Letters to the Editor

Data Quality of Life Cycle Inventory Data – Rules of Thumb

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A couple of papers on data quality were published in the last issues of the Int. J. LCA (Coulon et al., 1997; Kennedy et al., 1996 and 1997), as well as a discussion on the use of the Cumulative Energy Demand (Klöpffer, 1997; Frischknecht, 1997). I would like to comment on both these issues by briefly elaborating some results which to date have only been published in the Swedish language (Finnveden et al., 1996).

When interpreting the results of an LCA, it is important to have an idea of the quality and uncertainty of the inventory data. However, detailed information is often lacking, making rules of thumb useful. In the Nordic Guidelines on LCA (Lindfors et al., 1995b) two rules of thumb were suggested which can be used unless other information is available. It was suggested that emissions less than one order of magnitude different should not be regarded as significantly different and energy and raw materials use less than 50% different should not be regarded as significantly different. Although based on experience, these rules were not supported by any quantitative data. When reviewing a number of LCAs on PVC and alternative materials it was therefore of interest to compare different cradle-to-gate databases for PVC in order to see if these rules of thumb could be verified or qualified (Finnveden et al., 1996). The following data bases were examined in the comparison:

- Boustead (1994b), with average European data for 1989-1990.
- Habersatter (1991), based on data from some German industries.
- De Baere (1994), with data from PVC-production in Belgium.
- Norsk Hydro (1992) supplemented with additional data from Hydro (1995), with site-specific data from the plant in Stenungsund, Sweden.
- One set of confidential data from an European country with several plants.
- One set of confidential data from one company with several plants.

These databases are typical of the type of data a European LCA-practitioner would have chosen in the mid-1990s. The range of the data in the different databases may therefore indicate the typical uncertainty. Some of the results are presented in **Table 1** (more data are presented in Finnveden et al., 1996).

The results in **Table 1** indicate variation and uncertainties in LCA data which is larger than often assumed. For example, in the analysis by Kennedy et al. (1996 and 1997), it is assumed that data with low quality will result in a range of +/- 50%. This is a variation which is very low compared to the results in **Table 1**.

Table 1: Range of the various inventory parameters. The min. value has been set to one (based on Finnveden et al., 1996)

Parameter	Min.	Max.
Inputs		
Energy	1	1,5
Electricity	1	1,7
Limestone	1	500
Water	1	10
NaCl	1	1,8
Air emissions		
CO_2	1	2,4
SO_2	1	11
Nox	1	6,3
CO	1	18
Cl	1	66
HCl	1	17
CH	1	9
Metals	1	71*
Hg	1	7
Chlororganic compounds	1	11
Dioxins	1	41
Water emissions		
COD	1	1300*
BOD	1	24
Nitrogen	1	310*
Dioxins	1	1720
Tot. Solid waste	1	13

*These results are associated with apparent mistakes, see text

Some of the large variation in data can be explained by apparent mistakes. For example, reported data for "metals" are in some cases lower than reported data for specific metals (e.g. the sum of Hg and Pb), indicating that the parameter "metals" is not representing all metals. The same mistake appears for nitrogen compounds emitted to water where in some case emissions of nitrate are several orders of magnitude larger than emissions of "total N". Other types of mistakes can be noted by comparing the results for COD, TOC and BOD which all are different types of measures of organic material and which should be correlated to each other. Besides these apparent mistakes, there are probably also less apparent mistakes which can explain some of the large variation. It seems likely that different types of data gaps are responsible for a large part of the variation.

It is however important to note that large variations can be real. Differences in technology levels, existing at the same moment at the same place (even at the same plant), can in some cases result in a factor 10 variation in emissions (examples can be found in EKVALL et al., 1992; EKVALL, 1996). For the example discussed here, PVC production, large differences in mercury emissions can be expected if chlorine production with mercury-cells are compared to production with other types of cells.

The results presented in **Table 1** are similar to the results presented by COULON et al. (1997) from a similar type of analysis of unpublished data. Based on these results, the rules of the thumb suggested by LINDFORS et al. (1995b) can be further qualified (FINNVEDEN et al., 1996). It is suggested that if no other information is available, the variations suggested in **Table 2** can be used for current LCAs.

Table 2: Rules of thumb for variations that can be expected in results

Inventory parameter	Variation that can be expected
Central, non-substitutable resources	Factor of 2.
Less central and substitutable resources	A factor of 10 or more if they are completely substitutable.
Outflows that are calculated from inflows (e.g. CO_2)	The same as for the corresponding inflow.
Other energy related air emissions	A factor 10.
Other process-specific emissions	Factor 10-100 or higher if mistakes or very different types of technologies can appear.
Total amount of solid waste	Factor 10.
Specific types of solid waste	The variation can be very high partly due to different classification systems in different countries.

Finally, it can be noted that variation in results can in some cases be lower after an impact assessment. This is because the variation in the impact assessment results will be determined by the variation in the most important interventions, which can be more certain than the less important interventions.

To some extent the variation can be explained by differences in LCA Methodology, e.g. concerning the multi-output allocation problem for the simultaneous production of chlorine and sodium-hydroxide. BOUSTEAD (1994a) tried 21 different allocation principles for this case, resulting in a variation in the results up to 50%. Differences in allocation principles used can thus explain some variation, but not the order of magnitude differences noted for some emissions. Similar results were also noted by LINDFORS et al. (1995a) when using different allocation methods in other case studies.

The results in **Table 1** are also an indication that the Cumulative Energy Demand (CED) can be a useful indicator in LCA. This is because, despite the problems in calculating the CED pointed out by FRISCHKNECHT (1997), the variation and the uncertainty in the results are lower than for many other parameters, as suggested by KLÖPFFER (1997).

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References

BOUSTEAD, I. (1994): Eco-profiles of the European polymer industry. Report: Polyvinyl chloride. APME, Brussels, Belgium

COULON, R.; CAMOBRECO, V.; TEULON, H.; BESNAINOU, J. (1997): Data Quality and Uncertainty in LCI. Int. J. LCA 2, 178-182

DE BAERE, V.; HUYBRECHTS, D.; WOUTERS, G. (1994a): Milieubalans van kortcyclische PVC-verpakkingen. Eindrapport: tekst. VITO, Mol, Belgium

DE BAERE, V.; HUYBRECHTS, D.; WOUTERS, G. (1994b): Milieubalans van kortcyclische PVC-verpakkingen. Eindrapport: Tabellen en Figuren. VITO, Mol, Belgium

DE BAERE, V.; HUYBRECHTS, D.; WOUTERS, G. (1994c): Environmental balance of shortliving PVC-packagings. Summary. VITO, Mol, Belgium

EKVALL, T.; BAUMANN, H.; SVENSSON, G.; RYDBERG, T.; TILLMAN, A.-M. (1992): Life Cycle Assessment: Pilot study on inventory methodology and data bases. In: Product Life Cycle Assessment – Principles and Methodology, 132-171. Nord 1992: 9, Nordic Council of Ministers, Copenhagen, Denmark

EKVALL, T. (1996): Key issues in the assessment of wood fibre flows. Report 1996, 1, CIT ekologik, Göteborg, Sweden

FINNVEDEN, G.; LINDFORS, L.-G.; WENNBERG, L. (1996): Alternativa material till PVC. IVL Rapport No B1232, IVL, Stockholm, Sweden. (In Swedish)

FRISCHKNECHT, R. (1997): The Seductive Effect of Identical Physical Units. Letter to the Editor. Int. J. LCA 2, 125-126

HABERSATTER, K. (1991): Oekobilanz von Packstoffen Stand 1990. Schriftenreihe Umwelt Nr 132. BUWAL, Bern, Switzerland

Hydro Plast (1995): Environmental reports and correspondence with IVL

KENNEDY, D.J.; MONTGOMERY, D.C.; QUAY, B.H. (1996): Data Quality – Stochastic Environmental Life Cycle Assessment Modeling. Int. J. LCA 1, 199-207

KENNEDY, D.J.; MONTGOMERY, D.C.; ROLLIER, D.A.; KEATS, J.B. (1997): Data Quality – Assessing Input Data Uncertainty in Life Cycle Assessment Inventory Models. Int. J. LCA 2, 229-239

KLÖPFFER, W. (1997): In Defense of the Cumulative Energy Demand. Editorial. Int. J. LCA 2, 61

LINDFORS, L.-G.; CHRISTIANSEN, K.; HOFFMAN, L.; VIRTANEN, Y.; JUNTILLA, V.; HANSSEN, O-J.; RŠNNING, A.; EKVALL, T.; FINNVEDEN, G. (1995a): LCA-Nordic, Technical Reports No 1-9. TemaNord 1995:502. Nordic Council of Ministers, Copenhagen, Denmark

LINDFORS, L.-G.; CHRISTIANSEN, K.; HOFFMAN, L.; VIRTANEN, Y.; JUNTILLA, V.; HANSSEN, O-J.; RŠNNING, A.; EKVALL, T.; FINNVEDEN, G. (1995b): Nordic Guidelines on Life Cycle Assessment. Nord 1995:20. Nordic Council of Ministers, Copenhagen, Denmark

Norsk Hydro (1992): PVC and the Environment. Oslo, Norway