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Conclusions

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Coordination :
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Conclusions

Isabelle Blanc, Anne Ventura

Conclusions

During this workshop on Consequential LCA (C-LCA), discussions between the experts and the audience were lively and we will report them through the following summary articulated around three points: what are the questions to be addressed by C-LCA, what are the methodological issues of C-LCA and what are the research needs?

WHAT ARE THE QUESTIONS TO BE ADDRESSED BY C-LCA?

According to Reinout Heijungs, there is no difference between A-LCA and C-LCA when impacts are evaluated using constant multi-linear functions. Both types of LCA have thus a common mathematical basis. However, there was a strong agreement that their objectives are different, on importance to identify which question(s) to address for the system under study and on the identification of the frame to use, namely Attributional LCA, Decision LCA, Consequential LCA, Macro LCA and Backcasting LCA. Matching the issue and the proper frame has been illustrated by Alessandra Zamagni by relating a series of issues within the electricity production to each type of frame:

- Which environmental impact can be attributed to the consumption of an average kWh of electricity at low voltage level purchased in Italy in 2008? Such question is clearly to be handled by attributional LCA (A-LCA).
- Which environmental impact can be attributed to the consumption of an extra kWh of electricity at low voltage level purchased in Italy in 2008? This one is related to Decision LCA (DLCA).
- Which effect the decision to purchase an additional kWh of electricity has on the electricity market and/or on the environmental impacts? This issue requires to be treated with a consequential approach (C-LCA).
- What would be the global indirect environmental impacts of a new energy policy in Europe? To be able to answer such question needs economic models (sectoral IO models coupled to LCA models) named Macro LCAs.
- What technologies are appropriate for fulfilling society-wide demands that fit within sustainability constraints? Backcasting LCA is the frame to consider for this issue (BLCA).

Discussions mainly turned around the comparison between A-LCA and C-LCA. Jeroen Guinée pointed that “there is no A-LCA against C-LCA, the question is how

can we work together?” There should be a smart combination of approaches. Reinout Heijungs pointed out that the aim of A-LCA was to identify responsibilities of products in a given system whereas the aim of C-LCA was to assess the consequences of a change in a system. He used a simple example of a consumer basket to clarify the differences between A-LCA, aiming at attributing a part of the impact to the various elements of the basket, and C-LCA, aiming at evaluating the impact corresponding to an extra amount of a certain product.

Anne Ventura raised questions concerning the system expansion method used to avoid allocation as a valuable question to address in the frame of C-LCA. The term “system expansion” was qualified as misleading, because in that case, the change of functional unit drives the extension of system boundaries while the purpose is not to study the expansion of the system itself. Following this discussion we ended asking ourselves whether the system boundaries of C-LCA were identical to A-LCA or whether the definition of the functional unit was different as suggested by Jeroen Guinee.

As recalled by Enrico Benetto, consequential LCA has been identified as a relevant frame to study consequences at macro-level (ILCD decision context B) when changes in demand or supply of the market are foreseen.

The relevance of C-LCA for eco-design has been confirmed in the discussion: even if each decision is made at micro level, the sum of all decisions may have large consequences at macro level. This aspect was mainly highlighted through Björn Sandén’s presentation: he showed that with the aim of managing a system towards an advisable change, who showed that social mechanisms, initially considered as marginal causes, could induce drastic changes.

WHAT ARE THE METHODOLOGICAL ISSUES OF C-LCA?

How to set system boundaries?

As previously mentioned, discussions on the main difference between C-LCA and A-LCA have identified the shifting in system boundaries. In general you start A-LCA and then you enlarge the scale. However setting boundaries of a system for C-LCA is a very delicate issue: which system to account for?

Because C-LCA accounts for the interaction between the studied system and the background system, it requires identification of affected processes. Some methods are proposed like a procedure developed by Weidema and based upon a decision tree. But several simplifications reduce the reliability of practical applications, particularly regarding substitution mechanisms. Uncertainties remain high due to the fact that the market may change rapidly, so that sensitivity studies and use of scenarios are unavoidable. Varying scenarios is proposed to improve the robustness of the results.

System boundaries are set by the choice of scenarios and Jeroen Guinée raised was on how to build valuable scenarios. Isabelle Blanc stressed that the definition of interesting scenarios highly depends on the question C-LCA is in fact addressing.

A few participants highlighted that consequential LCA is still too much imprecise and inaccurate to be defended as a decision support frame towards top management in industry. In some cases, outcomes are more sensitive to uncertainties and these can be larger than marginal effect themselves. The question of assessing uncertainties related to prospective scenarios is raised and should not be overlooked to avoid discrediting C-LCA results.

How to model the link between foreground and background systems?

Alessandra Zamagni showed the complexity of this question due to the **complex chain of consequences involving many indirect effects and market mechanisms**. The chain of consequence is complex: from substitution effects to rebound effects. While substitution refers to the introduction of new products on a market that may (or should), after a certain amount of time, replace current products, rebound effect (or take-back effect) refers to the behavioral or other systemic responses of the market to the introduction of new technologies that increase the efficiency of resource use. The type of modeling the time evolution can be continuously dynamics, discrete, and some studies do not really model but use comparison between various states of systems with a static approach using average values. Choosing between static and dynamic models should be justified for both the foreground and background systems. Setting the temporal scale is still under debate and is indeed a part of the scenario definition.

Two presentations focused on biofuels were presented based on Economic models.

Enrico Benetto underlined the necessity to use economic equilibrium models and presented a Partial Equilibrium model (PEM) approach to investigate the consequential effects of the implementation of a biogas policy in Luxembourg, aiming at producing bio methane from energy crops (maize). Two different PEM models, one rooted in opportunity costs minimization and the other on revenue maximization, specifically developed for the consequential inventory, were discussed and the results compared to the classical consequential approach based on expert opinions. The main conclusion was that the two PEM models lead to similar results and could be effectively complemented by the expert opinion approach, especially for the mechanisms which cannot be included in the PEM due to lack of data or information.

Fabio Menten presented the results of the application of a TIMES model (MIRET) for the consequential LCA of a future biofuel technology. Demands for energy and energy services were treated exogenously and technology innovation was included (through performance improvements). The life cycle impact assessment characterization factors (mainly Global Warming Potentials) were directly included

in the economic model, differently from the previous study, were the LCA calculations were done separately from the PEM. It was found, as expected, that the consequences (to be included in the consequential inventory) do not scale linearly with the magnitude of the change and that the running of LCA calculation within an economic model is perfectly feasible.

To build up, Björn Sandén described a chain of effects from direct physical effect to linear response, negative feedback (mainly economic) and positive feedback (related e.g. to learning processes) which are more related to social mechanisms rather than purely economic ones. The influence of the last aspect on environmental impacts may be very large, but also very uncertain. If this effect is not taken into account there is a risk that society invests too little in advanced technologies with short-term drawbacks but potential huge long-term advantages.

Anne Ventura highlighted the issues of functional equivalence between products in the case of substitution mechanisms, in the civil engineering sector, treating the case of recycling of slag (as a co-product of steel manufacturing) into road pavements. If this question may be negligible for energy, it appears as a central one when studying construction materials. Equivalence of functions will not only depend on economic mechanisms, but on regulations (standards and responsibilities of decision-makers). Furthermore, economic aspects are very local, and related to availability and forecasting of stocks.

SYNTHESIS FROM DISCUSSIONS AND RECOMMENDATIONS

About questions to be addressed by C-LCA ...

This part is not a direct transcription of the discussions from the workshop but it reflects our current conclusions on the consequential LCA with the aim of extracting synthetic knowledge from the workshop, considering discussions and presentations with a year of distance.

Through discussions, we can propose common points that seem to have the agreement of the participants to the workshop, about questions to be addressed by C-LCA:

- C-LCA accounts for the interactions between the studied system and the background system
- C-LCA is relevant to enquire consequences of these interactions at the macro-level of the background system
- C-LCA has been identified as a relevant frame to address marginal change decision as well as large scale decision process.
- The questions addressed by C-LCA frame aim at forecasting consequences of these changes within a given period of time by modelling market mechanisms.

From these collective observations, we deduct that in all cases (marginal change or large scale decisions) questions addressed by C-LCA are related to the **changes induced by the perturbation of the background system**, and that considering changes (i.e. comparison between different states of a system) **induces a time-dimension problem**.

About allocation...

As a direct consequence of the above assertions, the use of “system expansion” to avoid allocation is not always synonymous of C-LCA, depending on how the time dimension is integrated. The importance of a proper distinction between “system expansion” and “substitution” was highlighted by the auditors, the former being an artificial (virtual) weighting of the value of the co-function whereas the latter being an actual consequential approach, where the substitution actually occurs in the market. We thus give the following recommendations:

- In system expansion approaches, where the aim is only to avoid allocation and not to study system changes, C-LCA is not a suitable frame and substitution should be treated using the current state of market.
- If long term consequences are forecasted, the C-LCA becomes a suitable frame, requiring defining scenarios and/or models of substitution mechanisms, as well as sensitivity analysis.
- In addition, because “system expansion” was considered as a misleading terminology by the audience, we recommend that it should be replaced by “functional expansion”.

What are the research needs?

The introduction of the workshop by Stéphane Lepochat highlighted the stakes of C-LCA for companies, public organizations and researchers, by a necessary balance between reliability of LCA results in a strategic decision context and efficiency of the method.

Several issues and perspectives have been addressed in the final discussion between participants:

- (1) It is essential to link LCA to other field of expertise and in particular we suggest fostering cooperation between LCA and macro-economic modelers.
- (2) The social dimension should not be left out. The example of mobility was given where consumer’s choices are found out not to be market based.
- (3) The definition of the decision context and question to be asked by consequential LCA is mandatory for a consistent study. To design realistic and comprehensive scenarios for consequential LCA is key and require defining probabilistic scenarios accounting for uncertainties. There is no such thing as a correct scenario.

- (4) The elaboration of a code of practice for C-LCA is needed to reach enough transparency and accuracy within an acceptable timeframe.
- (5) Consequential LCAs are of high interest for decision makers for political decisions such as the ones related to the energy debate worldwide or to urban design as reported through the *Efficacity* research program. International journals should significantly increase the publications of such studies.

We closed the workshop recognizing that C-LCA is currently facing several challenges but should go ahead because “*It is better to be roughly right than precisely wrong*” (John Maynard Keynes).

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