

Conference Reports

Recycling, Close-Loop Economy, Secondary Resources

10th LCA Case Study Symposium, 2–3 December 2002 in Barcelona, Spain

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After the SETAC Annual Meeting 2001, Spain was again the location of a major event for the LCA community. SETAC's 10th LCA Case Study Symposium was held in the lively and charming city of Barcelona together with the second European Meeting of the International Society for Industrial Ecology. This report gives an overview of the 19 platform presentations of the case study symposium, which were supplemented by 27 posters. Recycling, reuse, disposal, and other issues of the end-of-life (EOL) phase of goods and services were the overall theme of the presented and heavily discussed LCA applications, a very timely theme due to ongoing discussions on national and international regulations for the EOL of products in many sectors.

The conference was opened by PERE FULLANA (Randa Group, Spain), the chairman of the conference, and a representative from the Catalan Ministry of Environment by welcoming the participants to Catalonia and Spain. Bo Weidema (2.-0 LCA consultants, Denmark), the scientific chair of the symposium, then opened the floor for the presentations and discussions.

ANDREAS CIROTH (GreenDelta TC, Germany) started with a general discussion of the **role and relevance of case studies in LCA**. He compared LCA case studies to studies in other fields such as business management and concluded that LCA cases are different, since they cannot be validated by observations of reality. As an example for validation in business management, he presented a restructuring case of an engineering company, where the results of the analysis and subsequent decisions could be monitored by the resulting performance of the company. Therefore, Cirotth advocates improving validation procedures for LCA studies, so that results can be closer connected to reality.

The following presentations focused on LCA applications in the construction and building industries. JORIS BROERS (Ministry of Transport, Public Works and Water Management, The Netherlands) discussed **LCA of Construction Raw Materials versus Existing Raw Material Policies**. He pointed out that results of LCA sometimes differ from environmental policy standards and demands. In specific cases from the construction sector in The Netherlands such differences can be explained by a lack of addressing land use and other local environmental impacts in the LCAs. Also, leaching of heavy metals from construction materials are difficult to deal with methodologically if these heavy metals are natural trace materials in primary resources, e.g. sand, used for building materials. Broers stated that in addition to LCA other environmental assessments are necessary for policy making.

AGNES SCHUURMANS (Intron, The Netherlands) presented a study that **compared a new closed-loop recycling system for building and demolition waste (closed building cycle) to the conventional procedure where recycled brick and concrete**

materials are used for road foundations and filling materials. This was part of a feasibility study in the Netherlands. It was concluded that the envisaged closed building cycle system would lead to improvements in regards to energy consumption, global warming, waste generation, and land use, with the results on land use being very sensitive to the specific assumptions. The differences can be explained by a higher recovery of combustible materials in the closed system, because the recovery rate of the different fractions is enhanced.

BEATRIZ ESTÉVEZ (Universitat Politècnica de Catalunya, Spain) showed results of a **life cycle inventory analysis of concrete recycling** from the building sector, where the secondary material is used for road foundations and fillings (see above). Looking at emissions of CO₂, NO_x, SO₂, SO_x, and dust she found that this recycling system is preferable to the disposal of the construction waste.

A **combined view of material flow analysis (MFA) and LCA** was the focus of MARCEL WEIL's (Karlsruhe Research Centre, Germany) talk. He looked at the impacts from concrete mixtures with recycled content (partly closing the loop for the building sector) versus concrete with exclusively primary aggregates (gravel/sand). The LCA revealed that a reduction in the use of natural sand/gravel could only be achieved at the expense of a higher energy consumption. If one takes the overall picture into account by applying MFA, Weil concluded that no net conservation of mineral resources occurs for the closed-loop recycling system as long as there is high demand for open-loop recycling products for road construction applications.

BARBARA NEBEL (Wood Research Institute, Germany) elaborated on the **thermal utilization of residual and post-consumer wood from wooden floor coverings**. She explained that such wood applications both store carbon during their use phase and contribute to the substitution of fossil fuels via incineration of residual and post consumer waste, thus counteracting global warming.

The following presentation by GEORG ROMBACH (Hydro Aluminium Germany) looked at **constraints and potentials of aluminum recycling in Europe**. He showed that the possible growth of recycling is not primarily dependent on the available recycling technologies, but on parameters such as growth rates in different application sectors (e.g., automotive, construction), lifetimes of the products, the employed alloys, and recycling legislation. Essentially, the availability of aluminum scrap determines the recycling potential in this industry. However, he also pointed to improvement potentials in metal scrap processing and smelting operations.

MARY STEWART (University of Sydney, Australia) continued with **metals recycling, examining the global copper industry**. Implications of different refining technologies and locations for secondary copper production for strategic decision making were elaborated. A case study of recycling printed circuit board scrap available in California, USA, was examined in detail. The impacts of recycling this scrap in a smelter in Arizona, USA, versus China, or Chile, were compared by LCA and process level input-output modeling. Transport distances as well as the electricity mixes at the different sites were identified as the key parameters. Stewart concluded that no clearly preferred location could be identified, since not all considered impacts (global warming, acidification, water usage, eco-toxicity) show the identical ranking for the three options. The main benefit of this comparison was seen in the identification of the trade-offs relevant for the recycling decisions, which should be taken into account together with other issues in multi-criteria decision-making.

A general methodological analysis of reuse and recycling was presented by ROLAND GEYER (University of Surrey, UK). He examined the **impact of constraints in closed-loop supply chains** and discussed a case of reuse of components in durable goods as e.g., microchips in personal computers or in mobile phones. Typical constraints for the material flows identified by Geyer are limited availability of end-of-life products, feasibility of reprocessing, and market demand for the recycled/reused products. All these flow constraints together determine the optimal recycling rate, which can be anywhere between 0 and 100%. He has developed a model that can take these constraints into account, identify non-linearities, and the optimum rate of reuse/recycling.

ARNE EIK (NTNU, Norway) introduced an approach for **improving the eco-efficiency of single use PET bottle recycling in Norway using LCA and network theory**. With this approach he identified the reverse vending machine for take-back of the bottles as the focal point for improving the overall system. The performance of this machine, expressed in detection rate, compaction ability, etc. plays a crucial role for the achievable recycling rate and the totals cost of the system.

An **analysis of waste management and recycling by a linear programming input-output (I/O) model** was the topic of the presentation by SHINICHIRO NAKAMURA (Waseda University, Japan). The model expands the environmental I/O model to include waste flows and alternative technologies, the latter made possible by a linear programming approach. This Waste Input-Output Linear Programming (WIO-LP) model was

applied to identify waste management and recycling strategies for Japan that minimize landfill use and CO₂ emissions, if possible. It was found that an appropriate combination of available technologies could significantly reduce the consumption of landfill capacity without increasing the CO₂ emissions. However, options for reducing the effect on global warming are rather limited.

AMALIA SOJO BENITEZ (Autonomous University of Barcelona, Spain) **compared the urban waste management in the city of Puebla, Mexico, to that of Barcelona, Spain**. Both cities have a similar population size, but very different development levels. In Puebla 100% of the collected waste is landfilled, while Barcelona has a diversified system of recycling, incineration, and landfilling. Looking at the formal waste management and recycling system, one can conclude that the impacts of global warming, acidification, and summer smog are at least twice as high in Puebla, while human toxicity and nutrification potentials are higher in Barcelona (mainly caused by additional transports and recycling operations). However, Sojo Benitez stressed that there is a comprehensive informal recycling system in Puebla, as in any developing country, for valuable materials (mainly glass and metals) that could not be taken into account in the study due to a lack of data.

The second day of the case study symposium was opened by GUIDO SONNEMANN (United Nations Environment Programme) who gave the keynote lecture of the conference on **Recycling – Its Role in a Life Cycle Economy**, also on behalf of the head of UNEP's Sustainable Production and Consumption Branch, Fritz Balkau. Sonnemann explained that UNEP views recycling as an integral part of a life cycle economy, but stressed that the life cycle concept is the encompassing framework, which should be considered if one wants to move towards sustainable development. Dematerialization of the value chain, eco-design of products, cleaner production, as well as more sustainable consumption patterns are other important elements. The proliferation of LCA and life cycle thinking in management practice and the facilitation of its use on a worldwide level are therefore aims of the UNEP/SETAC Life Cycle Initiative, which has been strengthened by the explicit listing of the life cycle approach in the ten-year workprogramme that resulted from the World Summit on Sustainable Development 2002 in Johannesburg. Sonnemann conveyed UNEP's message that the notion of recycling needs to evolve beyond choosing the best technologies. The application of systemic life cycle approaches helping to determine where recycling is beneficial for the society, without causing significant secondary impacts, has to become more common practice.

After the keynote lecture STEFAN SEURING (Carl von Ossietzky University Oldenburg, Germany) discussed **challenges and possible solutions in recycling of textiles from clothes**. He mentioned that in Germany only 50% of the discarded clothes are collected and that of this fraction only half can be reused due to their condition or contaminations. He argued that this mixed collection hinders recycling rather than promoting it, since it is not possible to generate high purities of single fiber types, which is necessary for a quality recycling. As a promising example how to improve the situation he presented the

case of ECOLOG, a company which operates a recycling network for polyester clothing, involving manufacturers, retailers, consumers, and recyclers, where the consumer returns the clothes to the retailer. This example shows potential, but needs significant improvements in regards to communication and possible financial incentives for the consumer. At present, the returned fraction is still very small.

ANNA BJÖRKLUND (Royal Institute of Technology, Sweden) reviewed a set of published case studies that compared recycling to incineration scenarios for material fractions of household waste in regards to effects on global warming and energy consumption. The aim of this review was to determine if general recommendations regarding recycling vs. incineration can be derived. In many cases, recycling was found to be preferable to incineration, though this depends largely on the material or energy that is substituted by the EOL operations. For instance, materials recycling of plastics is generally better than incineration if virgin plastic is replaced, but worse when the secondary plastic replaces wood-derived products (and the incineration would replace fossil fuels). Björklund stressed that the most important findings were not the general trends, but the identification of the key factors that determine the single results, which were very often the assumed substituted material or energy sources as explained above.

NADINE HÖLZINGER (GreenDelta TC, Germany) advocated a concept in which single questions to be answered by LCA can be put in the overall context of a decision. She elaborated on this by asking **What is the Optimal Recycling Rate of a Beer Can or of a Car?** and presented an approach in which different levels of technology, different markets, and policies, etc. can be reflected in order to model the individual case. Reducing the costs for the conduction of LCA and increasing the flexibility to allow for modeling different technologies and other assumptions are the goals of this concept.

The next speaker, IVAN MUÑOZ (Autonomous University of Barcelona, Spain) talked about the **application of LCA to integrated waste management planning in Gipuzkoa (Spain)**. Seven alternative integrated waste management plans were compared for a time period until 2016. Overall, it was found that materials recycling, if there are separate collection systems for the fractions, is beneficial, though there are also potentials for improvement, e.g. in transporting the collected plastics. Muñoz stated that an integrated approach to waste management has clear advantages and that LCA is a suitable tool for developing the best strategies for a region.

STEFANIE HELLWEG (Swiss Federal Institute of Technology Zürich, Switzerland) presented a **comparison of municipal solid waste management scenarios for Switzerland, which comprised the status quo, a scenario with maximal feasible recycling efforts, end-of-pipe treatment (mainly incineration and composting), and a new two-step thermal treatment**. An infinite time period was considered in the impact assessment based on the Eco-Indicator 99 method. Hellweg explained that compared to the status quo, maximum recycling, and end-of-pipe scenarios did not differ by more than 20%, the largest shortcoming of end-of-pipe scenarios appearing to be the long-term emissions of heavy metals. The innovative thermal treatment (which recovers e.g., copper and cadmium from

the incineration residues) showed a relevant improvement potential, though with high uncertainties, since only a few of these plants are presently in operation.

In his second presentation, ROLAND GEYER analyzed **economic and environmental implications of reusing structural steel sections in the construction sector vs. conventional materials recycling**. He found that increased reuse is beneficial in an unconstrained system, but this could change if constraints such as technical feasibility, limited deconstruction, and market demand have a high influence. The complete production and consumption system has to be coordinated, including an improved communication between the various actors in the system, in order to utilize the potentials of reuse.

Awards for the best platform presentation and poster were given to ROLAND GEYER for his presentation on constraints in closed-loop supply chains (see above) and GREGORY HOUILLON and OLIVIER JOLLIET (Swiss Federal Institute of Technology, Switzerland) for a case study on treatment processes and recycling of urban waste water sludge, respectively.

The conference was an extremely fruitful platform for extended discussions on the presented case studies itself as well as on the role and potentials of case studies for decision-making in general. Among other issues raised, it was stressed by GERALD REBITZER (Swiss Federal Institute of Technology, Switzerland) that practicing LCA is much more than applying a software tool. Such tools support, but cannot replace the modeling of the systems to be assessed. Another point of importance, raised by MATTHIAS FINKBEINER (DaimlerChrysler, Germany) and others, was that comparative assertions, even if not termed as such, should be based on minimal criteria as established by the ISO 14040 series. GREGORY NORRIS (Sylvatica/Harvard, USA) challenged the LCA community to ask the question 'So What?' in regards to case study results, which points to the need for improvements in connecting scientific results to real-world decision-making. Another heavily debated issue was the importance of substitutions and replacements in recycling and other EOL strategies. On the one hand, substitutions make LCA results directly dependent on the underlying assumptions; on the other hand LCA then can provide very relevant insights on the products, which should be replaced to provide maximum environmental benefits.

The one and a half days of the case study symposium were directly followed by the meeting of the International Society for Industrial Ecology (ISIE). There was a large overlap of participants of both conferences, ensuring exchanges and enhancing the collaboration between the two areas of research [see also Ehrenfeld (2003) for the interactions between the life cycle and the industrial ecology communities]. This collaboration will be continued in the third joint meeting of SETAC and ISIE from December 3–4, 2003 in Lausanne, Switzerland, which will focus on the themes of information technologies and materials.

References: Ehrenfeld JR (2003): Industrial Ecology and LCM – Chicken and Egg? (Editorial). *Int J LCA* 8 (2) 59–60

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