Assessment of sustainability for the bioprocesses: Does it (really) follow life cycle thinking?

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In the wake of eco-design methodology development, the time has come to propose a sustainable process design that integrates not only environmental evaluation but also economic and social issues. All strategic decisions should respect the principles of sustainability. The environmental, economic, and social assessment of engineering choices is thus necessary and the agro-industry is not exempt. Design or re-design of any product relies on the choice of processes, which naturally leads to the development of an integrated product-process approach to agro-industrial processes.

Among the means of assessment processes and their consequences for the environment, the economy, and society, Life Cycle Assessment (LCA) derived from Life Cycle Thinking, has become the best adapted method at such a decision level. LCA was first developed to reduce the environmental impacts of a product, a process, or a service.[1] Since then, Life Cycle Costing and Social Life Cycle Assessment were developed to account for economic and social aspects in the LCA of a system. Historically oriented to the environmental impacts of a product, LCA has naturally extended its field of investigation to social, economic, and engineering aspects to become a Life Cycle Sustainability

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Assessment (LCSA) of product.[2] There are no mutually agreed standards, however, only guidelines from the United Nations Environment Programme (UNEP). In parallel, enterprise strategies constantly adapt to our rapidly changing world. In order to face these fluctuations, enterprises need more and more models that permit them to formalize, describe, and simulate their behavioral face to the external environment. General LCSA is a semi-formalized framework that includes system modeling but it needs other disciplines and other business competencies to analyze and explain the link between the system and its impacts.

A process-product-enterprise sustainability assessment approach guided by Life Cycle Thinking has recently been formalized by Busset *et al.*[3,4] This approach is part of a decision-making process in the context of system design or re-design. Environmental, social, and economic impacts of the enterprise occur at all levels of design: (bio)molecule, process, product, and enterprise. The proposed approach offers the opportunity to make LCSA possible through the federated integration of process, product, and enterprise models and their interaction with the external environment as well as through the proposal of an ontology from which these models are built. Considering the ISO 15704 standards that define an enterprise-architecture framework,[5] they place LCSA, process and system engineering, and business-process modeling within three dimensions: different levels of specificity (generic, partial, particular), different points of view (organization, information, resources, function), and different life cycle stages.

They propose an approach to design of the agro-process guided by sustainable evaluation. The approach allows systematically taking into account sustainable issues within agro-process design or re-design. Agro-process design is supported by a thermodynamic model based on mass and energy balances. Finally, the coupling between process simulation and sustainability assessment is realized through input and output data exchange. It aims at characterizing the environmental, economic, and social consequences of agro-process. The proposed approach is addressed to decision-makers. It may allow (i) a technologic choice of agro-industrial process, (ii) a choice of supply chain, (iii) a choice of input.

Even though some difficulties still remain with energy balances evaluation and social impacts estimation, this approach seems to be the most advanced, the most comprehensive, and the best adapted to the bioeconomy. Further investigations are in process to improve these two main issues. We will wait impatiently…

References

1. ISO 14040. *Environmental Management – Life Cycle Assessment Principles and Framework*. International Organisation for Standardisation (ISO), Geneva, Switzerland (2006).
2. Klöpffer W, Life cycle sustainability assessment of products. *Int J Life Cycle Assess* **13**:89–95 (2008).
3. Busset G, *Approach for evaluation of systems sustainability guided by life cycle thinking: application to olive oil agro-industry [PhD in French].* Institut National Polytechnique, Toulouse, France (2014).
4. Busset G, Sablayrolles C, Montréjaud-Vignoles M, Vialle C and Belaud JP, Computer aided process engineering for sustainability analysis of food production. *Chem Eng Trans* **43**:1339–1335 (2015).
5. ISO 15704, *Industrial automation systems–Requirements for enterprise-reference architectures and methodologies*. International Organisation for Standardisation (ISO), Geneva, Switzerland (2000).

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