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LCA History: Centrum voor Milieukunde Leiden (CML)

The CML Story

How Environmental Sciences Entered the Debate on LCA

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1 Introduction

The international debate on the standardisation of LCA methodology first began in North America at the end of the eighties, then in Western Europe within SETAC. It has been extensively promoted by some multinational corporations as well. One is, however, tempted to speak rather of two different 'LCA debates', or even 'debate cultures', rather than of one truly universal context of discussion, as the traditional concept of the 'scientific community' would suggest.

Within the European debate on the development of a standard LCA methodology, the Center of Environmental Science, Leiden University, the Netherlands (Centrum voor Milieukunde Leiden: CML) soon conquered a position of hegemony regarding the 'agenda setting' for further research on LCA. Most European experts today agree that the methodology published in English in the summer of 1993 by CML (Heijungs et al. 1992: Guide and Backgrounds) marked a breakthrough in the scientific foundation of LCA methodology.

Thus, this article deals with the genesis of the methodology developed by CML and its scientific, social and political context (1).

Then it traces its appearance and success on the international stage (2).

I pay special attention to discussions and differences in the conceptual and terminological areas (3).

From the beginning, my basic assumption was that there is no such thing as 'scientific progress' in which 'the truth' gradually reveals itself or where the best approaches gain a broad acceptance within the 'scientific community' through quasi-natural selection or an 'invisible hand'. I believe instead that LCA history in particular is a good example to show that scientific activities are basically social activities that can only be described within a broader societal context. I therefore try to analyse scientific developments from the outside and to sensitise the 'LCA community' to some of the conditions of their own making and development that are often talked about, if at all, rather in private than in public.

I tried to reconstruct the development of the CML methodology in its institutional context through the study of literature and other documents and through interviews with the individuals involved[1]. Due to limitations in time and financial resources, it was necessary to concentrate on developments until 1993 (English publication of Heijungs et al. 1992, Sesimbra workshop of SETAC). The performance of a reconstruction of the subsequent history of CML as well as of LCA influenced by CML (the making of the 'Eco-Indicator 95', or the standardisation process within ISO) would, of course, be a very interesting thing.

2 The CML Project: How LCA Developed Within the Dutch Universe

In line with the *Zeitgeist* which was in favour of academic reform and environmental protection at the same time in the Netherlands as well as in other rich Western societies, the **Center of Environmental Science** was founded as an interfaculty university institute in 1977. Helias A. Udo de Haes, who had been teaching biology at the *Rijksuniversiteit* Leiden for some years, has been its founding father and its director from the beginning. Gjalt Huppes, a political scientist with a specialisation in economics who had studied at Amsterdam University in the late sixties and early seventies started to work at CML in 1978. In the beginning, he primarily worked on agricultural issues. In the early eighties, searching strategically for scientific niches within the universe of environmental sciences in the Netherlands, he discovered the research on products. The studies in this field, often performed by students, developed slowly, resulting in a first publication in 1984 on the prospects of environmentally oriented product information. Around the same time, CML, and there especially Ester van der Voet, started to work with the tool of Substance Flow Analysis (SFA). International contacts in this field were established around 1986. The present section on 'Substances and Products', headed by Huppes (one of three departments within the institute), has its roots in this tendency to work simultaneously on SFA and on the environmental assessment of products[2]. LCA and SFA were both situated in the context of 'cycle management' as late as 1991 (Guinée et al. 1991).

Most scientific research activities at CML were, and are still performed on contract (about two thirds of the budget according to Udo de Haes), mostly funded by of the Dutch government. (In the past years, however, there is a tendency towards more studies funded by private business as well as by EU institutions.) CML had built up excellent relations with the Ministry of Housing, Spatial Planning and the Environment (VROM); they also funded most of the early work on products. Another 'resource' was the employment of conscientious objectors, who are allowed to work in scientific institutions in the Netherlands. Jeroen Guinée, then 25-years-old,

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* This study was undertaken between May and August 1997 within the 'LCA group' of the *Fachverein Arbeit und Umwelt* (*FAU*), an independent institute for applied environmental research funded by the Swiss Federal Office for Industry and Labour, aimed at practical training of unemployed scientists.

[1] I carried out interviews with Prof. Udo de Haes, Gjalt Huppes, Reinout Heijungs and Jeroen Guinée at CML and with Patrick Hofstetter and Arthur Braunschweig in Zurich. Special thanks go to Nico van den Berg who sort of introduced me to the 'Dutch tribe'. I also owe a lot to discussions with my colleagues Christian Pohl, Christoph Leumann and Samuel Bernhard from *FAU*, all of them environmental scientists, and especially with Thomas Baumgartner who also helped with the English.

[2] The terms of 'Life Cycle Analysis' and 'Life Cycle Assessment', and their common abbreviation 'LCA', do not play a substantial role in CML documents before 1991. Even in English, they preferred to speak of 'Integral Environmental Analysis' (Guinée and Huppes 1989) or 'assessing the environmental impact of products' (Udo de Haes 1990). The concept of Life Cycle, however, is also endorsed in these presentations. In Dutch, they first spoke of '*produktlevensloop*' (product course of life) (Rijsdorp et al. 1989).

who in fact was the first researcher trained as an environmental scientist at CML working on product assessment, joined CML in this way in 1987. It was only one and a half years later that he became part of the 'regular' scientific staff of the institute. Various case studies were undertaken in the late eighties: One on household packaging, resulting in an English language summary in a German publication of 1989; others on window frames and on milk package systems, the latter published in English in 1990. Simultaneously, software programmes appropriate to those product assessments were developed at CML.

A methodological survey of three product studies, one of which was the institute's own assessment of household packaging, was published in Dutch in 1989. The conclusions of this report are of particular interest since they marked the beginning of the criticism towards the then applied weighing methods related to legal emission standards (Rijsdorp et al. 1989) and of the call for a method taking into account the damages to both human and ecological health "based on real exposure and not on environmental protection norms" and suitable "for an integral environmental evaluation (*milieubeoordeling*) of products" (ibid., 40). The distinction between emissions (and extraction), on one hand, and the "environmental issues" (*milieuthema's*) influenced by them, on the other, already reminds one of the distinction made later between 'interventions', to be listed in the inventory, and the 'effects', to be assessed in a 'classification' section. Furthermore, according to the authors of that report, it is furthermore crucial for comparative product studies to "dispose of a well chosen comparative basis: the functional unit" (ibid., 38).

We may regard these statements as paradigmatic outlines of CML's intentions to further develop a methodology for environmental product studies. An explicit methodological 'research programme' with an 'international basis' was at the same time presented at a UN ECE Seminar on low-waste technology in The Hague (Guinée and Huppes 1989). CML researchers were convinced that science, basically environmental science, should guide environmental product assessment.

At the same time, however, it seems important to note that CML researchers themselves were still using weighing methods and classification factors based upon Dutch legal (political) standards in their own case studies until 1990 and even still in the SimaPro software programme developed in 1991. With reference to the study on milk package systems, Christiansen (1992) stated that, "The methodology is similar to the Swiss[3], although different limit values are used for the calculation of critical volumes (e.g. drinking water standards instead of waste water emission standards)". From the beginning, it seems that they tried to weigh emissions according to concentration (rather than to emission) standards. The environmental interventions were aggregated according to three criteria: Air pollution, water pollution and acidification (according to Baumann et al. 1992). A classification system according to relevant environmental issues such as the greenhouse effect or the ozone layer depletion was still to be developed in a larger research project.

The money for funding this **Methodology Project** (*Methodiek 1*, finally resulting in the famous 'CML Guide'), however, could not be found in the regular ministerial budget of VROM, even if the Dutch government and its bureaucracy at that time were demonstrating increased interest in the subject: A motion in the Parliament (in 1987/88) and the interministerial 'National Environmental Policy Plan' of 1990 (*NMP +*, based on the claim for 'sustainable development', as outlined in the Brundtland report) both mentioned the necessity for developing a 'product policy' (cf. VROM 1994, Cramer 1991). The research group willing to elaborate a complete methodology for environmental product assessment or for LCA according to the then new terminology developed in the US, and also consisting of some researchers working outside CML, therefore made their application to the 'National Research Programme for Waste Recycling' (NOH) which was funded by the Dutch government as well. The project was to be started in October 1990 and to run for two years. According to Huppes, the intention of this work from the beginning was to result not 'just in a book' but in a guide for performing LCAs. The supervision by a number bureaucratic and scientific boards was tight and ensured that the research team was forced to and capable of finding a broad consensus for the substantive direction of their work among relevant persons at the national level at the same time. One can say that the development of the CML method was not only funded by the Dutch government, but was consequently regarded at all times, at home and later abroad, as 'The Dutch Method'[4].

Reinout Heijungs, a young physicist with no special formation in environmental problems, today regarded by many as being brilliant, was employed to lead the scientific part of the project, whereas Huppes acted as the concrete 'conceptual head' of the research group. "He supervised, criticised, gave inputs on the conceptual level", as one of his collaborators characterised his position. Huppes did not have an academic formation in the natural, but rather in the social sciences. This might be one explanation for the stress that the CML people put on the clear distinction between 'subjective' and 'objective' components within the LCA framework. In the end, these components were attached to different social groups and scientific disciplines as follows:

"In the goal definition, discussions take place between different participants such as commissioners, consumers and LCA scientists and technological information is needed about product alternatives that can be significantly compared with each other in relation to the goal of the study. The inventory is pre-eminently a subject of systems analysis theories and process technology. The classification is based on environmental sciences, while the valuation is a subject of social sciences (e.g. decision theory). The improvement analysis is based on applied mathematics and knowledge about process technology." (Guinée et al. 1993).

The part of the 'environmental sciences', then called 'classification', is undoubtedly the most important contribution of CML to overall LCA methodology. This is why we can say that the debate on LCA 'entered' with the CML environmental sciences. However, the whole project can only be understood as an integral 'conceptual framework' for the LCA different from those existing or emerging at that time.

It was, after all, the result of a preoccupation for many years with the field of product studies and of the close co-operation of especially three persons who had been involved for quite some time and whose abilities almost perfectly complemented each other:

- Udo de Haes, well experienced in the academic world of natural sciences, was the '(environmental) scientific head' and at the same time, as the director of the whole CML, acted as the 'institutional backbone' for the project.
- Huppes, who grew up in the creative and conflictive climate of the sixties and seventies, was the 'conceptual head' with a well-

[3] The weighing (or 'valuation') method developed in the Swiss packaging study of 1984 (*BUS/EMPA*) was well known among European researchers capable of reading German. Within the CML, it was regarded as being quite important.

[4] An official Dutch government document issued in English (VROM 1994, 18 ff.) stresses the relevance of LCA for product policy and particularly appreciates the CML method that "takes account of recent international developments and may be regarded as an important step towards national and international standardisation." From the US point of view, the CML approach was recently called 'A Dutch Guide' (Title of Chapter 17 in Curran et al. 1996).

established sense for gaining political and social acceptance, and for integrating the research team.
- Guinée, the young environmental expert, might be called the 'hard worker of long standing' in the field of product assessment at CML.

Between October 1990 and October 1992 (date of the Dutch publication of the final report), the latter and the newly hired Heijungs were then those charged with carrying out the detailed work needed for the realisation of the original intentions[5].

The secure foundation of CML within the context of Dutch research policies open to environmental and product oriented problem-formulations, as well as within a society traditionally open to unconventional problem solving patterns, and the emergence of a well functioning team, agreeing on basic intentions, were necessary conditions for the successful elaboration of CML's methodology.

At the same time, in line with official Dutch government policies[6], CML researchers had the firm intention to develop a methodology not only for the Netherlands but for the whole world. (This was performed in contrast to the different studies sponsored by the Swiss government that were originally very much limited to Swiss circumstances[7]).

It was therefore crucial to establish international contacts, the more since the CML at that time (1990) was not very well known among peers in foreign countries[8].

3 All the World's a Stage: How CML Changed the International LCA Scene

An international debate on methods for environmental product assessment was initiated by the then US-dominated **Society of Environmental Toxicology and Chemistry** (SETAC) through organising a first workshop on 'Life Cycle Assessment' in Smugglers Notch (Vermont) in August 1990. European participation at that workshop was very meager: 6 out of 54 participants came from Europe; none of them subsequently played an influential role in the European methodology development. The results of that workshop were a 'Technical Framework', mostly dealing with inventory problems (Fava et al. 1991), and the 'magic triangle' as an overall concept, stating that an LCA should consist of three parts: The inventory, the 'impact analysis' and the 'improvement analysis'.

Only one month later, in collaboration with the Dutch 'Institute for Environment and Systems Analysis' (IMSA) and the 'International Professional Association for Environmental Affairs' the Brussels-based European Technical Center of the Procter & Gamble Corporation organised a European workshop on 'Life Cycle Analysis for Packaging Environmental Assessment' in Leuven (Belgium). The list of participants includes 34 names with a significantly higher presence of university scientists than at the Smugglers Notch workshop. A lower presence of industry staff and the complete absence of NGO representatives was seen to be the case complementary to this. "This meeting has made evident the enormous trench between American and European knowledge on the subject in the beginning of the nineties", is the judgement of two French journalists on the outcome of the Leuven workshop (Blouet/Rivoire 1995). In fact, nothing comparable to the 'Technical Framework' came from this workshop. Instead, Wouter van Dieren, director of IMSA and workshop chairman, outlined an ambitious working programme for the future (Van Dieren 1990).

From the point of view of CML, the Leuven workshop was the crucial step towards international recognition. Both Udo de Haes and Guinée were present, and a CML paper as well as a short speech made by Udo de Haes must have been quite persuasive to the public. Existing methods of environmental assessment of products were evaluated and the situation was analysed as follows: "[...] the scientific basis of methods for assessing the environmental impact of products is still inadequate. Current methods are substantially divergent and contain considerable gaps. [...] the results of such environmental assessments are not verifiable for target groups, nor is their demonstration always optimal." (Guinée et al. 1990, cf. also Udo de Haes 1990).

They were presenting a comparison of three European case studies on milk packaging that revealed the high degree of divergence in methods and results, and therefore the uncertainty prevailing in the whole area of product assessment (or LCA). A proposal for the listing of effect scores was presented which was marked by the 'classification philosophy' of the later methodology (Guinée et al. 1990). In addition, they were clearly pleading in favour of methodological standardisation judged as feasible, "Such a method could constitute the basis for a potentially important contribution to environmental conservation, through the improvement of the design of products and the influencing of purchasing behaviour." (ibid., 19).

After this first successful performance on the international stage, CML took the initiative to organise the next European workshop on LCA under the patronage of the European branch of SETAC that had just been established, supported also by Procter & Gamble[9]. The workshop in Leiden took place in December 1991 and was meticulously prepared and organised by the CML team. Jan Assies, a biologist who at that time was working at CML, undertook an extensive study on international developments in LCA methodology in preparation for the workshop (Assies 1992a)[10]. The two interim reports of the Methodology Project were put into circulation in the course of 1991, both after finding the approval of the various Dutch committees supervising the project and were translated into English in part (cf. note 7).

The methodological intentions of the organising institute led them to structure the workshop around four sessions: Inventory, 'classification', 'comparison and absolute judgement', databases and applications. The whole framework of LCA was covered and, in contrast to the three-step model of SETAC, a strict distinction between the 'objective' classification step and the 'subjective' valuation step was made. Experts from different European countries and from the US made their contributions. Dutch and Scandinavian researchers were especially active. The presence in number was higher than at any other LCA workshop in the early nineties (72 participants). A paper by Assies on the 'State of the Art' (Assies 1992) was sent to all participants in advance and functioned as the introduction for the workshop publication. Udo de Haes made the introductory speech and led the session on 'classification'. Huppes as well as Guinée made their contributions as well. In the 'classification' section, correspondence between the approaches by CML and a re-

[5] The two today still share an office at CML.

[6] The English translations of parts of the manual drafts (interim reports) indicate that the government intended to make the method known abroad (Guinée et al. 1991).

[7] The bibliographies of the two famous BUWAL brochures (Ahbe et al. 1990, Habersatter 1991) do not mention any major foreign case studies. Only the recent third BUWAL packaging study (Habersatter and Fecker 1996) does mention all relevant international literature.

[8] Neither the German Möller (1992), who made his methodological studies at the Fraunhofer Institut at the end of the eighties, nor the Swiss Fecker (1992), who was employed at EMPA St. Gallen, mention any of the case studies or methodological efforts undertaken in Leiden.

[9] This co-operation between CML and Procter & Gamble does not necessarily mean that intentions concerning LCA were really the same. In a speech made by a Procter & Gamble manager on LCA (Stalmans 1991), for instance, no argument supporting CML intentions can be found. In a report made on LCA application in that company, the CML was not mentioned (Marion et al. 1995).

[10] This research project was also funded by NOH and can be seen as a parallel project to CML's large Methodology Project.

search group from Chalmers Industrieteknik Göteborg (Sweden) concerning the environmental problems ('effects') to be considered was noted to be significant. This correspondence must have led the above mentioned French journalists to the surprising statement that effect-oriented classification (*indices reflétant des problèmes environnementaux*) had been developed by both Dutch and Swedish researchers (Blouet and Rivoire 1995).

Generally speaking, basic agreement and further collaboration between CML and Scandinavian institutes strengthened the international position of CML in the scientific field while the close organisational co-operation between CML and SETAC-Europe, dominated by Dutch speaking staff, might be regarded as crucial in the field of winning social acceptance. Van Dieren, a manager with good connections to both the industry and the environmental movement rather than a scientist interested to work on LCA methodology, still played a role in the choreography of the workshop, "In the end he told us how to proceed further", one participant remembered. (According to Huppes, relations to van Dieren at that time were important precisely because of his social position.) It seems, however, that the influence of scientists, especially of CML-director Udo de Haes, had grown considerably, especially with regards to setting the agenda for a further elaboration of LCA methodology in Europe. Most of the contributions, especially those fitting well into the methodological intentions of the CML[11], were eventually published in an 'official' SETAC publication (SETAC-Europe 1992).

After the Leiden workshop, even the US LCA community could no longer ignore the methodological achievements made in Europe.

In February 1992, SETAC organised their second US workshop which was destined to produce a standard document on the second part of an LCA, the 'impact assessment' (according to US terminology, cf. part 3). Officially, it was a transatlantic event (according to the Preface, Fava et al. 1993, V), although European participants were still a very small minority (7 out of 47). None of the Smugglers Notch participants from Europe was present at Sandestin, but it seems that at least some of those researchers and managers who were ahead in methodology and already influential in Europe, took part in the discussion this time. Udo de Haes headed one working group and, at the conceptual level, some points the Leiden workshop participants had agreed upon were integrated into the new 'Conceptual Framework': The introductory 'Goal definition and scoping'[12] as well as the subdivision of 'impact assessment' basically into classification and valuation, with the latter to be called 'subjective' (Fava et al. 1993, XXVII). However, from the point of view of CML, still no satisfying world-wide agreement on how to perform an LCA had been reached.

The CML team continued its efforts to complete the overall 'manual' or 'guide' which was published in Dutch in October 1992. They published a series of two articles in the newly established 'Journal of Cleaner Production', explaining here their conception of LCA to a scientific public throughout the world. Udo de Haes was active internationally in order to influence further methodological standardisation, before the English translation was published with quite a success in the summer of 1993. On a SETAC-Europe symposium in Potsdam (Germany) in June 1992, for instance, he presented the European part of the 'SETAC progress report' (cf. LCA News, May 1992).

Within the newly established 'LCA Steering Committee' of SETAC Europe, Udo de Haes pleaded in favour of the further elaboration of methodology by permanent working groups. According to Hofstetter, his influence in this context has been quite big, whereas those European LCA experts opposing CML's intentions had not been participating in the Steering Committee. For the 'Code of Practice', until today the standard document with world-wide recognition, he essentially took responsibility for the chapter on 'impact assessment' (Consoli et al. 1993), linking it to the outcomes of both the Leiden and Sandestin meetings. A transatlantic SETAC workshop held in the spring of 1993 in Sesimbra (Portugal) finally agreed on this document which, after all, can be seen as the 'highest common denominator' between American and European positions on LCA methodology. The shaping of the content of 'impact assessment' was probably the most CML could achieve within SETAC, which from the beginning has been dominated by US scientists. This influence, however, was not acknowledged by the overwhelmingly American editors of the 'Code of Practice': Udo de Haes' name, for instance, does not even appear in the publication. Moreover, no outsider reading it can see the big conceptual differences between the American way of Life Cycle Assessment and European methodological dynamics largely initiated by CML that were there from the beginning and have continued until today[13]. Hereafter, these differences are explained in a more systematic manner.

4 The Little Big Differences in Terminology and Framework and What it's All About

The first point to remember is that all standard terminology, not only for LCA, is in English which is the national language of the USA and, at the same time, *lingua franca* within (Western) Europe. In the field of environmental assessment of products, however, most available literature before 1990 was not in English, but in German[14]. The German term *Ökobilanz* was even somehow translated into English ('ecobalance'). This term was used, for instance, in a European evaluation study published in English, but written by two German speaking authors (Rubik and Baumgartner 1992). Of course, the original English terminology that had already emerged in the US could not easily be changed, as the unlucky career of the word 'ecobalance' indicates. (This might explain a lot of the difficulties CML had getting its terminology endorsed on a world-wide level.)

CML's position seemed to be very pragmatic, as long as only terminology was affected. They accepted the replacement of the original European 'Life Cycle Analysis' with the American 'Life Cycle Assessment'. This switch was only made in the course of 1991, between the first and the second interim versions of the Manual. The more 'normative' content of the term 'assessment' convinced CML (Udo de Haes 1992). The Dutch terminology, paradoxically, did not change, they kept on calling 'the thing' *levenscyclusanalyse*, probably because there is no Dutch word for 'assessment' beginning with an A.

The most interesting terminological confusion was arising around the term 'impact'. In the English edition of both 'Guide' and 'Backgrounds', after comparing the frameworks of SETAC (Code of Practice) and their own, the CML team clearly said, "In this study, the term *impact* has been avoided. *Interventions* indicate human interference in the environment, e.g. resource extraction and emissions (environmental releases). *Effects* indicate the resulting environmental problems." (Heijungs et al. 1992). The distinction between 'interventions' and 'effects', and the classification of interventions into effects, is a crucial point within the whole conceptual framework

[9] This co-operation between CML and Procter & Gamble does not necessarily mean that intentions concerning LCA were really the same. In a speech made by a Procter & Gamble manager on LCA (Stalmans 1991), for instance, no argument supporting CML intentions can be found. In a report made on LCA application in that company, the CML was not mentioned (Marion et al. 1995).

[10] This research project was also funded by NOH and can be seen as a parallel project to CML's large Methodology Project.

[13] The concepts of SETAC and that of CML are sometimes even seen as quite the same: In the first report on the Dutch Eco-indicator project, it is said that the Code of Practice "is closely related to, and largely based on the work by the CML" (Eco-indicator 1993).

[14] "Most literature [in Europe] was published by Swiss and German authors, less literature originated in the Netherlands and the United Kingdom." (Rubik/Baumgartner 1992).

of LCA. The term 'impact', however, had not always been avoided in English translations of CML documents. The step called 'classification' in the first interim version (Guinée et al. 1991) was changed to 'impact analysis' (US terminology) in the second interim version (Heijungs et al. 1991). 'Impact' is used synonymously with 'intervention', so that the 'inventory table' is therefore baptised the 'impact table'. At the Leiden workshop, the term 'impact' is used synonymously with 'effect' (Udo de Haes 1992a), and 'classification' is reintroduced. Despite this confusing use of (English) language, the English preface to the second interim version tells us that "the terminology used here conforms to the conventions that have been laid down at the SETAC-workshop, Leiden" (Heijungs et al. 1991). After all, in the major SETAC documents (Fava et al. 1993, Consoli et al. 1993), 'classification', together with 'valuation', became part of 'impact assessment' and, on the other hand, the term 'impact' could no longer be avoided in further European discussions.

More important than differences in the use of terms are conceptual differences. In this field, both sides were making compromises after 1990. CML statements listed three major points of discussion with US scientists (Udo de Haes 1992, Assies 1992):

- The importance of an introductory goal definition: Even at CML, only the second interim version of the Manual listed this as a step really separated from the other parts of an LCA. It is significant for the CML approach, however, that it was thought crucial to explicitly define the overall aim and the extent of a study in the beginning. It was, for instance, seen as important to define the social groups an LCA was actually addressed to (Heijungs et al. 1992, Guide, 19). The remarks made on this subject in the 'Goal definition' chapter of the Sandestin report are, on the contrary, still quite vague (Fava et al. 1993).
- The distinction between 'classification' and 'valuation'. As we have seen, these steps were clearly separated in the CML framework, whereas the old 'magic triangle' of SETAC did not foresee such a clear distinction. Within the SETAC context, it was impossible to get rid of that triangle, even if there were no longer any major conceptual differences between the two sides after the Sandestin workshop (cf. also Fava et al. 1993, XXV).
- The addition of 'improvement analysis': "This is certainly a logical further step which in Europe is considered optional rather than mandatory." (Klöpffer 1992) Assies stated that CML wanted to keep this process "consciously out of the framework of environmental LCA" (Assies 1992a). In the final report, CML treated this step as a fifth, optional component of an LCA: "An improvement analysis is only carried out if product innovation is the aim of the study. Normally an improvement analysis will not be undertaken if the study is used to compare products." (Heijungs et al. 1992, Backgrounds).

The first and the third of these differences listed above obviously have their roots in the fact that LCAs in the US usually were undertaken for internal use by industrial companies. For this application, of course, you do not require a detailed statement about the goal and scope of a study. This is rather a justification addressed to the public. On the contrary, statements on product improvement in the US are seen as a normal, even a compulsory part of an LCA, since the improvement of the environmental performance of products is usually the very aim of an LCA made within an enterprise. For the comparison of products to be used by consumers or public authorities, such an analysis would be rather useless as the CML correctly states (cf. above).

Another conceptual difference is hidden in the concept of the 'functional unit', endorsed by CML from the beginning (cf. Rijsdorp et al. 1989). The selection of a 'functional unit' only makes sense if the actual goal of a study is to compare two or more product alternatives fulfilling similar functions. The term 'function' indicates that the consumers' rather than the producers' point of view is taken at the starting point of the LCA. (In a capitalist market economy, the profitable selling of products and not their mere functioning is usually the ultimate aim of production!). It is therefore not surprising that the first SETAC documents edited in the US which were very much marked by the producers' point of view (Fava et al. 1991, 1993), do not use this term[15]. The 'functional unit' is only introduced into the LCA framework for the first time in the Code of Practice (Consoli et al. 1993), although, in contrast to the CML Guide, it is not mentioned in the glossary.

Summing up, we can distillate the following important points within the conceptual framework developed at CML which are constantly insisted on until the publication of the final report from the beginning:

- There are different funding agents and target groups for LCAs. Due to the institutional embedding of CML itself, the role of government policies is definitely judged more important than, for instance, in the US where a 'product policy' would directly contradict the official social philosophy.
- If a comparison of products is to be made, a 'functional unit' has to be defined at the beginning of an LCA.
- 'Objective' and 'subjective' parts of an LCA have to be clearly distinguished: The inventory and the classification (or 'impact assessment') are 'objective', while the goal definition and the valuation are 'subjective'.
- Classification along environmental compartments and valuation based on legal standards, as performed in the eighties especially in Switzerland, are to be overcome.

The most significant influence of CML's methodology at the international level was in the field of 'impact assessment'. In other words, the 'environmental sciences' paradigm entered the debate on LCA which was dominated by chemistry and technical sciences until then. Judgements could be based on 'scientific' findings about the contribution of products to environmental problems and did no longer have to rely on either legal standards (as was the case in most European studies) or on a mere inventory table (as was often the case in the US).

As we have seen, the success of CML's methodology as well as its limitations are, the result of a set of factors mainly laying outside the logic of 'scientific progress':

- Political structures at the national level (in the Netherlands) constitute the frame within which research is undertaken. Basic intentions of researchers, and therefore their results, are influenced by these conditions. (In the US, on the contrary, private business was the driving force behind LCA development.)
- Success on the international stage has a lot to do with taking initiative and being at the right time in the right place.
- Geographic distance, cultural and linguistic ignorance, and also the aforementioned socio-political differences, limit the international exchange of ideas and concepts even in the field of 'science'. On the one hand, language barriers have played a crucial role in the development of LCA. On the other hand, however, one cannot deny that Dutch researchers had a great advantage of being able and of being forced to follow discussions in the German and English speaking world at the same time.
- The social conditions of research in the Netherlands are marked by a strong pressure to seek consensus, which is probably a consequence of the political practice of 'accommodation' (Lijphart 1975) that had been followed for a long time after World War II. This tendency, differing very much from other countries such as Germany or France, provides a good background to seek and to gain acceptance at an international level.

[15]The Technical Framework spoke rather of an "equivalent usage ratio", which was later criticised by Udo de Haes (1992) "[...] because the quantity [or unit] is not a ratio, in fact."

One of the basic problems, still limiting the success of CML Methodology, and LCA according to the 'Code of Practice' in general, is practical applicability. To make a 'proper' LCA is a time-consuming and costly activity, especially for business firms (cf. Rubik et al. 1996). Furthermore, a single effect score is preferred by many applicants, and the CML method does not offer an unambiguous solution to the problem of final valuation. Even if we regard the 'openness' to different valuation approaches and the acceptance of subjectivity and normativity (cf. also Heijungs 1994) as, in fact, a strength of CML 'philosophy', the latter is still marked by a deep belief in technical and consequently unambiguous instruments for environmental assessment (and improvement) of products. The development of an 'Eco-Indicator' or a sophisticated refinement of the Swiss 'Ecopoints' method (Ahbe et al. 1990) would thus be rather complementary than contradictory to CML's own studies. Integration of qualitative aspects into LCA, according to CML statements, should be possible (Udo de Haes 1991), but is in fact very difficult since the 'objective' (inventory, classification) parts of the method are ruled by the logic of quantification which, beyond being a mere listing of interventions, corresponds to the logic of commodity exchange in the economy rather than to the logic of 'the environment'. There is an overall tendency towards perfection and precision in the area of LCA, not always in line with growing knowledge about and understanding of 'the environment'. The social scientist is reminded of the statement by C. Wright Mills on sociological research in the post-war period, "The thinness of the results is matched only by the elaboration of the methods and the care employed" (Mills 1959).

5 References

Ahbe S, Braunschweig A, Müller-Wenk R (1990): Methodik für Ökobilanzen auf der Basis ökologischer Optimierung. Ein Bericht der Arbeitsgruppe Öko-Bilanz, Schriftenreihe Umwelt Nr. 133, Bern

Assies JA (1992): State of Art. In: SETAC Europe, 1 ff

Assies J (1992): Methodiek voor Milieugerichte Levenscyclusanalyses. Internationale ontwikkelingen, stand mei 1992, Leiden

Baumann H, Ekvall T, Svensson G, Rydberg T, Tillmann AM (1992): Aggregation and Operative Units. In: SETAC Europe, 87 ff

Blouet A, Rivoire E (1995): L'Ecobilan. Les produits et leurs impacts sur l'environnement. Paris

Christiansen K (1992): From PVC and Alternatives to Milk Packaging. In: SETAC Europe, 133 ff

Consoli F, Allen D, Boustead I, Fava J, Franklin W, Jensen AA, de Oude N, Parrish R; Perriman R, Postlethwaite D, Quay B, Séguin J, Vigon B (eds) (1993): Guidelines for Life-Cycle Assessment: A 'Code of Practice'. Edition 1. From the SETAC Workshop held at Sesimbra, Portugal, 31 March–3 April 1993. Society of Environmental Toxicology and Chemistry, Brussels/Pensacola

Cramer JM (1991): Milieu als maatschappelijk probleem in Nederland. In: Boersma JJ et al. (eds), Basisboek Milieukunde. 4th Ed., Meppel, 76 ff

Curran MA (ed) (1996): Environmental Life Cycle Assessment. New York

Eco-Indicator Project (1993): Eco-Indicator Project: Developing the Eco-Indicator as a Decision Support Tool for Product Development. Report on Phase 1: Orientation. Duijf consultancy bv/PRé Consultancy

Fava J, Denison RJones B, Curran MS, Vigon B, Selke S, Barnum J (eds) (1991): A Technical Framework for Life-Cycle Assessments. Workshop Report. Society of Environmental Toxicology and Chemistry, Washington DC

Fava J, Consoli F, Denison R, Dickson K, Mohin T, Vigon B (ed) (1993): A Conceptual Framework for Life-Cycle Impact Assessment. Workshop Report. Society of Environmental Toxicology and Chemistry and SETAC Foundation for Environmental Education, Inc., Pensacola

Fecker I (1992): Was ist eine Ökobilanz? EMPA Bericht Nr. 222, St. Gallen

Guinée J, Huppes G (1989): Integral Environmental Analysis as Basis for Environmental Design. Discussion paper for the ECE-seminar on Economic implications of low-waste technology. Den Haag

Guinée JB, Udo de Haes HA, Huppes G (1990): Environmental Analysis and Evaluation of Products. Paper presented at a workshop of LCA-experts organised by Procter & Gamble, Leuven, Belgium

Guinée JB, Heijungs R, Huppes G (with assistance from Assies J, Huele R, van Oers L) (1991): Manual for the Environmental Life Cycle Assessment of Products – Outline. First draft version approved by the supervisory commission. Leiden

Guinée JB, Udo de Haes HA, Huppes G (1993): Quantitative Life Cycle Assessment of Products. 1: Goal definition and Inventory. In: J Cleaner Prod 1 (1) 3 ff

Habersatter K (1991): Ökobilanz von Packstoffen Stand 1990. Schriftenreihe Umwelt Nr. 132, Bern

Habersatter K, Fecker I (1996): Ökoinventare für Verpackungen, 2 Vols. Schriftenreihe Umwelt Nr. 250, Bern

Heijungs R (1994): Enige gedachten over normalisatie en evaluatie in LCA. Leiden

Heijungs R, Guinée JB, Huppes G, Lankreijer RM, Ansems AMM, Eggels PG, van Duin R, de Goede HP (1991): Manual for the Environmental Life Cycle Assessment of Products. Second interim version approved by the supervisory commission. Ms., Leiden

Heijungs R (ed), Guinée GB, Huppes G, Lankreijer RM, Udo de Haes HA, Wegener Sleeswijk A, Ansems AMM, Eggels PG, van Duin R, de Goede HP (1993): Environmental Life Cycle Assessment of Products. Guide, October 1992, Leiden

Heijungs R (ed), Guinée JB, Huppes G, Lankreijer RM, Udo de Haes HA, Wegener Sleeswijk A, Ansems AMM, Eggels PG, van Duin R, de Goede HP (1993): Environmental Life Cycle Assessment of Products. Backgrounds, October 1992, Leiden

Klöpffer W (1992): Survey of Activities. In: SETAC Europe, 29 ff

LCA News (1991): Bimonthly publication by SETAC Europe, Brussels

Lijphart A (1975): The Politics of Accommodation. Pluralism and Democracy in the Netherlands. 2nd, rev. Ed. Berkeley/London

Marion J-Y, Valenduc G, Vendramin P, Huybrechts D, Berloznick R, Wouters G, Hellenbrandt S, Teichert V (1995): Les Ecobilans: Utilité et limites d'un outil de concertation et d'aide à la décision. Rapport scientifique à la Fondation Roi Baudouin, réalisé par FTU Namur, VITO, IÖW Heidelberg, Bruxelles

Mills C, Wright (1970): The Sociological Imagination. Harmondsworth (first published in 1959)

Möller F-J (1992): Ökobilanzen erstellen und anwenden. Entwicklung eines Untersuchungsmodells für die Umweltverträglichkeit von Verpackungen. Munich

Procter & Gamble (1990): Life Cycle Analysis for Packaging Environmental Assessment. Proceedings of the Specialised Workshop, Leuven, Belgium, September 24 and 25, 1990, Organised by Procter & Gamble European Technical Center, Strombeek-Bever

Rijsdorp I, Huppes G, Muis H, Slob AFL (1989): Coördinatie van produktgerichte studies. Eindrapportage. Uitgevoerd in opdracht van het Ministerie van VROM. Leiden/Rotterdam

Rubik F, Baumgartner T (1992): Evaluation of Eco-Balances (SAST Project No. 7: Technological Innovation in the Plastics Industry and its Influence on the Environmental Problems of Plastic Waste). Brussels

Rubik F, Grotz S, Scholl G (1996): Ökologische Entlastungseffekte durch Produktbilanzen. Projekt Angewandte Ökologie Bd. 19, Landesanstalt für Umweltschutz Baden-Württemberg, Karlsruhe

SETAC-Europe (ed) (1992): Life-Cycle Assessment: Inventory, Classification, Valuation, Data Bases. A Society of Environmental Toxicology and Chemistry-Europe workshop, Brussels

Stalmans M (1991): Lifecycle Analysis, Environmental Quality and Consumer Products. Talk given at the Congress 'Innovation, progrès industriel et environnement – préparer le XXIème siècle', Strasbourg, June 4–6, 1991

Udo de Haes HA (1990): Environmental Analysis and Evaluation of Products. In: Procter & Gamble 1990, Appendix 1 (Summary of Guinée et al.)

Udo de Haes HA (1991): Analytic survey of methodologies for LCA. Paper presented at SETAC-Europe Workshop on LCA of Products. Leiden

Udo de Haes HA (1992): General Framework for Environmental Life-Cycle Assessment of Products. In: SETAC-Europe, 21 ff

Udo de Haes HA (1992): Workshop Conclusions on Classification Section. In: SETAC-Europe, 95 ff

van Dieren W (1990): Future Development. In: Procter & Gamble, 19 ff

VROM (Ministry of Housing, Spatial Planning and the Environment) (1994): Policy document on Products and the environment. The Hague

The life cycle assessment of a building can be performed using general LCA software, but it requires much time to quantify building materials, energy use etc. Therefore, specific tools have been developed to facilitate the use of LCA in the building sector: architects and engineers only have a few days to perform such a study, and appropriate interfaces are more convenient. Therefore this state of the art report focus on specific LCA tools for buildings. ENSLIC_BUILDING â€“ State of the art report. p. 4. 1.1 Software Tools for general LCA studies.Â be entered. Suitable for economic and environmental impact analysis for municipal solid waste. Gives high quality data and transparent results. Center of Environmental Science Leiden University Einsteinweg 2 P.O. Box 9518 2300 RA Leiden The Netherlands. http://www.cml.leidenuniv.nl. Environmental Analysis and Management Group.Â Challenges in the current state of LCA and especially LCIA and recommendations on how to overcome them to broaden its use. Challenges Recommendations. Conclusions.Â Life Cycle Assessment (LCA) has proved itself a valuable quantitative tool to support the way towards a life cycle economy by documenting the environmental considerations that need to be part of decision making for a sustainable development, which here is understood as satisfying the needs of the present generation without compromising the needs of future generations. Ecology is an environmental science in its most literal sense - the study of environments and the entities within it. Although closely associated with environmentalism and conservation today, it does not necessarily follow; an ecology can also be human gut flora, how the elements of an urban environment function and the ecology of soil nutrient cycles. The word â€œecologyâ€ comes from the Greek and means â€œhouse studyâ€ or â€œliving relations studyâ€.Â It's considered a form of environmentalism and it is usually associated with these sciences, but it also includes aspects of biology, botany, zoology, genetics, bacteriology, chemistry and physics. Ecology is about biodiversity in a given environment. CML-IA is a database that contains characterisation factors for life cycle impact assessment (LCIA) and is easily read by the CMLCA software program.Â Getting and using the database. The CML-IA database is available in two formats: Excel format (zipped): cmlia.zip (18.7 Mb). CMLCA format: cmlia_august_2016.lca (1.4Mb); most suitable for the import of characterisation factors in CMLCA. Instructions for the use of the Excel file: Download the file from the Downloads section. Discover how humans are impacting our Environment!Â Human impact on the environment has become one of the main topics for university staff all over the world. While they search for the answer, the public needs to do its part. At least, you need to be aware of all the factors that contribute to this state and share the knowledge.