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Abstract This article summarizes the panel session "Life Cycle Management approaches to support Circular Economy" of the 8th International Conference on Life Cycle Management (LCM2017 conference, Luxembourg). Four panellists were invited to share their point of view on this topic. Each of them brought a different perspective, addressing the topic from both the academic and industrial point of view; focusing on a raw materials aspect or considering a life cycle (or eco-design) related scope; in the context of a certification process (for products or activities) or of an eco-innovation process (including new business models for circular economy). After short presentation by each of the panellists, the discussion especially addressed the complementarity between several LCM concepts to be considered jointly when developing circular concepts and models.

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1 Introduction

Circular Economy (CE) is a concept that has gained some significant traction for some years, both on the policy and the industrial levels. It helps further structure Sustainability strategies and initiatives. And it can be described as an organizational principle which aims at evolving from the current linear economic model—where resources are extracted, manufactured, consumed and wasted—to an economic model which values resource efficiency, not only from a today's perspective, at every stage of the value chain and enables the biodiversity protection, as well as a development suitable for the well-being of individuals.

From the definition of a CE strategy to the implementation of action plans, as well as for the development of new business models in this field, processes, indicators and tools are necessary to support decision-making [1]. Life Cycle Management (LCM) approaches and expertise are thus suitable to ensure the Sustainability performance of decision-making. In this discussion panel session, 4 speakers from companies and academia presented some examples of LCM approaches (e.g. environmental impact assessment methods, eco-design, recycling, etc.), but also collaborative tools, in support of CE strategy definition and implementation.

2 A Decision Support Framework for Circular Economy Implementation in the Packaging Sector

Monia Niero (Technical University of Denmark) presented a decision support framework for the development of continuous loop packaging systems, which builds on the combined use of Life Cycle Assessment (LCA) and the Cradle to Cradle® (C2C) certification program [2]. The C2C design framework [3] inspired the creation in January 2014 of the Carlsberg Circular Community, i.e. a cooperation platform involving Carlsberg and a selection of global partners with the ambition to develop packaging products that are optimized for recycling and reuse, while retaining their quality and value [4]. As a first step of the framework, the environmentally optimal beverage packaging life cycle scenario is identified, both in terms of defined use and reuse. Second, the limiting factors for the continuous use of materials in multiple loops are identified considering the two requirements in the C2C certification process that address the material level (i.e. "material health" and "material reutilization" criteria) and the "renewable energy" criterion [5]. Then, alternative scenarios are built to meet C2C certification criteria, and LCA is used to quantify the environmental impacts of the resulting improvement strategies, for example, change in material composition, in order to guide the identification of the optimal scenario from an eco-efficiency point of view. Finally, the business perspective is addressed by assessing the potential for a green value network business model for a closed-loop supply [6]. The outcome is a list of prioritized actions needed to implement the most eco-efficient and eco-effective strategy for the beverage packaging, both from an environmental and an economic point of view. The decision support framework was tested in the case of the aluminium cans, with main recommendation from both the LCA [7] and C2C perspective [8] to ensure a system that enables can-to-can recycling. Designing packaging for "zero contamination" and improving transparency in materials composition to assure high quality recycling were the main lessons learnt from the Carlsberg Circular Community [2]. The suggested framework for optimization of continuous loop system can be applied and adapted by any other company familiar with LCA and C2C certification tools, based on eco-efficiency and eco-effectiveness approaches, respectively.

3 Leveraging an Ecodesign Foundation to Enable Circular Value Creation

Megann Head (Steelcase) presented Steelcase's strong foundation of eco-design practices, rooted in LCM principles. In the company, the three pillars that guide efforts to innovate, improve, and deliver on product promises include materials chemistry, life cycle thinking, and reuse/recycle. Each of these pillars are necessary aspects of product performance as the company transitions to circular business models. However, they may need to adapt, and new capabilities will need to emerge. New design sensibilities need to be utilized, expanding upon those already existing, such as design for disassembly and recycling. The new design sensibilities could be designing for refurbishment and remanufacturing and harvesting parts that feed new products. The products and services (business models) need to work together in a circular economy, so they both need to be developed with a systems mind-set. The existing tools used to evaluate these product-service systems, like Life Cycle Assessment, can be useful in initial evaluations, but do need some updates, such as for allocation, in a circular economy.

4 Raw Materials Are Products of Our Brain—What Does This Mean for LCM?

For Friedrich-W. Wellmer (Federal German Institute of Geosciences and Natural Resources) and Roland W. Scholz (former chair of Natural and Social Science Interface, Swiss Federal Institute of Technology), raw materials are products of the brain [9]. They are not a fixed parameter or quantity. They vary according to creativity, demand and supply, and technology. This means that URR (ultimate recoverable resources) cannot be a fixed quantity, as long as economic activity and innovations continue. Individuals do not need raw materials as such. They need an intrinsic property to fulfil a function. For finding solutions for functions, individuals have three

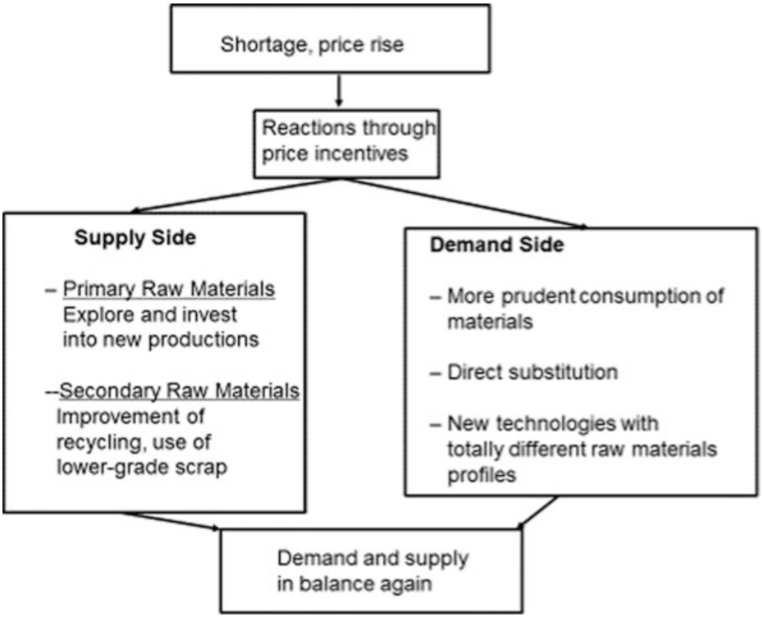

Fig. 1 The feedback control cycle of mineral supply [9]

spheres at their disposal: resources of the geosphere (natural resources), resources of the technosphere (atoms do not get lost) and the human ingenuity. Therefore, the driver proposed for finding solutions in a market economy is the price. Technology and human demand decide what of mineral resources are needed with what properties and to what amount. We also have to acknowledge that an increase of prices induces an increase of reserves. Thus the concept of scarcity is relative and may have to be adjusted also from a mid- and long-term perspective. Via the feedback control cycle of mineral supply in times of shortages and price peaks, there are incentives on the supply side to produce more functions from primary and secondary materials, and on the demand side to use less or to substitute materials, Fig. 1 [10]. More production, less consumption will re-establish a market equilibrium. This feedback control cycle also regulates the finding of the optimum in LCM. LCA helps to find better solutions while the market optimum will be determined by price incentives.

5 Collective Action to Settled New Circular Economy Business Models

A recent report from AFEP (2017) pinpointed that Multi Actor Action is a lever to set up new circular economy activities. Stéphane Morel (Renault) proposal is to discuss this statement and the potential for the life cycle community to contribute.

The creation of a new business model needs two pillars [11]. In one hand it is an explorative activity, on the other hand, it is a collective action. In the case of Circular Economy Business Models, we can particularly point out the necessity to set a dialogue between stakeholders from various horizons and motivations. In shorter recycling loops, you may introduce the notion of second hand parts and remanufacturing to customers and industrial plants. In longer loops you may design the product in a way that improve dismantling and sorting efficiency at its end of life. Collective action will involve all stakeholders committed in the new business model construction. But they are not spontaneous and need to be managed.

One proposal to manage this dialogue is to use the Collaborative Life Cycle Activities (Co-LCA) way [12] developed during the environmental footprint assessment of Renault first electric vehicle [13]. This scheme embeds three levels (Purpose, People and Action) and follow five steps: E1: Explore the topic; E2: Engage with appropriate stakeholders; E3: Elucidate the questions; E4: Evaluate the benefits; and finally E5: Extend to other activities.

To anchor the new business model and transform it into a dominant model, Stéphane Morel underlined the need for economic actors to measure the creation of shared value [14]. In order to proceed, four fields of benefits are proposed: 1/ financial income; 2/brand improvement; 3/knowledge sharing and 4/decision and anticipation accuracy.

As a conclusion, the LCA community is well grounded in collective action to carry comprehensive and complex studies [15]. Therefore, they are effective support to facilitate the creation of circular economy businesses. As a challenge for the next decade, though, this community shall continue to dig into data, but shall also open more largely to social and management science to build the bridge from utopia to real life businesses.

6 Key Issues and Learnings from the Discussion

One of the conclusion is that LCA and C2C can be complementary approaches to address circular economy issues. Indeed, C2C provides a vision for continuous use of materials through the avoidance of chemicals of concern, therefore facilitating the valorisation of materials over biological or technical cycles, while LCA allows to identify the intermediary milestones to be reached and provides a quantitative assessment of environmental impacts, both required to reach the vision set through C2C concept in a sustainable way.

It was also pointed out that one of the main challenge to overcome in the LCA field, within the circular economy context is the quantification of the benefits from recycling, both in terms of substituted materials and quality of the secondary material [16–20]. It was also noticed that an important contribution to solve the related issue of multi-functionality and substitution of primary material has been provided by the Product Environmental Footprint (PEF) pilots initiative through the definition of the Circular Footprint Formula [21].

As a more general finding, the assessment of circularity through the consistent measurement of positive aspects/benefits of circular economy strategies on the environment and society is one of the major evolutions to be addressed by LCM methodologies.

Another technical challenge for LCM tools is to bridge the gap between the measurement of CE indicators at a micro-level (e.g. product) and at a macro-level (e.g. national policy). This would support a better translation and management of top-down strategic initiatives into action plans (e.g. European Commission CE objectives implementation at a company level).

Finally, it was demonstrated that considering a market incentive (i.e. economic indicator, like a price signal) is often necessary to find the optimum level of resources consumption, when applying LCM approaches. A methodological challenge would be to integrate this indicator into LCA practices.

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