Life-Cycles and Sustainable Supply Chain

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Abstract. The former Prime Minister of Norway, Gro Harlem Brundtland defined sustainable development as "forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs." This definition must become the cornerstone of a renewed economic thinking even though companies simply offer a somewhat altered standard model to incorporate environmental considerations. In this article, we propose a discussion about the life-cycle concept from different points of view in order to consider the design and the implementation of Supply Chain to be more compatible with sustainable development.

Keywords: Sustainable Development, Supply Chain, Logistics, Product Life-Cycle

1 Introduction

A company is a system, i.e. an organic whole which groups together a limited number of elements organized according attributes and relationships. According to the systemic paradigm [1], the company interacts with its environment to evolve i.e. to modify/adapt its structure and/or its operation. This dynamic evolution results from succession of cycles including classical steps from development until removing. The result of companies interacting together in a Supply Chain intensifies this dynamic and multiplies the number of cycle to be managed.

In this article, we propose a reflection on the use of life-cycle concept as a structuring element in the design of a Sustainable Supply Chain. First of all, we present two points of view about the life-cycle concept; one focusing on industrial point of view and the second integrating upstream and downstream stakeholders in order to fit with circular economy concept. Next we discuss major types of logistics in particular sustainable logistics too often limited to an environmental dimension. In the third part of this article we propose an approach to design a sustainable supply chain based on the use of the life-cycle concept.

2 Life-cycle concept

Much research has been done to describe the life-cycle concept. In this article, we discuss two specific points of view about the life-cycle concept:

- From the “Idea” until the “Removing” (Industrial Life-Cycle);
- From the “Extraction” of raw materials to the “Disposal of waste” generated by the product’s utilization (Life-Cycle Assessment).

Industrial Life-Cycle describes the process from the emergence of a concept to the reality of the product available to consumers. Whether the product is tangible or symbolic [2, 3], it can be defined as "an object transformed by Man through a process which is not natural". Based on the assumption, any product impacts negatively the environment.

Life-Cycle Assessment focuses on “Production” phase of ILC such as presented in Figure 1. LCA takes into account all the activities that are involved in the Supply Chain: raw material extraction, manufacture of the product, its distribution, its use and the disposal or recycling of this product. LCA aims at identifying all environmental negative impact of these steps in order to reduce these impacts.

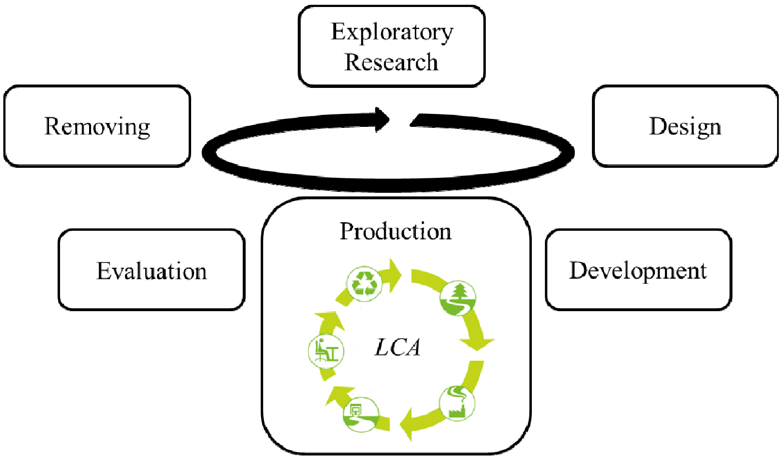

Figure 1: Industrial Life-Cycle and Life-Cycle Assessment

One considers that negative impacts will be minimal if a closed Supply Chain is implemented. This is the objective of “cradle to cradle” which proposes to create and to recycle in an infinite way [4]. The recovery of waste and the use of recovered materials should be encouraged in order to manufacture products again and again to conserve natural resources. Figure 2 presents such a proposal and insists on the necessity of the transport between all steps. Today's business model now joins the shortening of product life cycle. In fact, although efforts are being made on each step of the cycle, they are offset by the increased weight of transport.

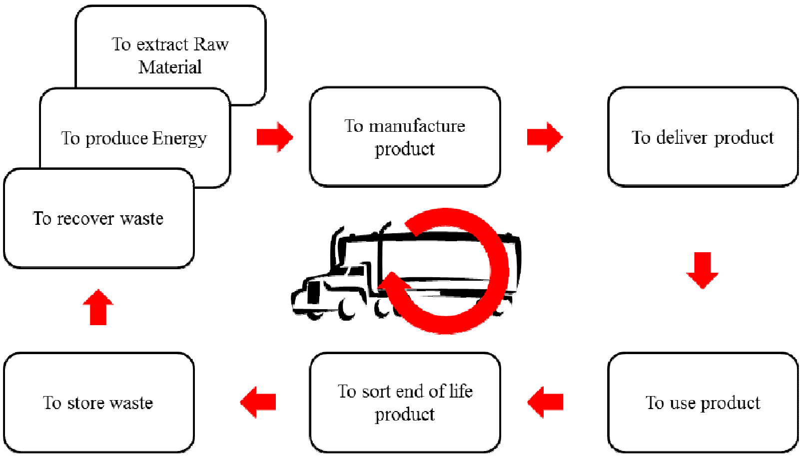

Figure 2: Closing the loop

In previous research [5], we insist on circular economy principles. Moving away from the linear model, the circular economy model advocates in favor of long-life goods, reusable products, reconditioning activities and waste prevention. Therefore business models today must break away from 17th century heritage of accounting constraints and focus on how products are used to increase the quality of company decisions about sustainable development needs by lengthening product life-cycle. This implies that LCA back in ICL to be built in the first phase to configure the entire Supply Chain.

3 Sustainable Supply Chain

3.1 Supply Chain and logistics

Supply Chain Management considers combination and implementation of various logistics operations. Logistics plans, implements and controls the flow and storage of goods, services and related information from raw material extraction until product delivery in order to meet customer needs. Four different categories may be considered:

- *Inbound logistics* considers activities for the production of transformable resources (some call raw materials), the production of consumable resources (such as water, gas, electricity, ...) and the production recycled resources and different means of transport of these resources;
- *Internal logistics* concerns all flow of raw materials, components, subassemblies and products within the production system;
- *Outbound logistics* considers activities associated to product's transportation, product delivery and product use;

- *Reverse logistics* considers operations related to the reuse of products and materials. It includes the management and the sale of surpluses, as well as products being returned to vendors from buyers [6].

A new transversal approach, *Sustainable Logistics*, answers actual and future production problematic. It does not consider a specific operation but aims at achieving all operations in coherence with sustainable development definition. For this reason it fits in the context of national strategies for sustainable production and consumerism. In France, it aims at guiding the economy toward a green and fair economy: "The National Strategy for Sustainable Development proposes a common architecture for all national stakeholders (either public or private sectors), to help them structure their own sustainable development program around strategic choices and indicators that have been the subject of a broad consensus [7]". In particular, it aims at ensuring coherence and complementarity of French commitments either at international and European level on a specific sector or a transversal way.

3.2 Sustainable Supply Chain

Research on Sustainable Supply Chain (SSC) is new and widely used by the global research community in different fields of application: waste, green logistics, eco-design, sustainable procurement, etc. [8] defines sustainable logistics as a discipline that takes into account both the economic, ecological and social development in the logistics decisions.

The finality of sustainable supply chain management is to maximize the profits of the chain while minimizing environmental impacts and maximizing social issues [9]. Considering this finality, SSC management must prolong product life-cycle while focusing on Sustainable Logistics operations management, resources, information and financial flows.

3.3 Sustainable Supply Chain strategy

Supply Chain or Sustainable Supply Chain SSC can be considered as a system of systems according following definitions:

- Metasystem that are themselves comprised of multiple autonomous embedded complex systems that can be diverse in technology, context, operation, geography and conceptual frame" [10];
- System resulting from the collaborative functioning of independent component systems (which can function independently to meet their own operational mission)" [11];
- System of systems respects five necessary conditions: operational and managerial independence, evolutionary development, emergent behavior and geographic distribution are respected [12].

Supply Chain global strategy must target system collaboration and existing management tools such as SCOR®[1] which aims to achieve this objective. Level 1 is

[1] Supply Chain Council: https://supply-chain.org/

the most conceptual level of SCOR® and is used to describe the scope and high level configuration of a supply chain. SSC must integrate all steps of product life-cycle and in particular the “Exploratory Research” to focus on the use of the product by the customer for prolonging the cycle. This proposal increases the number of stakeholders and the dimension of the system of systems. The strategy must consider four views and projects these views on a 3 dimensional performance referential (Figure 3).

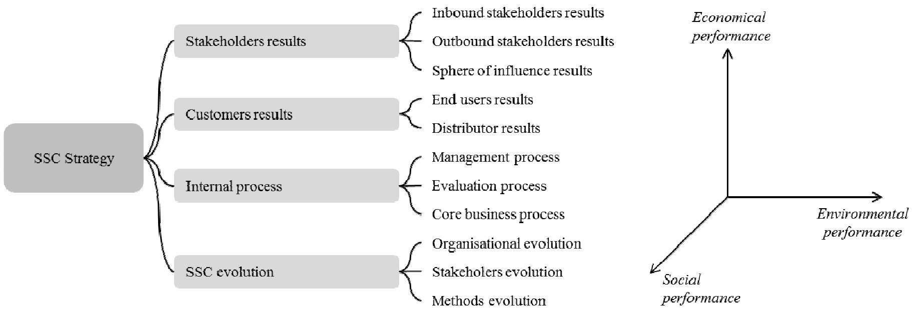

Figure 3: SSC strategic definition

Decisions associated to this conceptual representation are done in an integrated way considering that they directly impact the performance in LCA, for example:

- to guide sustainable consumer behavior,
- to manage sustainable production,
- to preserve natural resources (minimize raw materials / maximize recycling),
- to save energy and to develop renewable energy,
- to promote sustainable transport,
- to improve the governance of sustainable development.

The first four decisions above fit naturally with circular economy principles that that we have presented. Transport and governance issues need to be developed.

3.4 Transport issue

It seems obvious to favor short product channels or networks since we have highlighted the great carbon impact of transportation in a "cradle to cradle" close loop (Figure 2). In reality, the reasoning is not so simple. A European example, such as exotic fruits, does not necessarily worsen the ecological carbon footprint of a product. Exotic countries propose ideal climatic conditions for local fruit growth. The same climatic conditions can be artificially imitated in Europe with substantial energy consumption (Greenhouses maintained at 20°C and simulated lighting). The carbon footprint of exotic fruit produced in Europe is 6 times greater (3 grams) than exotic fruit produced in Africa - yet transported by plane! Therefore, if a production process is CO_2 efficient, it is not so obvious that transport increases systematically carbon footprint of consumer products.

Of course, it is healthier and preferable to consume fruit locally according to the seasons of given geographic latitudes especially as it promotes local economies.

The carbon impact of transportation is increasingly important as a product nears its final destination, i.e. a city, since the logic of mutualizing is very difficult to implement. Research has been conducted to optimize such transport mutualizing in cities [13, 14]. Research shows such approaches are very demanding in information and underlines the limits of existing management tools. For example, even SCOR® remains sketchy about the nature, structure and even the standard coding and exchange of data used in transport activity in the supply chain.

3.5 Governance issue

System collaboration underlines governance problematic solving. “Governance ensures that stakeholder needs, conditions and options are evaluated to determine balanced, agreed-on enterprise objectives to be achieved; setting direction through prioritization and decision making; and monitoring performance and compliance against agreed-on direction and objectives”[2].

SSC increases the size of the system of systems, the number of stakeholders and thus, the number of needs, objectives to take into account. It is therefore necessary to define in a very precise way the management mode when developing SSC strategy in order to ensure the balance between all these elements. Governance topic has been discussed in AFIS forums and led up to a tutorial entitled "System of Systems Architecture and Engineering." As an example, last kilometer delivery is very important in term of financial and environmental costs in the supply chain. Different ideas emerged to reduce these costs but many experiments have been abandoned due to stakeholder interest incompatibility. Research is actually conduced to solve such problem merging public and private interest implementing global governance.

4 Conclusion

The historical model of industrial development has been in a crisis for a long time. The industry is entering a spiral negatively impacting the environment, the human society and even the world economy. Far from the definition of Gro Harlem Bruntland, this historical development undermines the integrity systems of living and unbalances the sharing of excessive wealth. The result is the development extreme social tensions.

Research on sustainable logistics seeks an escape from this spiral. It cannot ignore research about "Systems Engineering and Sustainable Products". This includes following sub-themes such as: strategy, governance, operational and support functions, life cycle design (or eco-design), modeling, architecture, assessment, etc. This research is carried out within a virtual workshop whose aim is to deepen the impact of Reasonable Sustainable Development. Participants explore different fields of application but in the same philosophical framework for introducing the circular

[2] IT Governance Institute: http://www.itgi.org/

economy. This article is a natural result of these discussions and proposes a more global vision, based on the concept of product life-cycle, when designing SSC to go beyond “cradle to cradle” cycle to include: circular economy principles and prolonging product life-cycle. Our more global vision proposes companies must break with traditional basic economic models, to adopt a more collaborative sustainable development model which allows the sharing of common issues.

The outlook is promising but is based upon the profound questioning of attitudes, and in particular, the questioning of economic models developed over the past two centuries. Major industrial powers are now asking many questions. For example in China, the "Law for the promotion of circular economy" came into force on the 1st of January 2009. Now local Chinese governments in more than 100 cities are participating in a national government competition to the best circular economy city system. You can be sure that they will become worldwide showcases of circular economy.

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