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Switching the focus from product function to business profit: Introducing Business Model LCA (BM-LCA)

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Abstract. Recent years have seen much interest in business models as vehicles towards sustainability, cf. [1]. Conventional LCA, however, fails to properly capture the environmental impacts of a business model. Here, we introduce the background and the principles of Business Model LCA, a new LCA methodology for the assessment of environmental performance of business models. Methodological innovations are based on an understanding of the difference and relatedness between product and business. The key innovation is that BM-LCA centres its analysis on the 'business model' instead of the 'product function' as in conventional LCA. This requires the functional unit to represent the business (e.g., as 'profit per time unit') and the need to couple the monetary flows of the business to the material and energy flows of the product system via a set of 'coupling' equations. BM-LCA contributes to environmental business analysis and could open up a new avenue of research where LCA and business analysts collaborate on business model innovation for sustainability.

1 Backgrounds to BM-LCA

There are many backgrounds to our development of business model-LCA. Perhaps the most important one relates to the environmental sustainability challenge to the economy. Another is limitations of current LCA methods and studies in company and business-related analysis.

1.1 Environment and economy: the sustainability challenge

As the economies around the world have grown and developed, so have the material flows through our societies and the pressures on our ecological environments [2, 3]. This has led to many calls for decoupling (e.g., [4]) and a need for understanding the environmental

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performance of economic activity. Social and management scientists have identified business models as the 'engines' of the economy [5] and pointed to their critical role for achieving sustainable production and consumption [6]. Building on the realisation that business models not only deliver value to customers and shareholders but could also contribute towards environmental sustainability, much research has gone into business models for sustainability [1, 7]. However, it is often unclear if sustainable business models effectively deliver on sustainability promises [8]. It seems that many so-called sustainable business models are assumed to be sustainable by virtue of sustainability-oriented design strategies, such as 'circularity', 'sharing', or 'servitization'. It is doubtful if such design strategies suffice as proxies to sustainability assessment and for decoupling.

To determine the environmental performance of business models, there is a need for appropriate assessment methods [8, 9]. We find here that a life cycle perspective would be useful since business models shape production and consumption systems [6] and because LCA is good at modelling these. Nevertheless, since conventional LCA is used for assessments of products, we propose certain modifications so that LCA may capture the environmental performance of the business model instead. With clear links between environmental and economic performance, analysis towards decoupling becomes possible.

1.2 Limits of LCA: Lacking assessments of business models

Several developments of LCA methodology aim at incorporating an economic dimension to make the life cycle perspective more relevant to business and companies. One approach is monetisation of environmental impact. This has been applied to life cycle impact assessment to enable comparison of environmental impact costs with other economic costs and benefits for a product system [10]. This approach has produced life cycle costing (LCC) as a form of LCA used for identifying the cost hotspots of a product system [11, 12]. Another is Organisational LCA [13], which takes the company as unit of analysis. O-LCA can be said to sum up life cycle environmental impacts of the entire product portfolio of a company. Another form of analysis produces eco-efficiency metrics by combining product environmental impacts with cost analyses, for example, customer's total cost of ownership [14] or with LCC.

Neither of these life cycle methods are directly useful for the environmental assessment of business models. In LCC and with the eco-efficiency metrics, the unit of analysis is the product system and not the business model. Moreover, the monetised flows in LCC are typically cost and/or negative externalities and thus not directly relevant to the economic performance of a business model. Eco-efficiency metrics can use different cost analyses, but costs alone do not provide sufficient information on the economic performance of a business model. In O-LCA, the company is the unit of analysis, but the environmental analysis is aggregated and without reference to business models. If a company operates a single business, O-LCA comes closer to business model environmental assessment, but does so without clear links between determinants of environmental and economic performance.

Several LCA studies claim to be environmental assessments of business models, but so far, we have not found any of these to address business as such. In studies comparing rental and conventional sales models (e.g., for next-to-skin garments [15], water purifiers [16], power-tools [17]), we noticed that conventional LCAs of product systems are made, and what represented the different business models are differences in product designs assumed to reflect some physical consequences of different business models in the analysed products. The studies thus take product function as the basis for comparison and are without quantified economic analyses. In a few studies evaluating product-service systems [18] (for, e.g., passive durable products such as furniture and exhibition equipment [19], energy-intensive equipment separating air into its constituents, i.e., O_2, N_2, Ar, etc. [20]), attempts to add economic considerations to the environmental assessments are made, typically using LCA and LCC in parallel. These studies provide insights into emissions and cost hotspots throughout the product life cycle, but have a 'hands-off' approach to business as such.

1.3 Need for rethinking LCA to enable analysis of business model

Even if environmental LCA has been linked to different forms of economic analysis, analysis has remained product-centred, with economic analyses not reflecting the economic performance of a business model. Analysis towards decoupling is therefore not possible. What is needed is a method that links economic viability of a business model with its environmental consequences. This can be achieved by switching the focus in LCA from the product function to the business model. Such a change to a core feature of LCA cannot be achieved without reworking elements of LCA modelling and methodology.

2 Principles of BM-LCA

2.1 From product to business: modifying the functional unit

From the perspective of a company, a product is not an end in itself—it is a means for business. A company can replace one product generation after another while still operating the same business model. A business model, simply put, is how a company makes money, often around a particular product or service and for a particular market; the profit formula includes the costs and the revenue streams for this [21]. BM-LCA builds on this definition.

Since the key function of a business model is to be economically viable, i.e., to make money and be profitable [21, 22], it is this function that needs to be reflected in the functional unit of LCA. This means then that the functional unit needs to be expressed in economic terms instead of product-related physical terms. More concretely, since a function of a business model is to generate 'profit', the functional unit in BM-LCA needs to express a 'measure of profit'.

For comparability, the functional unit in BM-LCA expresses economic equivalence in contrast to conventional LCA where it expresses physical equivalence. Furthermore, since profitability is measured over a time period, the functional unit needs to reflect this too. This results in a functional unit expressed as 'a given profit level over a given time period'.

As mentioned, the product is just one means to business. Others include pricing, marketing, production and distribution networks, c.f., [23] (which is why assessments centring on the product system are insufficient). For all these exist very concrete links between the product itself and the business around it that determine profit levels as well as environmental impact levels. Thanks to these links, it is possible to develop a BM-LCA model that couples the technical system of the product life cycle to the company's monetary flows of the business with that product. These links are expressed in a set of equations that we call 'coupling equations', and the profit-based functional unit ties it all together for a quantitative analysis of the environmental and economic performance of the business model.

2.2 Principles illustrated: actor analysis and coupling equations

In order to figure out the business model in relation to the product life cycle, it is necessary to identify cost and revenue streams for the company and place these within the life cycle model. This is difficult in a conventional LC model since it does not show the actors in the product system. Therefore, it becomes necessary to add actor analysis to LC modelling. Figure 1 illustrates the difference between the LC model in a conventional LCA and in BM-

LCA. The actor analysis entails mapping out what parts of the product system belong to the business company and what belongs to other actors. This simplifies the identification of the economic parameters of the business relative to the product system.

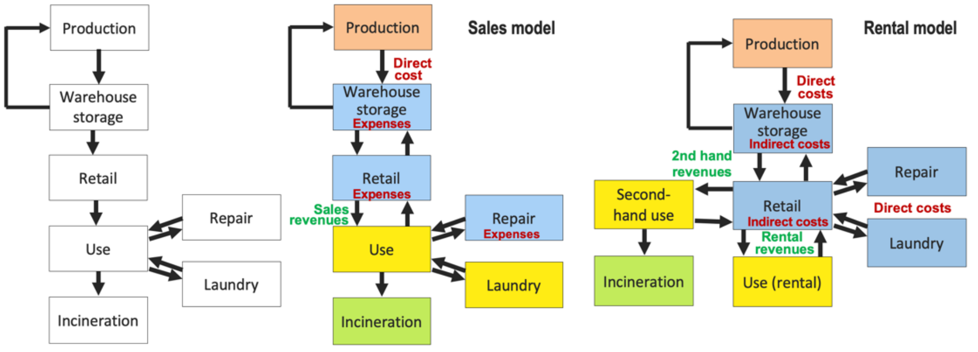

Fig. 1. Life cycle models (examples refer to the selling and renting of garments). A conventional LC model (left) is 'actor blind'. For BM-LCA (middle and right), an actor analysis has been performed, identifying life cycle stages belonging to the business company in blue, suppliers in red, consumers in yellow, and other actors in green. Text in red and green indicate major monetary flows of the business for the company.

Business operations (e.g., procurement, sales, marketing) are performed around the product. These also come with operating costs (e.g., employee wages, rents). All these are related to the product and can be described through a set of coupling equations. Each coupling equation links business elements (such as price) to product system elements (such as product item). The whole set of coupling equations express the economic-environmental relationship between the business model and the product system. Examples of a few coupling equations are found in Table 1.

Table 1. Examples of coupling equations, with parameters relating to business in bold and product technical system in italic. (The presented equations apply to the LC models in Figure 1).

Sales revenues = Number of *garment* **sales** x **price** of *garment*
Sales costs = Number of *employees* x **salary** / *store*
Rental revenues = Number of rental **transactions** x rental **price** (where rental transaction depends on profit level, rental price, jacket maintenance costs, jacket replacement rates, 2nd hand sales and retail store costs)

Business operations relate both to profitability (via cost and revenue streams) and product system (via the coupling equations). While profitability is expressed in the profit-based functional unit, the coupling equations links the product system to it. Hereby, the business model is analytically coupled to the product system. However, in contrast to conventional LCA, comparison of product system environmental impacts is made on the basis of economic equivalence, which has implications for environmental impact levels. Since different business models consist of different arrangements around the product offer, they will require different product volumes to achieve a certain profit level, owing to differences in pricing, sale or rental type of transactions with customers, and more. Consequently, environmental impacts for different business models will differ, even when product design is identical.

2.3 Methodological implications

In terms of LCA methodology, the key innovation to LC modelling is having business as the function-in-focus in BM-LCA, which places the innovation in the goal definition and scoping phase of LCA. BM-LCA can be described as an LCA with a more elaborated goal definition and scoping phase in order to account for each business model, where the function-in-focus is the business, resulting in a profit-based functional unit (basis of comparison) since this is what reflects the function and economic viability of a business model.

We have divided the goal definition and scoping phase into a descriptive phase and a coupling phase. In the descriptive phase, the studied business models are detailed and described in relation to the product systems using actor analysis (as in Figure 1). In the coupling phase, the coupling equations establish the relationship between the physical flows of the product system with the monetary flows of the business (as in Table 1). The functional unit, which is determined as the profit level that the business models must achieve, is also defined in the coupling phase.

Once the coupling equations have been set up, the product system is modelled in a conventional manner. It means that the basic structure of an environmental LCA model is not changed but added upon: the monetary flow system of the business model is attached to the conventional LCA model by identifying the points at which costs and revenues occur for the business company in question, and the profit-based functional unit provides the reference flow since a certain profit level will require a certain amount of product. Further detailing of the methodological procedure will be presented in a forthcoming paper [24].

3 Discussion and conclusion

Using LCA for the environmental assessment of business models is possible through methodological innovations that capture the business model around a product. A key innovation is the profit-based functional unit, which enables a coupling of the physical flows of the product system to the monetary flows of the business system.

The switch from LCA comparisons centring on product function to business profitability has multiple implications in terms of analytical possibilities and usefulness. With BM-LCA, it becomes possible to analyse the environmental impacts of business model decisions, not just those related to product design decisions. This also means that it is possible to see if decoupling is achieved or not in business model innovation. More generally, the method enables systematic environmental analysis of business as such and can be used for environmental critical analysis of ‘business-as-usual’ or greenwashing.

From a profit-based functional unit follows that the product system in the LCA is scaled to correspond to a certain profit-level. This is an interesting feature that in part addresses criticism of conventional LCA for not analysing environmental impact of total production and consumption volumes well and worthy of further investigation.

A focus on business requires an actor analysis on the life cycle, so that the company and its business transactions with other actors can be identified in the life cycle model. The actor analysis enables business managers to identify what’s within the company’s direct control or sphere of influence in the product system and helps them direct their attention to environmentally critical activities in a more constructive way, thereby hopefully avoiding excessively green claims.

Forthcoming papers will detail the BM-LCA methodology [24] and examine the learnings from a first case study for business model innovation [25]. Still, more research is needed, for example, to further test and develop BM-LCA on more cases and business models. Even so, we hope the methodology opens up new avenues of research where life cycle researchers and business scholars collaborate towards an environmentally viable economy.

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