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.

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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 relative importance of empirical parameter uncertainty and the uncertainty arising from the choice of decision variables, and show the degree of shifting between the options as well as the full range over which the options potentially act. Principal component analysis is considered particularly valuable to provide an overview of the results, where it is able to clearly present any trade-offs that have to be made between selection criteria, and the 'spread' of the options under consideration over the decision space.

Lauren Basson (University of Cape Town) presented an approach for the integrated consideration of both technical and valuation uncertainties during decision making supported by LCA-type environmental performance information. The integrated approach for the management of uncertainty is demonstrated for a technology selection decision for the recommissioning of a coal-based power station. Distinguishability analysis showed that it was not possible to obtain a conclusive answer with regard to the preferred technology, due to the extensive uncertainty in the LCA-based environmental performance information. Principal component analysis of the ranking of the design scenarios demonstrated that valuation uncertainties had the most significant effect on the ranking of the design scenarios. The results suggest that stakeholder involvement is important, and that the 'encoding' of value judgements and preferences into LCA are to be avoided.

Ralph Rosenbaum (EPFL Lausanne) presented an approach for estimating uncertainties for toxicological impact characterisation in LCA. He proposed combining uncertainties estimated for intermediate results from the chemical fate, human intake fraction, and toxicological effects. Results were presented for impact contributions in the contexts of aquatic ecosystems and human health. The approach presented is transparent and easily applicable in practice to combine the uncertainty of the emission inventory with those of the impact assessment phase in a life cycle assessment study.

Claudine Basset-Mens (INRA, France) presented a case study looking at uncertainty and variability in an LCA of pig farming systems, focussing on aquatic eutrophication. The quantification of uncertainty took into account the variation in technical performance, emission factors, and the influence of the functional unit. For various farming systems, variability was investigated through differentiating by the production mode and farmer practices. For natural systems, variability due to physical and climatic characteristics of catchments, that modifies nitrate fate, was explored. For the eutrophication impact category, the variability of field emissions and the choice of the functional unit was influential. Concerning inter-system variability, differences in farmer practices had a larger effect on eutrophication than differences between production modes. Finally, the physical characteristics of the catchment and the climate strongly affected the eutrophication result.

Raquel Ferret (TEKNIKER, Spain) discussed the influence of agricultural data uncertainty in an LCA of biodegradable hydraulic lubricants. She found that fertilization practices and machinery operations in the agricultural step in the biodegradable hydraulic lubricant production has the main environmental impact. A Monte Carlo simulation has been performed showing that the eutrophication score is dominantly affected by input data uncertainty.

Stefanie Hellweg (ETH Zürich) presented an LCA on two plant-growth regulators considering various sources of uncertainty. These uncertainties were expressed as probability distributions and assessed via Monte-Carlo Simulation. The results showed that differences in median impact scores of a factor of 1.6 were sufficient in the impact categories of global warming, acidification, and eutrophication for a significant distinction of the products. By contrast, dispersions are large concerning the toxicity impact categories and the photooxidant creation potential. The implications of these uncertainties on the decision-making process were discussed and tentative rules of thumb for estimating the significance of results were put forward.

In the **Platform discussion**, uncertainties in the weighting between various impact categories were named as a potentially relevant uncertainty. Involvement of stakeholders could be one solution to this problem. Aggregating LCIA methods include the danger of hiding uncertainties, although some methods consider different weighting schemes, e.g. according to cultural theory. An alternative approach could be the open illustration of the tradeoffs involved, such as presented in the talk of Basson. The question was also posed as to whether probability functions of LCI and LCIA flows are trustworthy. It was stated that more case studies are needed to learn about the shape of distribution functions and about the importance of different types of uncertainty and variability in LCA. Meanwhile, the application of different probability functions for uncertain parameters may be a pragmatic solution to address this uncertainty. It was concluded that uncertainties in LCA are typically large. There was concern that LCA becomes a meaningless tool because results may often be insignificant. Additionally, background processes may frequently dominate the uncertainties of the foreground system, especially if generic uncertainty factors are used that are 'on the safe side'. One comment to this problem was that the level of significance needs to be determined within the context in which the decision is made. In general, large confidence intervals of 90% or higher are applied. These high levels of significance may be suitable, e.g. if large monetary investments are a consequence of a decision. However, in some situations, a smaller level of significance (e.g. 75%) may be sufficient, for instance if two products are compared that perform equally with respect to other criteria, such as price and performance. Another possibility to deal with high uncertainties is to identify the parameters with the highest contribution to variance and try to reduce their uncertainty. In some cases, other solutions to reduce uncertainty may also be found (e.g. the re-definition of the functional unit). In any case, it was stressed by several participants that one should acknowledge that the aim of uncertainty analysis is not to take away uncertainty, and even not to reduce it. Its ultimate aim is to accommodate uncertainty in the decision-making procedure by giving it an appropriate place. There are various possibilities to do this, ranging from specifying confidence intervals to using uncertainty as a separate decision criterion. It was also stated that we may just have to accept that LCA cannot always give a clear decision-recommendation due to the uncertainties involved, but that it may rather be used to understand the problems and tradeoffs involved in a decision.