

## **COUPLING BUSINESS MODELS WITH LIFE CYCLE ASSESSMENT FOR SECOND LIFE APPLICATIONS: ADVANTAGES AND LIMITATIONS**

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### **Abstract**

The evolution towards sustainability of industries leads to reconsider business organization taking into account economics, social and environmental aspects. This paper focuses on the link between economics and environmental aspects. It aims to conceptualize the interactions of Business Model and Life Cycle Assessment approaches to propose a "Sustainable" Business Model, based on second-life applications.

This represents a double challenge. Firstly, both approaches should evolve and go beyond their limits. Regarding second life applications, a literature review shows that LCA and BM approaches are limited by their focus on the product (process or services) function and the creation of value for a unique application on a single enterprise. Secondly, it is necessary to think over a methodology to integrate both approaches. To this end, the paper proposes a conceptual analysis of the respective limits and cross-fertilization of these approaches to better think of product second life models.

### **Keywords**

Business Models, Life Cycle Analysis, Reuse, Second Life Application

## **1. INTRODUCTION**

In line with the Kyoto Protocol and the Intergovernmental Panel on Climate Change's reports about the causes and consequences of climate change, an environmental paradigm has emerged that insists on the need to develop an analysis of the environmental impacts of productive activities, products reuse strategies and recycling processes. "Sustainable development" models are still under studies to tackle at the same time the economics, social and environmental challenges. Several strategies are proposed for better manage material resources such as circular economy, functional economy, ecodesign.

The present paper focuses on products reuse and second applications strategies with the idea to extend the products life [1]. The economic interest comes from the fact that the added value due to the initial production of the product is fully or partly preserved. The environmental interest comes from lower consumption of resources compared to manufacturing a completely new product. By keeping components, material extraction and energy consumption can be reduced; however, business organization should evolve and thus the economic impact has to be reconsidered.

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Thereby, the reuse of products on second life applications is considered as a key strategy regarding the economic, social and environmental pressures. An analysis must be done about the weaknesses of Business Model (BM) and Life Cycle Assessment (LCA) approaches and their cross-fertilization in order to define and to evaluate second life applications. This analysis enables to identify the added value of combining BM and LCA for supporting the decision of actors while testing different second use scenarios.

## **2. WEAKNESSES OF BM AND LCA APPROACHES**

In order to face challenges related to second life applications, both BM and LCA approaches show some shortcomings. Even if scholars do not completely agree about its definition, BM concept is viewed as a device commonly used to articulate the constituent parts of a business, associating the creation and capture of value [2-6]. A BM describes the value offered by an organization to their various customers. The notion of “proposal of value” is critic in the BM analysis. BM approach and tools highlights how firms create and capture this proposal of value, how to identify the targeted market segment, how to define the channel through which the value is distributed to customers, what is the nature of the relations between the firm and its clients, what are the key resources and activities needed to achieve the proposal of value, who are the strategic partnerships; finally, what and how monetary flows are generated by the BM [5]. A first weakness of such an approach lies in the concept of value considered as a product value or indeed a use value. According to our knowledge, the environmental value has never been explicitly mentioned except if it corresponds to a dimension requested by the consumer. It means, the environmental impact of activities are almost absent from BM analysis. Moreover, BM provides information about such a system generates and captures value; as well as, the different components of the company value chain coexist together as a whole. Business Model analysis focuses mainly on the company level and do not accustomed to deal with a whole branch of activity. The traditional BM framework views the value chain as a linear process not as a circular process, ignoring potential second life of product. More precisely first and second life BMs are disconnected.

LCA aims at identifying the environmental impacts of goods and services based on three main principles: life-cycle, multi-criteria and multiple-components approaches. It enables to identify resource and energy consumption as well as waste production and elementary flows used to build environmental impacts. In order to integrate economics in this methodology, Life Cycle Costing is often used [7]. However, it is a restricted view on the economic impacts that can be enlarged considering local dynamics, activity creation, networks reinforcement, etc. Considering second life applications, LCA faces with several difficulties such as the perimeter of the study (limits of the considered business), the definition of the functional unit and the allocations of impacts between the first and the second applications. LCA is able to deal with several actors belonging to a branch of activity. However; when the network of actors evolves due to the introduction of second life applications, LCA reaches its limits even more when the new network of actors is not perfectly known yet. Moreover, the functional unit changes between the first and second life of products, which makes it difficult to apply LCA tools. Finally, when a product goes through several life cycles, an arbitrary choice has to be made to allocate environmental impacts to one or another life.

## **3. BUSINESS MODEL APPROACH TO IMPROVE LIFE CYCLE ASSESSMENT**

The integration of economic aspects in product life cycle analyses is mainly reduced to the costing, which neglects others dimensions of economics development on the design of new industries. An approach based on BM could help enlarge the representation of the economic

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impacts (e.g. dynamic sense of local players, identifying externalities) in the life cycle analysis.

The definition of the boundaries of the study meets some difficulties, seeing the several businesses interactions to articulate first and second life cycles. The identification of direct relationship between goods (or services) associated to one functional unit could be useful to define the boundaries and limits of the LCA (focus on the resources consumption and transformation). Introducing (open) BM [2] enable to enlarge the perimeter of the study, considering new actors into the model with strong economic links.

To include the whole environmental impacts, allocation process can be used. However, there is a lack of knowledge to clearly define the proper allocation rate without considering economic aspects and specific stakeholders predefined on the BM. When the product life cycle considers multiple businesses, the emergence of new actors increases the complexity of the analysis and questions the coordination of actors. To avoid this allocation problem, the functional unit of the second life application must then include partially the first life functional unit. Then, LCA of the second life cannot be modelled only considering the value chain of the second application. LCA for the reuse of a product must include the first and second value chain. Consequently, there will be a mix of different functional units which responds to the analysis of a more complex value chain.

To summarize, BM brings new elements for LCA models definition. The concept of business strategy can bring a structuring way to identify the uses of materials and allocate the environmental impacts. Each one of those strategies has a central role as element on the LCA model. A middle of life strategy must be considered instead of being at the beginning-of-life of the second application or the end-of-life of the first application. Then, the economic dynamic related to the link between the two life cycles could then be an input point for LCA and the new functional unit. Figure 1 illustrates the changes that BM analysis could bring in Product Life Cycle model for LCA. Conventional product life cycle model must be built according LCA leads (a) a linear model coming from the first life to the second life. Furthermore, BM analysis leads us to model the transition process on (b) as a central value chain. In this model, the beginning-of-life and end-of-life could include other multiple businesses, changing the way to define the LCA functional units and the environmental impacts' allocation.

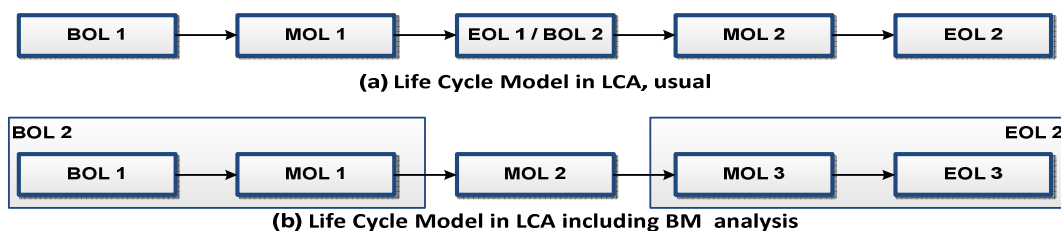


Figure 1. Evolution of Life Cycle model for LCA due to BM analysis (BOL: Beginning of Life, MOL: Middle of Life, EOL: End of Life)

## 4. INTRODUCING LCA IN THE BM APPROACH

LCA approach fosters the internalization of the environmental impact of economic activities. The considered value is not only a product or use value but also an environmental value. Considering environmental value implies to introduce a second life applications perspective. It becomes possible to exceed a linear or "filière" vision (with sequential BM) in favor of a systemic and circular vision of BM.

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Moreover, LCA introduces the global vision of the product life cycle embracing potentially different fields of application. It leads to integrate new actors and even new industrial sectors into the analysis compared to the first life applications. It challenges the actors of the first life BM, questioning their ability to capture the second life value of a product partially created in the first life. Therefore, BM does not take into account only the first product application but also the potential second life of the product.

In a circular economy, a reused product can feed several fields of application while being differently valued. Thinking on the product's second life, it is possible to impact the product first life value. The capture of value in the first life is not the same if a second life exists or not. Second life changes the global value of the product, modifying the borders of incumbent activities and mobilizes new actors. New entities try to capture the value. Hence, a new network of value is created between the actors negotiating for capturing the value. Whereas the company that provides the initial product is at the core of the value creation (but not always of its capture), it could be of second importance in second life applications. It seems that the value creation could become more collective and dynamic in that case.

## 5. CONCLUSION

In this paper our contribution is to consider the internalization of the environment in the BM, based on the use of LCA. The interest of linking LCA and BM approaches is also discussed and it shows that each approach can feed the other one. This framework (coupling LCA and BM) is currently tested on a specific case: the definition of Lithium-Ion Batteries' second life.

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