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► **To cite this version:**

Guillaume Busset, Jean-Pierre Belaud, Mireille Vignoles-Montrejaud, Caroline Sablayrolles. An Integrated Approach for Designing an Agricultural Process Guided by Sustainable Evaluation: Application to Olive-Oil Production. *INSIGHT*, 2013, 16 (4), pp.32-36. 10.1002/inst.201316432 . hal-03521418

HAL Id: hal-03521418

<https://hal.science/hal-03521418>

Submitted on 11 Jan 2022

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To cite this version:

Busset, Guillaume  and Belaud, Jean-Pierre  and Vignoles-Montrejaud, Mireille  and Sablayrolles, Caroline  *An Integrated Approach for Designing an Agricultural Process Guided by Sustainable Evaluation: Application to Olive-Oil Production*. (2013) INSIGHT, 16 (4). 32-36. ISSN 2156-485X

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Integrated approach for agro-process design guided by sustainable evaluation: application to the olive oil production

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1. Scientific and industrial context

Industrial production systems and their consequences on the world constitute an important scientific issue. To consider technical, economical, quality and environmental dimensions, the development of industrial production system is based on models that simplify real system in order to represent it with different objectives.

a. Process approach

In terms of quality, process approach is recommended by ISO 9000 standard. It consists in representing the system at any level (technical, tactical or strategic) as a set of processes with inputs, outputs, control, constraints (ISO 2005). Process approach is also the base for environmental impacts assessment of a system within the life cycle assessment methodology.

b. Enterprise models, levels and views

At a technical level, process design is organized by Process Systems Engineering (PSE) based on the modeling of physical, chemical and biological processes. At tactical level, Business Process Management (BPM) is based on modeling of business process. At a strategic level, Enterprise Engineering (EE) supply models of enterprise. A system – typically an enterprise – can be seen from 4 main views: organizational, functional, resources, information (Ulmer 2011). The different models from the different levels take elements from the different points of view of the system.

c. Sustainability assessment

At a transversal level, life cycle analyst is considered as a specialist of life cycle assessment. The evaluation of environmental, social and economic impacts of a system is usually modeled with Life Cycle Assessment (LCA) method. Up to day, only environmental and economic LCA are well applied, even though social LCA is being undertaken. The integration of the three methods is a critical issue in order to assess any system in terms of sustainable development.

d. System engineering for multilevels sustainability

Whatever the level of enterprise, systems and processes are modeled in order to improve knowledge and agility of systems. Modeling also helps to design a system considering future impacts on environment, social and economy at the early stages of the life cycle. Life cycle thinking is intrinsic to process approach. As a consequence, sustainable life cycle assessment of a system can be undertaken at the different levels of a system study. Life cycle assessment can be coupled to process systems engineering for “process eco-design”, to “business process management for “business eco-design” and finally to enterprise engineering for “enterprise eco-design”. System engineering is usually and successfully applied to aero-spatial, aeronautic, informatics and mechanic systems. We think that it can be also applied to agro-industry.

e. Integration of LCA to the different levels of enterprise models

At a technical level, integration of chemical and agro-chemical processes design with sustainable life cycle assessment has been yet studied by Azapagic (2006), Gilliani (2010) or Jacquemin (2012). However, no generic integrated approach has been yet formalized within a system engineering based framework, neither for chemical process, nor for agro-industrial process.

Furthermore, any work has not been led to integrate LCA, PSE and SE. System engineering and process approach are common to all these domains, using tools from system engineering is proposed in order to integrate them. It seems crucial to know how technical and tactical levels of modeling are linked and how sustainable life cycle assessment can model interactions between a system and its environment.

In this context, a comprehensive approach is proposed for design an agro-process in a sustainable perspective.

2. Methodology for definition, application, verification and validation of the approach for the design of agro-processes

The proposed approach has the objective to design for sustainability. Sustainability is chosen as the center of the approach. The question is: how LCA methodology is going to integrate data and models from other domains?

product, a process or a service (ISO 2006). After, life cycle costing and social life cycle assessment has been developed to take into account economic and social aspects in life cycle assessment of a system. However, any norm does not exist, but only guidelines from UNEP. General LCA is a semi-formalized framework that includes system modeling. It focuses on a functional point of view but with elements taken from other points of view such as resources. The originality of the LCA is to link system and its environment through impact assessment. Does the environment have to be internalized into system borders or does it have to be studied as a new point of view? Furthermore, LCA needs to describe all the inputs/outputs that pass through every process that constitutes the system. LCA is only a descriptive method between the system and its extern environment. It needs others disciplines and other business competences to analyze and to explain the link between system and impacts on the environment. LCA is defined as a product oriented approach but product is only the result of process. Consequently, LCA must be considered more as a process approach.

LCA uses factors of characterization for inputs/outputs that cross the system. Environmental and economic factors are well known and easy to apply but social factors remain more complicated. However, the principle is to qualify and quantify impacts of inputs consumption and outputs emission of processes of the system. Environmental indicators are for instance global warming, ozone layer depletion, acidification, eutrophication, non-renewable resources depletion; economic indicators are investments, salary, benefits, spend, etc.; social indicators are number of employees, work creation, human rights, etc. The limits of LCA methodology concerns the modeling of the system. No formalism defines the way to represent the system, but in other disciplines with other objectives, there exist some formalism to establish models of process at the levels described before.

b. Enterprise architecture framework

Considering LCA limits, we proposed an approach based on LCA method but using architecture frameworks for modeling agro-processes. Considering ISO 15704 norms that defines enterprise architecture framework, we place LCA, PSE and BPM within three dimensions: different levels of genericity (generic, partial, particular), different point of view (organization, information, resources, function) and at different life cycle stages (ISO 2000). These life cycle phases are: identification, concepts, needs definition, specification/design, implementation, operation and dismantling (Vernadat 1999).

c. LCA, BPM and PSE in enterprise architecture framework

LCA method focuses on elements taken from the different points of view and is usually applied to implementation, operation and dismantling phases. Nevertheless, LCA can be applied during earlier stages in order to consider future impacts cited above as soon as possible. It can also be applied to any level of genericity. BPM supplies a representation of the system at functional, resources and information point of view. It may represent the system at any life cycle phase. It is applied at any level of genericity. PSE represents the system in a functional and operational point of view, at any level of genericity and at any phase of the life cycle.

We propose to map the different results and models given by PSE, LCA and BPM in order to align models and to get an overall consistency.

d. Experimental data collection to approach validation and verification – OiLCA project

The approach relies on OiLCA project results oriented LCA, life cycle costing (LCC) and ecolabel design (OiLCA 2011). An application was also developed and is available on the website (oilca.eu). This project is a partnership with industrial research agents: Centre Technique de l'Oliver in France, CITOLIVA, Instituto Andaluz de Tecnologia and Fundació Centre Tecnològic de Manresa in Spain and CVR - Centro para a Valorização de Resíduos in Portugal. This project led to a database with actual economic and environmental data from 59 companies from the olive oil production and to an application for carbon footprint and cost calculation.

3. Conclusion & perspectives

System engineering was used for a better understanding of sustainable assessment of an agro-industrial system. It was used to develop a methodology within enterprise architecture framework. Finally, the integrated approach could be completed with optimization tools in order to find best solution in terms of sustainability.

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