Development of a conceptual framework to take the dissipation of non-energetic abiotic resources into account within Life Cycle Assessment

Alexandre Charpentier Poncelet [1,2], Bertrand Laratte [2], Philippe Loubet [1], Guido Sonnemann [1,3]

[1] CyVi Group, ISM, University of Bordeaux, Talence, France

[2] I2M, Ecole nationale supérieure des arts et métiers (ENSAM), Talence, France

[3] CNRS, CyVi Group, ISM, UMR 5255, Talence, France

Abstract

Life cycle assessment is a valuable tool to assess the ecological performance of a product system holistically. However, it is still an imperfect tool for which some of the impact categories especially need to be revisited. Abiotic resource use is an impact category for which much debate has been going on in the last years. Methodological choices in the existing indicators are often criticized, and the usefulness of results is of questionable relevance to decision takers in the industry or the policy makers. Dissipation of those resources has been identified as a promising way forward. Dynamic material flow analysis can serve as an important basis to account for dissipated flows in a product system at different scales, and therefore serve as first steps towards the integration of dissipation in life cycle assessment. The ongoing work presented here aims at proposing a sound methodology based on dynamic material flow analysis to implement the dissipation of abiotic resources in life cycle assessment.

Keywords:

Dissipation, Life Cycle Assessment, Minerals, Metals, Material Flow Analysis

1 INTRODUCTION

In order to face challenges concerning increasing resource uses in modern societies, much interest and efforts have been put towards a more circular economy in recent years, and measures which are promotive of resource efficiency are now being put into motion. Life Cycle Assessment (LCA) may play an important role in supporting product eco-design, policy-makers and decision-takers in governments and industries for the consideration of natural resource efficiency without an impact shift towards other environmental concerns.

LCA is a tool allowing to assess environmental impacts of a product or service over its whole life cycle. Recent developments for the Natural Resources Area of Protection (AoP) in LCA have put current methods tackling resource use under review by many (e.g. [1], [2]), and methodological choices and intelligibility of the methods has been challenged. It has been proposed that the safeguard subject for mineral resources is their capacity to fulfill provisioning functions for humans (materials, energy, food, space, etc.) (perspective 2 from [3]). Therefore, the damage on resources should be quantified as the reduction or loss of this capacity caused by human activity. Dissipation has been identified as a relevant approach for this perspective compared to methods based on resources depletion [4]. It allows a better identification of where resource are lost (dissipated), including within the technosphere, and as a consequence lose their potential value for human use. However, no consistent method has been developed to include dissipation within LCA thus far. In this regard, we propose a conceptual framework to include the dissipation of metals and minerals within LCA based on dynamic Material Flow Analysis (dMFA).

2 METHODOLOGY

dMFA data may be used as an input to better consider the dissipative losses of mineral resources in the life cycle of products. Two options to link these data to LCA are identified in figures 1 and 2.

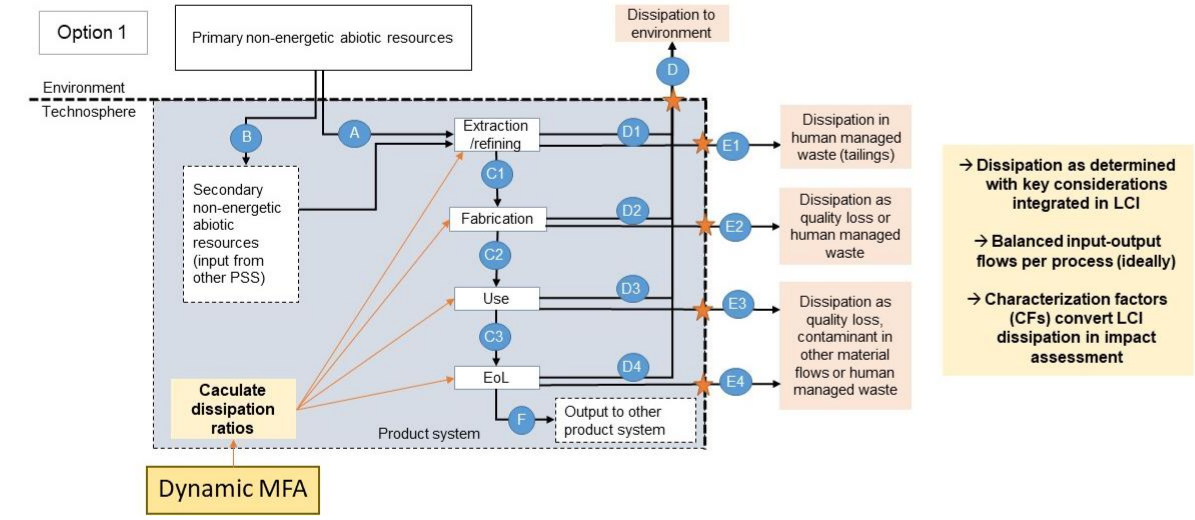

Fig 1. Modelling of dissipative flows in LCA using a simplified resource-centric viewpoint using dynamic MFA to update or create new life cycle inventories (option 1)

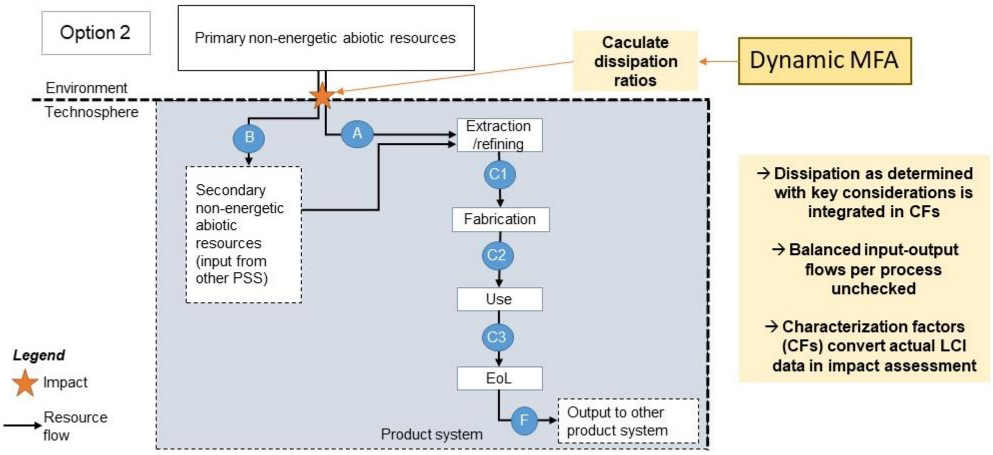

Fig 2. Modelling of dissipative flows in LCA using a simplified resource-centric viewpoint using dynamic MFA to calculate characterization factors (option 2)

In Figure 1 and Figure 2, flows for one abiotic resource are represented in a simplified theoretical product system. Input flows to the product system include both primary elementary flows (A) and secondary (B) resources. Intermediate resource flows within the product system are marked as C1, C2 and C3. Output flows from the product system are distinguished in 3 different fractions: dissipated to environment (D), dissipated to other material flows and human managed waste (E) and looped into other product systems (F). E1, E2 and E3 flows are not elementary flows, as they do not cross the technosphere-environment boundary, but still reside in technosphere as unavailable resources, thus impacting the AoP Natural Resources.

One could say that option I would be preferable according to ISO 14040 [5], as dissipated content depends on the product system. It allows for mass balance check for every process separately and for the system, as well as to link new inventories to dissipation to other impact categories if the environmental compartments which receive escaping elementary flows are indicated. Option II also implies that there would be a loss of information about where resources are lost over the life cycle, and it would not enable to compare between different systems using a same resource in different ways if global scale is chosen.

The two options are not mutually exclusive: they could be combined and completed with other data in order to optimize between precision of the characterization, data availability, and the feasibility of implementation of this approach in LCA. Indeed, different product-specific phases of the life cycle present product system-dependent dissipation patterns. If it desired to go in a more detailed view, i.e. by product sector or product category, design-related, use-related and recycling-related dissipation could be accounted for based on characteristics of the products.

Finally, adding a scarcity based factor in the calculation of characterization factors will enable to relate these dissipative flows with a factor of scarcity for different resources (production ratio, geological scarcity, availability, etc.), which will enable to differentiate between resources which easily get dissipated and those which don't.

3 RELEVANCE FOR ECODESIGN

Using such an indicator, lower dissipation profile materials will have a lower environmental impact under the Natural resources AoP without shifting impacts to other impact categories. If integrated in LCA, it could serve as a better support for the eco-design of products based on LCA results, especially concerning the choice between multiple materials for a same application.

4 CONCLUSION AND OUTLOOKS

The developed framework represents the first steps towards evaluating dissipation rather than depletion of mineral resources in an LCA context, with an appropriate inventory and impact method. This will lead to the possibility to distinguish between dissipated minerals and recycled ones, which are kept within circular economy and contribute to resource efficiency, and help to support decision-making based on such criteria.

REFERENCES

[1] Drielsma, J. A., Russell-Vaccari, A. J., Drnek, T., Brady, T., Weihed, P., Mistry, M., & Simbor, L. P. 2016. Mineral resources in life cycle impact assessment—defining the path forward. International Journal of Life Cycle Assessment 21(1): 85–105.

[2] Klinglmair, M., Sala, S., & Brandão, M. (2014). Assessing resource depletion in LCA: A review of methods and methodological issues. International Journal of Life Cycle Assessment 19(3): 580–592.

[3] Dewulf, J., Benini, L., Mancini, L., Sala, S., Blengini, G. A., Ardente, F., … Pennington, D. 2015. Rethinking the area of protection "natural resources" in life cycle assessment. Environmental Science and Technology, 49(9): 5310–5317.

[4] Zampori, L., & Sala, S. 2017. Feasibility study to implement resource dissipation in LCA. JRC Technical Report. EUR 28994 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77238-2, doi:10.2760/869503, JRC109396.

[5] ISO, 2006. ISO - 14040 — Environmental Management — Life Cycle Assessment — Principles and framework. Geneva.