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Normalisation in product life cycle assessment: An LCA of the global and European economic systems in the year 2000

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ABSTRACT

In the methodological context of the interpretation of environmental life cycle assessment (LCA) results, a normalisation study was performed. 15 impact categories were accounted for, including climate change, acidification, eutrophication, human toxicity, ecotoxicity, depletion of fossil energy resources, and land use. The year 2000 was chosen as a reference year, and information was gathered on two spatial levels: the global and the European level. From the 860 environmental interventions collected, 48 interventions turned out to account for at least 75% of the impact scores of all impact categories. All non-toxicity related, emission dependent impacts are fully dominated by the bulk emissions of only 10 substances or substance groups: CO_2, CH_4, SO_2, NO_x, NH_3, PM_{10}, NMVOC, and (H)CFCs emissions to air and emissions of N- and P-compounds to fresh water. For the toxicity-related emissions (pesticides, organics, metal compounds and some specific inorganics), the availability of information was still very limited, leading to large uncertainty in the corresponding normalisation factors. Apart from their usefulness as a reference for LCA studies, the results of this study stress the importance of efficient measures to combat bulk emissions and to promote the registration of potentially toxic emissions on a more comprehensive scale.

1. Introduction

Life cycle assessment of products (LCA) has become a widely recognised method for quantifying the environmental performances of products (*c.f.* EC, 2001; Curran, 2006). Numerical scores make it possible to compare product alternatives on the aspects of climate change, ozone depletion, acidification, eutrophication, toxicity, fossil energy resource depletion, and more environmental impact categories. All environmental releases, fossil energy resource extractions and land use activities that belong to a product life cycle are translated and aggregated in the right proportions to deliver an environmental profile in terms of the overall contribution of the product to a limited number of impact categories (Guinée et al., 2002). A comparison of environmental profiles reveals the relative environmental performance of product alternatives in the context of every single impact category. Despite their apparent simplicity, however, LCA profiles are not in every respect interpreted so easily. Impact scores are expressed in complex units, and reflect environmental impacts in a way that does

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not correspond directly to perceptible problems or prevailing threats. Their absolute value as an assessment measure remains difficult to interpret as long as it is not placed in an adequate environmental context. This is what LCA normalisation aims at.

LCA normalisation offers a reference situation of the pressure on the environment for each environmental impact category. Normalisation makes it possible to translate abstract impact scores for every impact category into relative contributions of the product to a reference situation. This reference situation exists of an environmental profile on a higher scale — that is, the environmental profile of an economic system that the product life cycle is considered to be part of. The fact that the normalisation results are expressed in the same unit for each impact score makes it easier to make comparisons between impact scores of different impact categories (Norris, 2001). Since product life cycles often have a global coverage – e.g. including resource extractions in diverse geographic regions – the global system is the most promising candidate to act as a reference situation (Guinée et al., 2002).

A number of normalisation methods have appeared during the past 10 years. An overview is given in Table 1. Some methods are shown to be specific for a limited region or for a limited number of impact categories.

This study can be considered as a follow-up of the study by Huijbregts et al. (2003), in which 1995 was used as the reference year, and which distinguished economic systems on three levels: the world, Western Europe, and The Netherlands. A follow-up was considered necessary for three reasons:

- Acquiring more up-to-date emission and extraction data (year 2000 instead of 1995) and more up-to-date boundaries for the European region (28 instead of 15 countries);
- Extending the number and improving the quality of emissions and extractions (although the availability and quality of the data for toxic emissions appeared to be still limited);
- Including more up-to-date impact assessment models in the normalisation factor calculations for many impact categories, including global warming, ozone depletion, toxicity and acidification.

The outcomes of this normalisation study can be interpreted as an LCA study of the economic systems as a whole on both the European and the global level. LCAs of economic systems can also be used in a broader context than normalisation, for instance by comparing the impacts of different economic systems with each other and by identifying the most important emissions or extractions within a specific impact impact category or economic system. Both aspects will be discussed and quantified.

2. General methodological choices

2.1. *Reference system*

Although the global economic system may be considered as the most justifiable reference system for normalisation from a scientific point of view, policy makers are often interested in reference systems on a lower geographic level, since this provides a more direct link to political goals. In this study, we accounted for the group of 28 European countries, formed by the 25 countries of the European Union in 2006, supplemented with Iceland, Norway and Switzerland, as an alternative reference system besides the world economic system. This European system will be further referred to as EU_{25+3}.

With respect to demarcation in time, different alternatives exist. In the most usual approach, emissions that have occurred during the reference year are used as the reference emissions. In an alternative, approach, the reference system is not the year of emission as such, but the year during which the emission has been caused initially. This last approach accounts for the delay between production and use on the one hand and waste treatment and emission on the other, that occurs for certain emissions. While the first approach has the practical advantages of relative simplicity, transparency and feasibility, the second approach is the most correct one in a theoretical sense, since this approach creates a reference system that corresponds to the product-oriented LCA approach. Differences will be negligible for processes with a small time delay or a constant character, but may become distinct if production processes with long-lived emissions show abrupt changes (e.g. CFC production) or for future processes handling current products as waste and differing substantially from current waste treatment processes.

Table 1 – Overview of LCA normalisation methods

Literature reference	Reference areas	Reference years	Intervention types	Number of impact categories
Wenzel et al. (1997)	Denmark	1990	Emissions	11
Breedveld et al. (1999)	The Netherlands	1993/1994	General	13
	EU_{15+3}	1990/1994	General	12
Huijbregts et al. (2003)	The Netherlands	1997/1998	General	13
	EU_{15}	1995	General	13
	World	1990/1995	General	13
Strauss et al. (2006)	South Africa	2001	Abiotic resource extraction	2
Stranddorf et al. (2005a,b)	Denmark	1994	Emissions	11
	EU_{15}	1994	Emissions	11
	World	1994	Emissions	11
Bare et al. (2006)	United States	1999	General	10
Lundie et al. (2007)	Australia	2002/2003	Toxic emissions	5
This paper	EU_{25+3}	2000	General	15
	World	2000	General	15