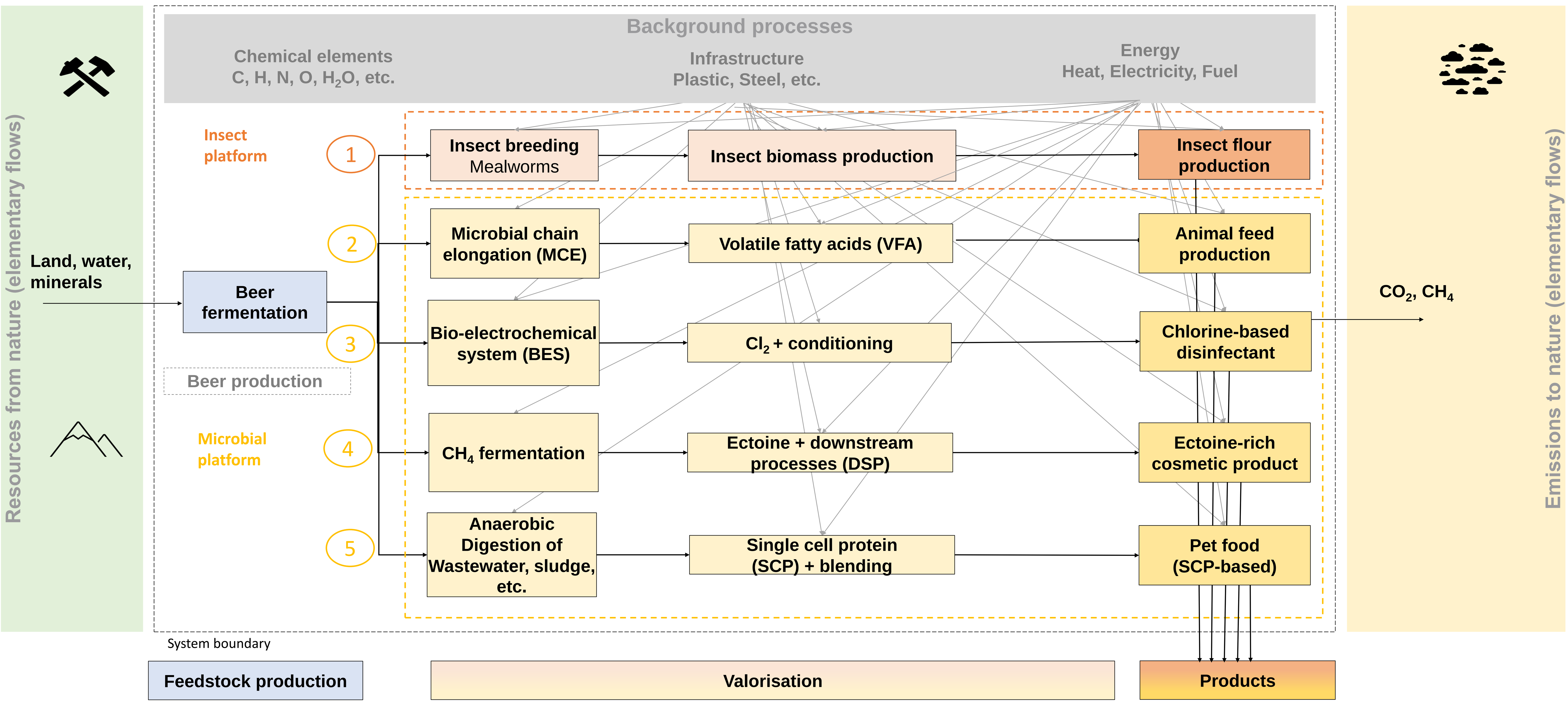

Figure 1. CHEERS System model of all platforms

Goal and Scope

The goal of our project is to provide a comprehensive evaluation of the CHEERS biorefinery system to valorise wastes (namely brewer's spent grain, yeast, wastewater, and CO_2 from fermentation) produced in a brewery in Europe with a comprehensive LCSA by considering not only its environmental aspects but also social and economic dimensions (Figure 2). By taking a holistic perspective, LCSA aims to identify potential hotspots, trade-offs, and synergies across different life cycle stages and sustainability dimensions. The assessment will follow internationally recognized standards and methodologies such as ISO 14040/14044, EU ILCD and PEF methods, and the UNEP Guidelines on social LCA. Through this LCSA, the project aims to gain a holistic understanding of the environmental and social implications associated with the evaluated processes.

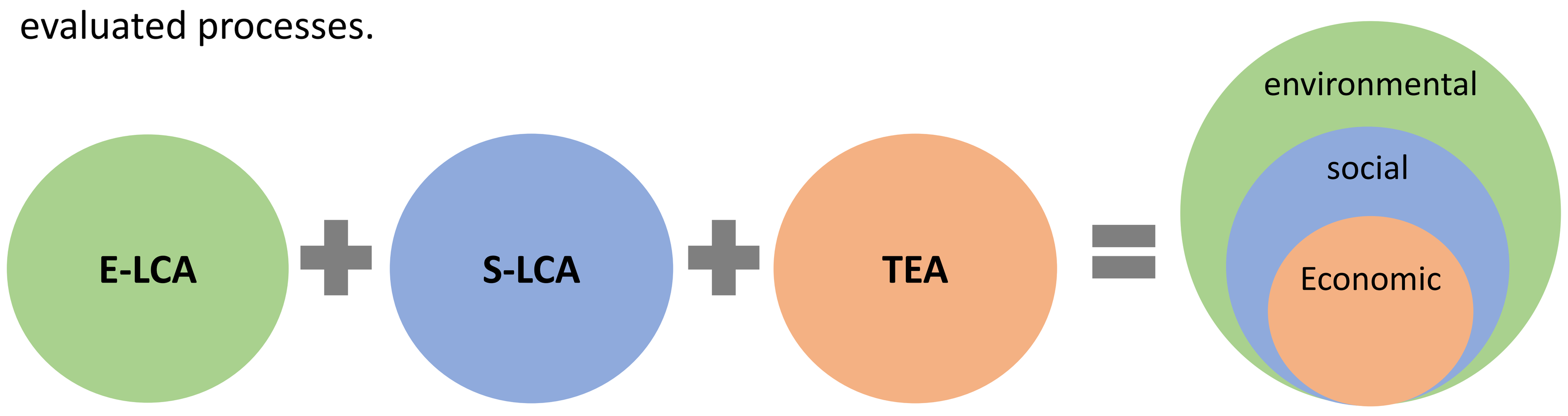

Figure 2. Environmental Life Cycle Assessment (E-LCA), Social LCA (S-LCA) and Techno-Economic Analysis (TEA) within the LCSA

Methodology

E-LCA

E-LCA will cover various categories, such as greenhouse gas emissions, energy demand, biodiversity, and resource depletion. A specific focus will be given to conducting a life cycle biodiversity impact assessment, which aims to measure the project's effects on biodiversity in industrial sites and supply chains.

S-LCA

S-LCA evaluates socio-economic benefits following the UNEP-SETAC guideline. This assessment will involve identifying activity variables, defining subcategories, and engaging key stakeholders. The S-LCA will adhere to established scientific protocols and guidelines, and it will be conducted alongside the E-LCA.

TEA

TEA assess the economic feasibility of the process. It evaluates technical aspects, performance, and costs, including capital and operating costs, raw materials, energy consumption, production capacity, and revenue generation potential. The objective is to determine the economic aspects, such as profitability, return on investment, and potential cost-saving measures.

Disclaimer and Acknowledgements

CHEERS
Producing novel non-plant biomass feedstocks and bio-based products through upcycling and the cascading use of brewery side-streams
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