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BRING ON THE 'SOFT' SCIENCES: EXPLORING IMPLICATIONS OF GROUNDING LIFE CYCLE METHODS IN THREE SOCIO-MATERIAL PHILOSOPHIES

Mathias Lindkvist & Henrikke Baumann. Chalmers University of Technology, Sweden.*
** Environmental Systems Analysis, Chalmers, 412 96 Gothenburg, Sweden;*
mathias.lindkvist@chalmers.se

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ABSTRACT

By not separating product flows from management, we target the little studied problem of how different management practices actually influence the environment. We test the *socio-material* philosophies actor-network theory, object-oriented ontology and agential realism on the life cycle assessment (LCA) cases bread and cement, through three examples. We conclude that socio-materiality point out that managers could benefit from an increased contextual understanding of the material and energy flows that their decisions influence. For LCA analysts, it highlights that including actual practices and action networks of people handling the flows could be useful for reaching effective use of LCA flow model results.

INTRODUCTION

Despite decades of attention, environmental issues like global warming seem still to be dangerously out of control, and one core area where knowledge is lacking is regarding how different management practices actually influence the environment. We therefore here describe systematic approaches for accounting for both interactions between the people along product life cycles and their interaction with machines and other entities that cause environmental impacts. Thus we hope to develop a presumably central premise of life cycle management (LCM).

Our starting point is that a consistent philosophy of science for LCM now can be found in fields of the social sciences and humanities where a *material turn* has taken place. The idea is that humans and material objects are inseparable and should be described as *socio-materialities*. Socio-materiality has been exploratively combined with the LCA approach in an organization studies context (Baumann, 2008). It is here, for LCM, further illustrated and advocated for by using empirical cases and additional socio-material philosophies.

MATERIALS AND METHODS

Three socio-material philosophies are here explored by applying them to socio-material life cycle studies on bread and cement (Lindkvist & Baumann, 2010). A large number of management practices of potential environmental significance were found — three of them are used here for a socio-material explication.

Bread and cement from an LCA perspective

The bread in our example comes from Swedish cradle-to-gate systems, from agriculture to retailing. Many flows come together in the bakeries, which therefore are important socio-material nodes. Further, LCAs on average bread impacts and different scales of production and bread types exist. Significant environmental impacts are found at most life cycle stages, and different bread systems result in different total environmental loads.

The cement in our example comes from Swedish cradle-to-gate systems, from raw material quarries to the cement plant. LCAs on cement point out large emissions from the production of the intermediary product clinker, where both fossil fuels used for heating and the chemical reactions needed for clinker creation contribute.

Socio-materiality for LCA

Socio-materiality has, in the social sciences where it is adapted from, been used for taking materiality into account in addition to their already well-developed knowledge on interactions between humans. It emphasizes that both humans and material objects influence each other. Thus, for life cycle studies, humans, technical processes and flows are considered simultaneously. The socio-material interactions of life cycle flows are often complex, as illustrated in Figure 1. Multiple actors may handle different parts of a single process or a single actor can be involved several processes. Of particular interest for LCM is that socio-materiality is systematically described in three philosophies: *actor-network theory* (ANT), *object-oriented ontology* (OOO) and *agential realism*. Taken together, they reinforce the need for more systematic socio-material analyses. Also, each of the philosophies highlights different aspects of socio-materiality, which is related to their respective disciplinary origins.

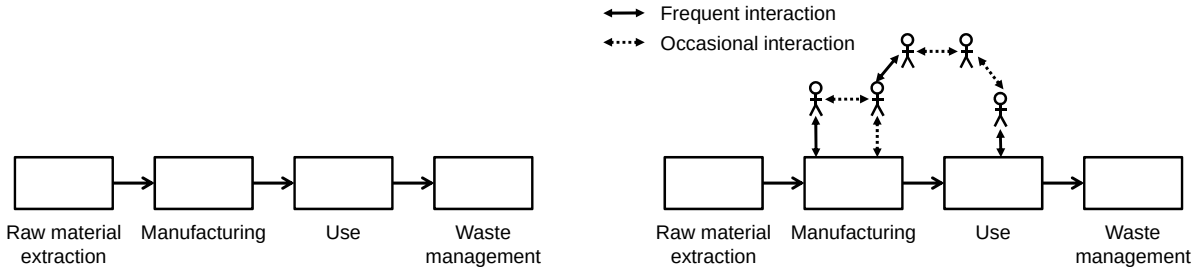

Figure 1. Product flow in LCA (left) and with socio-materiality partly added (right). The frequent and occasional interactions exemplify how interactions have different characteristics.

In **Actor-network theory (ANT)**, humans and material entities are seen as constantly interacting with and influencing each other. It emerged in the early 1980s as an approach for explaining the production of science and technology, and has since spread. A central concept is *translation*, which for example refers to how humans and electrons interact in a laboratory to let electrons leave physical traces that become graphs. Even the electrons are vital for the outcome; material entities are *actants*. (Latour, 2007) In the LCA context, translations take place when humans, for example, operate machines or interpret LCA data and reports.

Object-oriented ontology (OOO), like ANT, treats humans and non-humans as similar regarding how they interact with their surroundings, but it also emphasizes the limitations in how much different entities know and can influence each other. Philosopher Graham Harman has developed OOO since a decade, from phenomenology. Central conceptions are that

humans as well as material entities are *objects*, and that they only perceive a limited share or none of other objects' *qualities*. (Harman, 2011) For LCA, these limitations may refer to interfaces that put constraints on how persons, machines and control centers can be managed.

Agential realism, like ANT, views events as ongoing processes where both humans and material objects matter, but also theorizes on how alternatives exclude each other and that humans have but cannot entirely control their ethical responsibility. It grew out of a critique by physicist and feminist philosopher Karen Barad of a solely social focus in the influential texts by social theorist Michel Foucault and feminist scholar Judith Butler. (Barad, 2007) The focus on exclusions may be relevant for LCM when identifying excluded environmentally significant aspects in discussions on outsourcing.

RESULTS

Bread – a socio-material LCA view

The first socio-material bread example centers on the link between production and sales via a bakery CEO, concerning the discarding of unsold products. For one of our studied bakeries this discard rate had increased along with the growth in number of shops owned by the bakery. OOO here helped in pointing out some links in this bread system where information transfer was insufficient. The CEO carried out sales monitoring on his own. With time he found it increasingly difficult to determine production levels relative to actual demand. The bakery had started to deliver to more shops, where proportion of discarded bread increased as well. Also, the sales varied significantly from one day to another, in complex patterns. Using Figure 1, socio-material links are added to the LCA between production and retail processes. These links go through several persons, and in several cases the contacts are only occasional.

The second example concerns a bakery's change of suppliers. A local supplier was replaced by a nationwide organization and this was found to increase the environmental impacts from transports. The reason for the increased transport distances was that the nationwide organization performed larger purchases to pressure purchasing prices. Using agential realism helped in further pointing out that one practice excludes another for several reasons. The bakery joined this nationwide organization since it was too small to handle the increasingly complex fluctuations of the foreign currency rates applicable to many of their ingredients. This was in turn related to a large share of the bakery's production being pastries requiring many more ingredients from exotic countries, such as orange peels and almonds, than ordinary bread. However, they did produce bread as well, and the bulk bread ingredient flour gives rise to significant environmental impacts if supply distances increase. Thus, a small-scale bakery ended up using more distant supplies since trade mechanisms were pressing while not taking into account their previously less environmentally impacting practice.

Cement – a socio-material LCA view

The cement example revolves around the socio-material relevance of maintenance, particularly for the clinker burning oven. Good maintenance can prevent the large additional emissions that each stop of this oven causes through its long heating up sequence. However, using ANT, this socio-material practice can be seen in a different light by taking into account a series of translations that were also netted together. A daily coordination meeting for maintenance activities at one studied plant was set in place to be able to distribute the staff to

the most relevant tasks only after several severe breakdowns at the plant had already occurred. Using Figure 1, the production process in LCA is opened up to show how all activities that the maintenance staff control relate to each other in a dynamic pattern.

DISCUSSION

The examples illustrate activities that regulate the environmental impacts, and the difference between the left and the right side in Figure 1 becomes significant. Occasional human interactions are the only management links between sales and production in the first bakery case and dynamic interactions are added to the cement case. The socio-material approach has the advantage of mapping the actual organization around the product flow, instead of the risk that regular LCA is used combined with arbitrary assumptions about the organization.

Also, some practical conclusions for managers and LCA practitioners can be drawn from this study. For managers, complexity and sometimes 'messy' situations are probably no surprise, but a more systematic socio-material approach to LCM might be needed before making decisions that will have large impacts on the product flows. Otherwise, good LCM intentions may backlash. For the LCA analyst, taking the humans that control material and energy flows into account might be an effective means for actually, for example, reducing environmental impacts from hotspots pointed out by LCA flow model results.

Eventually, ANT is found to be most straightforward for the analysis among the philosophies. Therefore, it seems to be a good starting point for adopting a socio-material perspective. However, using OOO and agential realism is here found to add some clarifications on limitations in how people and material objects interact and on that many practices cannot easily be combined, respectively. Thus the three philosophies seem complementary.

CONCLUSIONS

We conclude that socio-materiality point out that managers could benefit from an increased contextual understanding of the material and energy flows that their decisions influence. For LCA analysts, it highlights that including actual practices and action networks of people handling the flows could be useful for reaching effective use of LCA flow model results.

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