Conference Reports: 22nd Discussion Forum on LCA

Evaluation of Long-Term Impacts in LCA

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Abstract. When looking at a product's life cycle, emissions and resource uses, as well as the resulting impacts, usually occur at different points in time. For instance, construction materials are often 'stored' in buildings for many decades before they are recycled or disposed of. The goal of the LCA Discussion Forum 22 was to present and discuss arguments pro and contra a temporally differentiated weighting of impacts. The discussion forum started with three talks that illustrated the importance of temporal aspects in LCI and LCIA. The following two presentations discussed the economical principles of discounting, the adequacy of this concept within LCA, and the ethical questions involved. After one further short presentation, three groups were formed that discussed questions about temporally-differentiated weighting, and consequences for LCI as well as LCIA (damage assessment and final weighting). The discussion forum ended with the following conclusions: (a) long-term impacts should be considered in LCA, and (b) long-term emissions should be inventoried separately from short-term emissions. There was no consensus on whether short-term and long-term impacts should be weighted equally. Some prefer to weigh short-term emissions higher, because they are considered to be closer. Consistent and approved forecasts should be used when considering future changes in environmental conditions in LCI and LCIA.

Introduction

In Life-Cycle Assessment (LCA), decision makers are often faced with tradeoffs between current and future impacts. Such tradeoffs raise issues of (intergenerational) fairness and equity that are ethical in nature. Life-Cycle Assessment involves many of such temporal issues. One typical example is waste incineration, where immediate emissions to the air from the incineration process have to be weighted against future emissions of slag landfills.

During the development of the new database, ecoinvent 2000 [1], it became apparent that the impact potential of long-term emissions might be large if they were assessed with the same impact factors as current emissions. This is particularly true for waste treatment processes (and has long been recognized as a challenge within this field). These results raise the question as to whether the same weight should be assigned to the impacts of short-term and long-term emissions, and whether current impact assessment methods are able to correctly deal with these long-term emissions.

While LCI has started to provide time-related information, most current LCIA methods make no explicit differentiation between emissions (and, ultimately, impacts and damages) at different points in time. For instance, whether an emission contributes to ozone depletion today or in 200 years is treated equally in most methods. Eco-indicator 99 [2] was the first method that explicitly addressed the issue of discounting and age weighting in LCIA. Besides that, some forms of implicit discounting are common practice, e.g. temporal system boundaries. Huijbregts et al. [3] found that metal toxicity potentials differed up to 6.5 orders of magnitude depending on the time horizon chosen in the fate model. The question remains, as to whether temporal cut-offs or any other type of differentiated weighting (e.g. discounting) should be applied in LCA.

The goal of Discussion Forum 22 was to present and discuss arguments pro and contra a temporally differentiated weighting of impacts and to provide input for LCIA method development.

1 Temporal Issues in LCA

The discussion forum was opened by Rolf Frischknecht (ESU-services) with an overview of the presentations, which covered time aspects in inventory analysis (G. Doka), fate analysis (M. Huijbregts), damage assessment (R. Müller-Wenk), and final weighting (S. Hellweg and A. Leist).

Gabor Doka (Doka Life Cycle Assessments) illustrated the importance of temporal issues in the inventory analysis. Doka described the modeling approach of landfills used within the ecoinvent project [4]. Two time horizons are distinguished: a short-term time frame of 100 years and a long-term time frame of about 60,000 years, which is the estimated time until the next ice age in Switzerland. The emissions of landfills are modeled as a function of waste-input (e.g. the emissions of cadmium depend on the cadmium content in the waste) and the technology used. For the quantification of future emissions, field data was used as well as models, which consider important key parameters of landfills such as pH value and water flow. The results (on the level of fully aggregating LCIA methods) show that long-term emissions are very relevant with respect to disposal processes. In contrast, their importance in other processes of the database is limited. Depending on the material, disposal contributes between less than 10% and more than 40% to the total environmental impact (PE incinerated and PVC landfilled, respectively). Uncertainties in projections of long-term emissions are large, but they are comparable to other uncertainties such as those about the composition of waste.

After Doka's talk on temporal issues in LCI, Mark Huijbregts (Nijmegen University) and Ruedi Müller-Wenk (St. Gallen University) followed up with temporal issues in the LCIA. Huijbregts focused on the time-horizon dependency of fate

factors using the multicompartment model USES-LCA [5]. He compared the difference in fate factors of about 1000 substances for two time frames: First, exposure was integrated over100 years. Second, an infinite time frame was chosen. Fate factors of metals differed substantially between the two time horizons, by up to seven orders of magnitude. Huijbregts mentioned the need to further improve the modeling of partitioning, removal, bioaccumulation, and bioavailibility of metals. Moreover, the effect assessment should be related to the ambient situation. This would require a modeling of future background concentration levels.

Müller-Wenk focused in his talk on the time lag between emission and damaging effect with the help of the example of stratospheric ozone depletion. The emission of the halogen source gas causes a temporary concentration increase of this gas in the troposphere. Gas migration to the stratosphere takes roughly 3 years. In the stratosphere, the energy of sunlight decomposes the gas molecules, resulting in the production of reactive halogen gas. Depending on the type of the compound, the life-time is between 3 and 100 years. A reactive halogen gas molecule is acting immediately as a catalyst in an ozone-destroying process, and it can maintain this catalytic function for months. A lower ozone concentration immediately increases the UVB radiation. The accumulation of UVB exposure by human skin takes several decades. As a consequence, the additional cases of skin cancer show up between a few years and more than 100 years after the emission time of the halogen source gas. Müller-Wenk concluded that even if all emissions of halogen source gases were completely stopped now, the 21st century would still witness a sizeable amount of new skin cancer cases per year.

2 Temporally Differentiated Weighting and Ethical Questions

In the second part of the discussion forum, it was discussed how LCA should deal with the temporal issues presented by the first three speakers. Stefanie Hellweg (ETH Zurich) introduced the economical principles of discounting and discussed their transferability to LCA. Discounting in economics can be motivated by pure time preference, productivity of capital, diminishing marginal utility of consumption, uncertainties, and changes in the price level. Discounting across generations, because of pure time preference, possibly contradicts ethical values and sustainability goals. However, it has to be acknowledged that decision makers often use positive discount rates in practice, because of pure time preference – either because they might profit from imposing environmental damage on others instead of themselves or because people in the far future are not of immediate concern to them. Discounting because of the productivity of capital assumes a relationship between monetary values and environmental impact. If such a relationship is accepted, discounting could be applied. However, future generations should be compensated for the environmental damage. It is likely that they would demand a higher compensation if the real per capita income increases. As both the compensation and the discount rate are related to economic growth, the overall discount rate would be reduced. Moreover, it needs to be taken into account that environmental catastrophes would decrease the growth rate of the economy and thereby influence the discount rate. Uncertainties could justify both positive and negative discount rates, but it seems more appropriate to consider them in scenario analysis, together with changes in the absolute magnitude of damage, rather than in the discount rate.

Anton Leist (University of Zurich) discussed ethical questions. Leist differentiated between an anthroprocentic and biocentric point of view. According to anthroprocism, only the welfare of humans and possibly other living beings, to which we establish social relations and in which we have human interests, is of concern to us. Biocentrism, on the contrary, includes all 'life' per se. Leist adopted an anthroprocentic point of view, as morality is always associated with human views and values. Ecological justice or fairness can only be discussed in the context of social relationships between humans. Therefore, it makes sense to distinguish between the 'near' and the 'far' future concerning intergenerational, environmental damage: While we can establish direct social relationships to people in the near future, e.g. three generations or approximately 100 years from now, it will not be possible to do the same with people in the far future. To generations in the far future, we therefore have no positive duties, i.e. a just distribution of welfare. However, the argument of non-malificence may apply, according to which we should not harm or damage them. Social relations to people in the far future cannot be lived personally, but possibly some kind of community unites us with coming generations, i.e. we have appreciated living in a cultural background and therefore want to pass it on to future generations. Such social bindings would probably get weaker the more distant in time future generations are.

3 Short Presentations

One short presentation was held by Ollivier Jolliet (EPFL Lausanne), on time aspects in LCIA and on bioavailability of metals. He proposed to use strict time horizons encompassing both LCI and LCIA. If the impact of CO_2 emitted today is determined based on a time horizon of 100 years, the impact of CO_2 emitted in 20 years should be determined based on a time horizon of 80 years. No impact would be assigned to CO_2 emitted in 100 years from now within such a 100-year framework.

4 Discussion

Three discussion groups were formed. The first group discussed tradeoffs between current and future impacts. There was agreement among the participants that long-term impacts should be considered in LCA. LCA was classified as an appropriate tool to handle such impacts ('if not LCA, what else?'), because it should consider all impacts from 'cradle to grave'. It was also mentioned that LCA serves as an awareness tool, and therefore it makes sense to point to potential future impacts or future risks of impacts.

However, long-term impacts occurring in the far future should be marked as such, because the close future of less than 100 years appears to be more accessible to us than the far future thereafter. Some prefer to weight long-term emissions differently than short-term emissions, because of time preference. Also, uncertainties increase with an increasing time horizon.

The second group dealt with the consequences for LCIA methods due to temporally differentiated weighting. First, impact categories were identified where impacts occur over a long time horizon: land use, global warming, ozone depletion, metal toxicity, acidification. Relevant future scenarios and dynamic models are required to account for a changing environment in a consistent way. The question as to whether or not one is able to perform long-term assessments was confirmed, although it was admitted that uncertainty increases with the extension of the time frame. No solution was ready on the table on how to assess this increased uncertainty. Finally, the group found no fundamental reasons to completely exclude long-term impacts from LCI.

The third group discussed the consequences of a temporally differentiated weighting for the LCI modeling. The group saw no need for a more detailed disaggregation in time than the differentiation between short-term and long-term made in ecoinvent. If a further differentiation were needed, its resolution would need to be higher for the near future as compared to the resolution required for the far distant future (e.g., 10, 20, 50, 100, 200, 500, 1000 years). The group suggested allocating research resources to a spatial differentiation rather than to a further differentiation in time. The ecoinvent landfill model and fate models used in the impact assessment partly cover the same mechanisms, but have primarily been developed independently. A harmonization of the two models seems to be due.

In the final discussion, it once again became apparent that there was no consensus concerning how future emissions should be included in impact assessment. There was agreement that long-term impacts should be included in LCA and that long-term emissions should be reported separately from the short-term emissions. There was no consensus on whether short-term and long-term impacts should be weighted equally. Some prefer to weigh short-term emissions higher because it is closer to them. Consistent and approved forecasts should be used when modeling future changes in the environment in LCI and LCIA. The elevated uncertainty in emission factors of pollutants released during thousands of years and the elevated uncertainty in the fate and damage analysis of such far future emissions were acknowledged. However, no ready-made solution was presented on how to include uncertainty in impact assessment.

The presentations of the Discussion Forum and background information are available on the Internet <http://www.texma.org/LCA-Forum/lca-forum.html>. On this webpage, there is also more information about the Discussion Forum series, as well as an announcement of the coming events.

References

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Conference Reports: 2nd Biannual Meeting of iEMSs

Complexity and Integrated Resource Management: Uncertainty in LCA

Osnabrück, Germany, June 14–17, 2004

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The International Environmental Modelling and Software Society organised the second international iEMSs Conference, held June 14–17 2004 in Osnabrück. The conference included research contributions from environmental modellers and software developers and users from a wide variety of disciplines, including the field of Life Cycle Assessment. Special emphasis was given to the analysis and modelling of complex human-technology-environment systems and the implications of complexity and uncertainty for management concepts and decision making. In this context, a session on 'Uncertainty in LCA' was organised focussing on tools to treat different types of uncertainty in an LCA decision-making context. All papers can be accessed through http://www.iemss.org/iemss2004/

Reinout Heijungs (Leiden University) started the session with a review of approaches to treat uncertainty in LCA. The review discussed the typology of uncertainty that may be encountered in LCA, the qualitative and quantitative techniques that are available to address these uncertainties, the inclusion of these techniques in LCA software tools, the (graphical) possibilities to show uncertainty in LCA outcomes, ways to simplify the uncertainty analysis, the inclusion of uncertainty analyses in case studies and (the difficulties in) the interpretation of uncertainty information.

Philippa Notten (University of Cape Town) reported three graphical options to interpret output samples from quantitative uncertainty analyses. The results were from case studies within the coal-fired power generation sector. It was found that box and whisker plots are good at representing the rela-