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The Dynamics of Adoption and Integration of Life Cycle Assessment

Case-studies of Five German Companies

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The Dynamics of Adoption and Integration of Life Cycle Assessment Case-studies of Five German Companies

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Preface

This report[1] is part of the research results achieved in the project „The Use of LCA's in Business Decision-making Processes and its Implications for Environmental Policy" supported by DG XII within the framework of European Community's „Climate and Environment"-Programme. The project is carried out by five institutes:

- Institut für ökologische Wirtschaftsforschung gGmbH, Heidelberg (Germany) (also the co-ordinator of the whole project);
- Istituto Ricerche Ambiente Italia, Milano (Italy);
- Gothenburg Research Institute (GRI), Gothenburg (Sweden);
- Institute for Prospective Technological Studies (IPTS) of the European Commission - Joint Research Centre, Seville (Spain);
- ökoscience Beratung AG, Zurich (Switzerland).

The objectives of the project are to

- make a comprehensive inventory of LCA applications in four countries (Germany, Italy Sweden and Switzerland);
- examine the role of LCA techniques within business decision making;
- identify the factors influencing this role in a negative and positive way (barriers and opportunities);
- examine the links of business decision-making and their implications for environmental politics and analyse the relevance of LCA for public environmental politics.

It's main focus is dedicated to four countries, namely Germany, Italy Sweden and Switzerland.

Altogether the research is focussed on two key issues:

- On the one hand, it is concentrated on the use of LCAs within business decision-making processes, i.e. the project analyses how LCA influence the processes.
- On the other hand, the interactive relevance of LCA to politics is examined, i.e. the expectations of business regarding policy-making activities and of policy-makers regarding the business use of LCA.

Methodologically, the study used a number of approaches. At first, a theoretical framework for decision-making has been developed; this framework presents the state-of-the-art. Following this, two different empirical approaches on the ways business deals with LCA have been carried out:

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[1] We wish to thank Susanne Nisius for her support and the colleagues of Ambiente Italia, GRI, ökosciene and IPTS for their work carried out within the whole project.

- A survey which was carried out in spring 1997 based on a questionnaire that was standardised and used for the four selected countries (Germany, Italy, Sweden and Switzerland)[2].
- Through a set of at least 20 case-studies onto the use of LCA in business (at least five case-studies for each of the four countries: Germany, Italy, Sweden, Switzerland). These case-studies include enterprises of different branches and sizes.

Both empirical research methods deliver complementary results and enlarge the empirical findings. This paper reports on the five German case-studies in detail. The results of the whole research are published by Frankl/Rubik (1999).

The whole research would not have been possible without the impressive willingness of the 20 European companies to support us as case-study companies. The companies were ABB Italy (I), AEG-Hausgeräte (D), Akzo-Nobel Surface Chemistry (S), Bosch und Siemens Hausgeräte (D), Cartiera Favini (I), Ciba Speciality Chemicals (CH), Ericsson (S), Ernst Schweizer (CH), Fiat Auto (I), GlaxoWellcome (I), Henkel (D), Holderbank Cement und Beton [HCB] (CH), Italtel (I), Landis&Gyr Utilities (CH), Kraft-Jacobs-Suchard (CH), Norsk Hydro (S), Perstorp Flooring (S), Volvo (S), Weleda (D) and Ytong (D).

Finally, we wish to thank two sponsoring companies, namely AEG-Hausgeräte GmbH, Nürnberg/D, and Weleda AG Heilmittelbetriebe, Schwäbisch-Gmünd/D, which supported the publication of the overall results (Frankl/Rubik 1999) financially.

Heidelberg/Leipzig, July 1999

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[2] The comparative results for all four countries have been published by Frankl/Rubik (1998); national reports have been published for Germany (Rubik 1998) and Sweden (Beckmann/Baumann 1998).

1 Introduction and background information

1.1 Introduction and structure of the report

The whole project analysed the relevance of LCA for business and public policy decisions. Hence the project did not focus on the methodology of the LCA concept, but on its application. To get information about the use of LCA, empirical data were collected by means of an inventory of LCA-studies, a company survey on business applications of LCA and company case-studies. In this report we concentrate on the five company case-studies we carried out in Germany. The report is divided in three main parts:

After this short introduction, **chapter 1** gives some background information about the concept of LCA (section 1.2) and the research project underlying this report (section 1.3). Subsequently it describes the techniques employed for the information and data collection (section 1.4).

Chapter 2 provides a set of complete case-studies. The chapter begins with a short introduction into the case-study sample (section 2.1), gives an overview on the structure of case-studies (section 2.2) and then presents the five studies we carried out in Germany (sections 2.3 to 2.7).

In the final **chapter 3** we draw conclusions from the case-studies. Section 3.1 deals with general findings regarding the selected LCA-studies, like motives for carrying out an LCA or typical application patterns. Section 3.2 presents general findings regarding the integration of LCA in the decision-making context and section 3.3 considers the use of LCA against the background of the institutionalisation theory.

1.2 The concept of LCA

The procedures for initiating, conducting and reporting LCA studies in a proper manner have been defined by several international organisations during recent years. Many workshops have been carried out on LCA since 1990. In particular in 1993, in response to an increasing need for guidance in LCA, the European and North American organisations of the Society for Environmental Toxicology and Chemistry (SETAC) organised a „Code of Practice" Workshop in Portugal. The outcomes of the workshop were summarised in a booklet called „Guidelines for Life-Cycle Assessment: A Code of Practice" (SETAC 1993).

More recently, the guidelines and principles relating to LCA studies were defined by ISO/TC 207/SC 5 working group using specific international standards, namely ISO 14040 (ISO 1996). Methodological details are reported in the supplementary ISO standard 14041 which has already been accepted and the Draft International Standards (DIS) 14042 (Impact Assessment) and 14043 (Interpretation).

The ISO-standard 14040 defines an LCA as following: „LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by:

- compiling an inventory of relevant inputs and outputs of a product system;
- evaluating the potential environmental impacts associated with those inputs and outputs;
- interpreting the results of the inventory analysis and impact assessment phases in relation to the objectives of the study" (ISO 1996, p. iii)

The assessment includes the entire life cycle of the product, process, or activity, encompassing extracting and processing raw materials, manufacturing, transportation, distribution, use, re-use, maintenance, recycling and final disposal (SETAC 1991).

As recommended by ISO (1996) and SETAC (1993), LCA studies should be carried out in four main steps. These four main steps are:

(1) Goal and scope definition,

(2) Inventory analysis,

(3) Impact assessment and

(4) Interpretation.

Goal and Scope Definition

In the first step of an LCA, the **goal** and the **scope** of the study have to be clearly defined and agreed upon with reference to the application(s) intended. Therefore, the goal of an LCA shall include motivations for the study, intended applications and audiences, initial data quality requirements and type of critical review (ISO 1996).

Furthermore, it is important to define the system in terms of its functional service and its boundaries. This is the subject of the scope phase, which should also include the method of impact assessment and subsequent interpretation, the data requirements, all assumptions made and the limitations (if known). All these parameters are defined according to the stated goal of the study and should be clearly stated, comprehensible and transparent. They should also indicate the representativeness of the system (and of its boundaries) in terms of technology, geography, time, market, data and data sources. In comparative studies, the equivalence of the systems being compared shall be evaluated before interpreting the results.

The appropriate definition of all these parameters at a very early stage of the study is of crucial relevance for effectively-conducting the whole LCA. Ambiguous goal and scope settings at this stage can lead to confusing results, misleading interpretations, and can cause relevant losses of time and money.

In its turn, the scope should be sufficiently well defined to ensure that the breadth, depth and detail of the study are compatible and sufficient to address the stated goal. However, it is important to realise that LCA is an iterative technique. Therefore, if needed, the scope of the study may be changed during the study as additional information is collected (ISO 1996).

Inventory Analysis

The Inventory Analysis phase provides a comprehensive view of the flows of materials, energy, water and pollutants, in and out of the system boundaries. This phase is fundamental, since its reliability will affect the complete study. The issue is not a trivial one, since many product life cycles imply both complex systems and subsystems and complex energy and material flows. However, there are precise guidelines (i.e. SETAC 1993) and ISO standard 14041 for LCA practitioners on how to take key decisions related to the definition of the systems and their boundaries, the definition of the functional unit, the data collection and calculation procedures, particularly as far as energy accounting and allocation rules are concerned.

Again, ISO 14040 points out that the process of conducting an inventory analysis is iterative. During this „learning by doing" process, new data requirements or limitations may be identified. This might require changes in data collection procedures and/or even revisions to the goal or scope of the study itself.

Impact Assessment

Both Goal Definition and Scoping and Inventory Analysis phases are well defined, understood, and coded (e.g. in SETAC 1993, ISO 14040, ISO 14041). On the other hand, the Impact Assessment while conceptually defined, is much less developed in terms of practical guidelines. The ISO standard 14042 is in progress and is expected to be accepted 1999.

The impact assessment aims at understanding and evaluating the environmental impacts based on the Inventory Analysis, within the framework of the goal and scope of the study. Of course, many of these impacts are context-specific and cannot be generalised. Different eco-systems might be particularly sensitive to specific pollutants, thus the same process might have very different environmental impacts in two different places.

Methodologically, the Draft International Standard (ISO/DIS) 14042 for impact assessment includes three ***mandatory*** sub-phases:

- Selection of impact categories, category indicators and models,
- Classification and
- Characterisation.

In the first sub-phase, categories should be identified and results of the inventory phase should be assigned to the impact category.

In the second sub-phase, resulting data from the Inventory Analysis are classified according to a number of impact categories. General impact categories are:

- resource depletion,
- human health and
- ecological impact.

Specific impact categories such as global warming, acidification or eutrophication may then be identified. The selection of impact categories is goal-dependent.

In the characterisation phase, impacts in each of the selected categories are analysed, quantified and calculated. For this purpose, scientific knowledge about environmental load-response relationships is needed. Furthermore, models to represent potential and uncertain effects or impacts are needed. Inventory data alone are not a measure of environmental disturbance, as they do not provide data on exposure.

Currently, various modelling approaches are used, e.g.

- the use of equivalency factors such as ozone depletion potential, and
- the use of toxicological data, such as non-observed effect concentrations.

Beside the three mandatory sub-phases of an impact assessment, the ISO/DIS 14042 introduces ***optional*** elements, namely normalisation, grouping, weighting and data quality analysis. These optional sub-phases discuss and judge the level of environmental disturbance.

Clearly, this is a subjective procedure. Not only environmental risks are debated; some advocate the consideration of other complex social impacts, and the need of the product itself might be called into question in this phase (Fussler n.y.). Therefore, any qualitative or quantitative valuation must be as transparent as possible. All factors and assumptions used, leading to a decision on environmental preferences, should be justified and explained.

Interpretation

In the Interpretation phase, the results of the Inventory Analysis or the Impact Assessment, or both, are organised into results that are comprehensible for decision makers. These findings may be presented as conclusions and recommendations, consistent with the goal and scope of the study. Again, drawing conclusions may involve an iterative process of reviewing the scope of the LCA as well as the nature and quality of the data collected.

It is worth noting that ISO 14040 explicitly mentions that the Interpretation of results may concern the findings of the Life Cycle Inventory only (always according to the defined goal and scope) and does not necessarily require an Impact Assessment.

Although in many cases improvement assessments based on Life-Cycle Inventory data are being performed, formal systematic procedures for this phase are not yet fully established. However, this is the most productive phase for a company, since the global view of the product life-cycle provides new insights and improvement opportunities. It is worth mentioning that all real improvement opportunities absolutely depend on the quality of the Life Cycle Inventory Analysis.

Finally, all LCA studies should include an appropriate Reporting and Critical review phase (SETAC 1993, ISO 1996). This is particularly important if the results of the LCA are to be communicated to any third party other than commissioner and practitioner of the study. ISO precisely defines the criteria for third-party reporting. It also clearly indicates the need for critical reviews, their general description as well as the guidelines for conducting critical review process itself.

1.3 The research project

Companies are the main subjects which determine both the economic and the environmental life-cycle of products. Once a product has been designed and produced, both the economic and the environmental life-cycle have already been very much determined. Of course, they are influenced by the behaviour of users and of the people responsible for waste management. But these are mainly determined by the early steps within an enterprise. The crucial factors are the design and product development phases. The US National Research Council (1991) estimated that more than 70% of the costs of product development, its production and its use is determined by the design steps of a product. In the same way quite a lot of the environmental burdens of a product along its environmental life-cycle are pre-determined during the design & development phase. This means that companies have to consider as early as possible environmental aspects, in order to improve the eco-profiles of their products.

LCA supports business in their consideration of environmental issues. It helps them to delineate their share of product responsibility and the results bring the environmental dimension into the business decision making process. However, companies remain confronted

with complex decision-making situations integrating many aspects, such as technical and economic matters, risks, work environment or safety issues.

The research on LCA during the last years was and still is focused on improving the methodology and integrating diverging interests. Indeed, the „LCA-technique" has improved considerably. Especially the Society of Environmental Toxicology and Chemistry [SETAC] has pushed this process by preparing a „Code of Practice" (SETAC 1993) and by organising a series of international workshops in Europe and the United States. Since 1995, the „International Journal of LCA", an international research journal which deals exclusively with LCA, exists. These activities, a lot of workshops, conferences, meetings and research activities, have contributed to the elaboration of international standards.

However, the very important methodological discussions and progress of the last 5-10 years have concentrated on the improvement of the method as such. The incorporation of the method into the application context has been stressed not nearly enough; this is a new challenge. New questions arise: What is the contribution of LCA to decision-making processes? How does business deal with LCA results? Which departments of a company use LCA? Do they have specific demands? What is the relationship between the environmental dimension represented by LCA and other dimensions? Who promotes LCA within companies? A lot of questions which might easily be extended.

Some research has been undertaken just recently. Rubik/Grotz/Scholl (1996) explored potential environmental benefits of LCA; also the demand for „streamlined" techniques have been supported by several publications (e.g. SETAC 1997). Nevertheless, the questions with regard to the role of LCAs within the decision-making processes have hardly been examined. First experiences have been delivered by FTU/VITO/IÖW (1995a and b) and Baumann (1998). The objective of the project of which some results are presented in this report is therefore to improve the state-of-the-art research in this direction. As mentioned, two different empirical approaches on the ways business deals with LCA have been carried out:

- A survey which was carried out in spring 1997 based on a questionnaire that was standardised and used for the four selected countries (Germany, Italy, Sweden and Switzerland).
- A set of at least 20 case-studies into the use of LCA in business (at least five case-studies for each of the selected countries: Germany, Italy, Sweden, Switzerland). These case-studies include enterprises of different branches and sizes.

Of course, the empirical bases of both methods are completely different. A survey is able to consider a much larger number of companies whereas a case-study analysis has to be restricted to a very selected number of cases. On the other hand, the advantages of case-study research are that they deliver a clearer and more comprehensive picture of the examined companies (see Yin 1994). Both empirical research methods deliver complementary results and enlarge empirical findings.

The case-studies examined how LCA is applied in specific companies and what role they play in these companies' decision-making processes. The companies we looked at were selected according to the following criteria:

- existence of LCA-studies within a company,
- instructiveness (e.g. economic importance of company, LCA-pioneer),

- the willingness of a company to co-operate.

The companies come from different sectors; in Table 1.1, we have classified all 20 companies according to the NACE-categories elaborated by Eurostat (1996). As far as this is concerned, it has to be clarified that the allocation of companies to the NACE categories has been carried out according to the procedures of Eurostat, namely, the main area of economic activities. This is sometimes a little artificial, but it is the most appropriate way to present the companies.

Table 1.1. Overview of selected case-study-companies

Sectors (according to NACE-terms)	Germany	Italy	Sweden	Switzerland
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying	–	–	Norsk Hydro	–
Manufacture of food products and beverages	–	–	–	Kraft Jakobs Suchard (KJS)
Manufacture of pulp and paper and paper products	–	Cartiera Favini	–	–
Manufacture of chemicals and chemical products	Henkel Weleda	GlaxoWellcome Italy	Akzo Nobel Perstorp Flooring	Ciba Speciality Chemicals
Manufacture of other non-metallic mineral products	Ytong AG	–	–	–
Manufacture of fabricated metal products, except machinery and equipment	–	–	–	Ernst Schweizer
Manufacture of machinery and equipment n.E.C.	AEG Hausgeräte Bosch and Siemens Hausgeräte (BSH)		–	–
Manufacture of electrical machinery and apparatus n.E.C.	–	ABB Italy	–	Landis & Gyr
Manufacture of radio, television and communication equipment and apparatus	–	Italtel	Ericsson	–
Manufacture of motor vehicles, trailers and semi-trailers	–	Fiat Auto	Volvo	–
Construction	–	–	–	Holderbank Cement and Beton (HCB)

Table 1.1 shows that the main focus was on the chemical industry with six companies. In addition to that, we investigated companies from several other sectors.

1.4 The methodology – techniques for the information and data collection

In order to structure and compare the collected data of all case studies, information was collected in a, as far as possible, systematic and symmetric way; this meant that the procedure concerning method, structure and interviewed persons and institutions were almost standardised. Therefore, a „guidebook" was used with a list of research topics which were to be examined during the research process, namely

- the company and its background,
- description/characterisation of the LCA-study,
- description of business-external context (legal and socio-economic context),
- motives / background of an LCA,
- decision-making „culture",
- industrial and country-specific „culture",
- objectives of the LCA,
- organisation of the LCA,
- interaction and communication,
- decision, information,
- assessment of the case-study,
- future policy relevance of LCA.

Each of these twelve points contained several specific questions. These topics and the questions were to be used during the work on each case-study.

Data and information for the case-studies were collected in different ways, the most important were:

- interviews (verbal and by phone),
- observation of meetings,
- analysis of written documents.

Although the interviews followed the agreed determined line of questions they had predominantly a narrative character. In some case-studies, diaries were kept.

The collected information has been brought together, analysed and presented in a case-study report.

The five German case-studies reports are presented in this publication forming chapter 2.

2 The case-studies

2.1 The case-study sample

The five German case-studies cover companies of different sizes and branches: AEG Hausgeräte GmbH, Bosch and Siemens Hausgeräte GmbH (BSH), Henkel KGaA, Weleda AG, and YTONG AG.

All firms are part of internationally operating groups of companies. Whereas BSH, Henkel, Weleda, and YTONG belong to the leading companies, AEG is a subsidiary of the Swedish Electrolux Group. Although the companies are all rather big, the number of employees varies considerably from 996 (Weleda Group) to 41,000 (Henkel Group).[3]

As already depicted in table 1.1 the German case-studies cover three different branches: Two firms (Henkel and Weleda) belong to the chemical industry, another two (AEG and BSH) are manufacturers of electrical appliances and one company (YTONG) produces building materials. As a producer of „classical" chemical products Henkel is the only company that comes from an industry that was severely criticised as ecologically harmful.

The case-study companies more or less clearly belong to the eco-pioneers of their branches. They show different degrees of experience with LCA: some are beginners, others have been working with LCA for a few years.

All companies sell their goods primarily to consumers (via retailers), e.g. the companies hold positions rather at the end of the product life-cycle. The complexity of the single products respectively the range of products the companies supply differs significantly: whereas all YTONG-products are made from the same basic material, the electrical household appliances produced by AEG and BSH consist of numerous different components. The products of Weleda and Henkel also consist of various ingredients, but they are largely based on different combinations of the same standardised substances.

2.2 The structure of the case-studies

The first part of each case-study begins with a general description of the company, e.g. its history, products and environmental engagement (section x.x.1.1). The chapter proceeds with depicting the company's external context which means its competitive situation and the relevant legislation (section x.x.1.2).

The selected LCA-study is subject of the second chapter. It depicts the LCA-process (section x.x.2.1), the methodological choices (section x.x.2.2) as well as the results and recommendations of the LCA (section x.x.2.3). The measures that have been taken on the grounds of the LCA-study are regarded in section x.x.2.4.

The third chapter of each case-study deals with the company-internal context of the application of LCA. It describes the decision-making culture of the company (section x.x.3.1) and analyses the integration of LCA in the process of product innovation or the procurement (section x.x.3.2). Section x.x.3.3 reports on the strengths and weaknesses of LCA and its

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[3] Numbers of people employed in 1996.

future role in the company as well as on the interrelations between the company's LCA-activities and public policy.

In the fourth and final chapter we draw conclusions from the case-study. Special emphasis is laid on the way of integrating LCA in the company's decision-making processes, the building-up of internal LCA-capacities, and the relevance of LCA compared to other (environmental) management instruments.

2.3 Case-study AEG Hausgeräte GmbH

2.3.1 Company background

2.3.1.1 General description of the company

2.3.1.1.1 History and organisation structure of the company

The history of the AEG Hausgeräte GmbH, company with limited liability, goes back to the year 1883, the foundation of the German Edison Company. Already in 1889 it was renamed in „Allgemeine Elektrizitätsgesellschaft, AEG" (general electric power company) and produced the first electrical household appliances. At that time the household appliances division was part of the AEG Group. After economic problems in the early 1980ies, the household appliances division was taken over by the Daimler Benz Group. In the beginning of the 90ies it was hived off from the Daimler Benz Group again and since 1994 the AEG household appliances division is a 100% daughter of A.B. Electrolux, Stockholm. In the first two years the integration into the Electrolux Group only partially affected the organisational structure of AEG, but from 1997 significant restructurings have been taking place (please refer also to chapter 3.1).

The Electrolux Group manufactures in own companies in more than 90 countries; 92% of the turnover is made outside Sweden. From the beginning of 1997, the Electrolux GmbH is responsible for the approximately 30 associated companies in Germany. These are Zanker, Juno, Zanussi, and Progress as well as AEG Hausgeräte GmbH (see AEG 1997b, p.134).

Within Germany, the AEG Hausgeräte GmbH has production sites in Nuremberg, Rothenburg ob der Tauber, and Kassel. The company's management and administration are also located in Nuremberg.

2.3.1.1.2 Products, markets, turnover and employees

The business activities of the Electrolux Group can be divided into four divisions: household appliances, commercial appliances, outdoor products, and industrial products. The major field of action are the household appliances, by showing a high synergy potential with the commercial appliances (see AEG 1997b, p. 134).

The AEG Hausgeräte GmbH manufactures a wide range of products: cookers and floor care products (division HOT) are produced in Rothenburg ob der Tauber, washing machines, dryers, and dishwashers (division WET) in Nuremberg, and refrigerators and freezers (division COLD) in Kassel.

The shares in sales of the different products groups are depicted in table 2.1. Washing machines and dryers are responsible for 31% of the company's turnover.

Table 2.1: Shares of the different product groups in the 1994 and 1996 sales of AEG Hausgeräte GmbH (see AEG 1995c, p. 25, AEG 1997a, p. 4 and Hoppenstedt 1997)

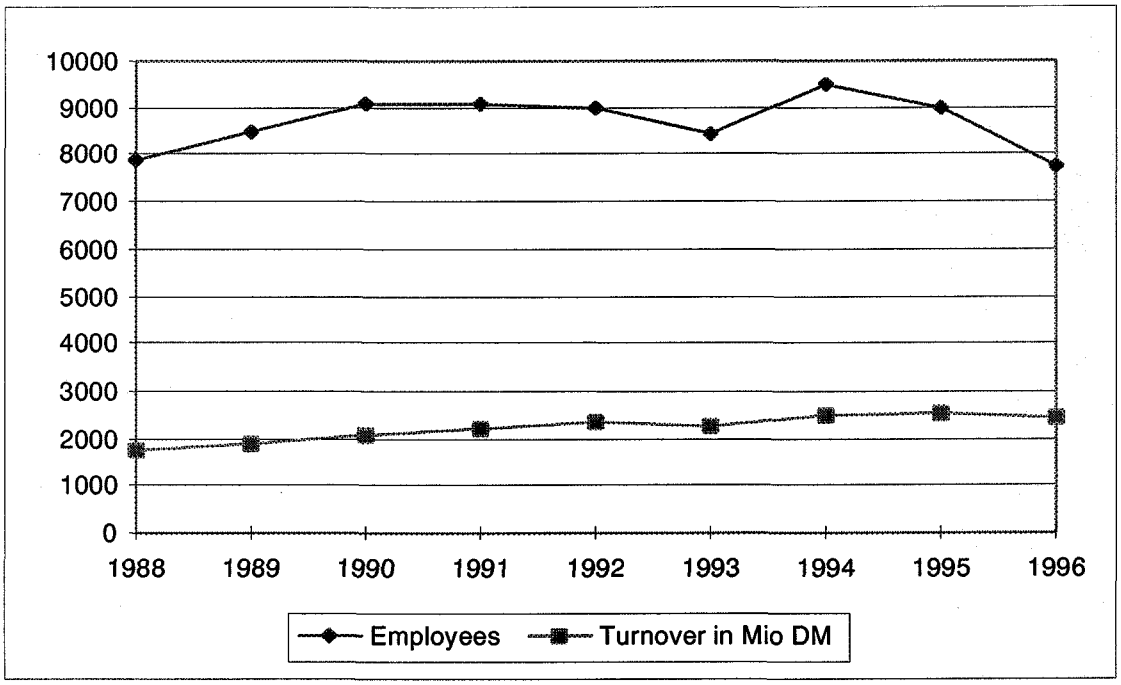
Product groups	Shares in 1994 sales (total: DM 2.51 billion)	Shares in 1996 sales (total: DM 2.46 billion)
Washing machines and dryers	31%	31%
Dishwashers	10%	15%
Cookers	20%	20%
Refrigerators and freezers	18%	14%
Electrical appliances for heating rooms and providing hot water	7%	6%
Small appliances	8%	8%
Service	6%	6%

Products of the AEG Hausgeräte GmbH cover the medium and high price ranges. Corresponding to this strategy, sales are concentrated on traditional specialist shops or compatible forms of distribution.

In 1996 the Electrolux Group's sales amounted to SEK 110 billion (DM 26.2 billion). Worldwide 112,300 employees were working for Electrolux; approximately 60,000 of them in the European Union and 11,000 within Germany (see Electrolux 1996, p. 50-51).

The AEG Hausgeräte GmbH employed 7,750 people by reaching a turnover of DM 2.46 billion. How the turnover and the number of employees developed in the past eight years is shown in figure 2.1.

Figure 2.1: Turnover and employees of AEG Hausgeräte GmbH (worldwide) (figures supplied by AEG)



Although the number of employees was varying and has been reduced significantly in the last two years, sales were increasing quite constantly. With roughly 63% the German market holds the biggest share in AEG's turnover.

At the location of Nuremberg more than 3,500 employees work in the production works and the affiliated central departments (state 1997).

2.3.1.1.3 Environmental problems and activities

Traditionally, the household appliances branch is relatively little related to ecological problems. Inputs and production processes are hardly regarded as harmful to the environment. But the high energy and water consumption of the produced household appliances has been criticised in recent years. Thereto, efforts have been made to reduce the use of water and energy. The success became visible, for example, in a 40% reduction of energy consumption of household appliances in the period from 1978 to 1994 (see ZVEI 1997).

AEG was one of the first suppliers of household appliances to pay attention to environmental aspects. When AEG Hausgeräte faced severe financial troubles in the beginning of the 80ies, a new company philosophy was needed that could help to maintain AEG's hold on the market. Subsequently a „unique image as an eco-pioneer" was built up through a „consequent environmental orientation" (see AEG 1993b, p. 24).

Since then AEG has been seeing itself as an „innovative supplier of high quality products that meet ecological and economic requirements" (ibid, p. 15).[4] The underlying environmental principles are: saving resources - preventing waste - preventing pollutant emissions.

[4] Translation by the author.

In the mid 80ies AEG started an environmental oriented advertising campaign (ibid, p. 23). For the company the harmony of economy and ecology plays a decisive role: „...I think that an ecological oriented company philosophy is only credible, if also its economic rationality can be proven." (Carlhanns Damm, chairman of the management board, ibid, p. 16).[5]

After a multitude of ecological product innovations (see table 2.2), the potential for further reductions in water and energy consumption and noise emissions of classical appliances is regarded as almost exhausted. At AEG Hausgeräte GmbH the future task is seen in increasing the use of secondary resources (see ibid, p. 70f.). A first step towards this aim was the invention of the vacuum cleaner „Eco-Vampyr" which is not only energy-saving, but also consists of recycled material to approximately 40% (see AEG 1995d, p. 5).

Since 1991 retailers are chosen also on the grounds of ecological aspects. Thereby the ecological principles of AEG should reach consumers (see AEG 1993b, p. 73). Together with another company, DASA (Deutsche Aerospace), AEG offers a take-back system for old appliances since 1994 (see König 1996, p. 49). If possible parts are recycled; otherwise they are properly disposed off. Ecological criteria were also set up for the procurement. Input suppliers, for instance, have to meet „substances prohibition standards" (Stoffverbots-Werknorm; see AEG 1995c, p. 68).

Table 2.2: Important „eco-innovations" of the AEG-Hausgeräte GmbH (following AEG 1997b, p. 156 and AEG 1997a, p. 9)

Year	Innovation	Effect
1976	First washing machine with an energy-saving washing-programme	Reduced energy consumption
1980	First energy-saving freezer	Reduced energy consumption
1986	First detergent-saving washing-machine	Reduced detergent consumption
1987	First induction-cooker on the German market	Reduced energy consumption
1988	50%-reduction of the CFC-content in the insulation of all refrigerators and freezers	Ozone layer protection
1988	Beginning of labelling synthetic parts	Recycling
1993	First 100% CFC-free refrigerators and freezers	Ozone layer protection
1993	Energy-saving, PVC-free, vacuum cleaner with recycled parts and sixfold filter system	Reduced energy consumption; recycling
1995	Washing machine with „dirt-removal programme"	Reduction in use of chemicals
1997	First dryer with heat pump	Energy consumption reduced by 50%

5 Translation by the author.

All German AEG production works have been registered in accordance with the European Environmental Management and Auditing Scheme (EMAS). Thereto AEG is the first supplier of household appliances to have validated all its locations (see König 1996, p. 48 and Gege 1997, p. 271).

The comprehensive environmental orientation also influences the product development process. The so-called „product development process organisation" (Produktentstehungsablauforganisation, PAO) which also considers ecological criteria is explained in chapter 3.2.

All in all, the AEG Hausgeräte GmbH can be regarded as the ecological pioneer of the branch. The environmental activities of the company find increased resonance in the public. For example, CAPITAL and WWF have chosen the former chairman of the management board, Carlhanns Damm, as „Eco-manager of the year 1993" (see AEG 1995d, p. 6).

2.3.1.1.4 LCA-activities

The LCA activities of the AEG Hausgeräte GmbH have started in 1992, when a first LCA-study was conducted together with the Daimler Benz research centre in Ulm. At that time Daimler Benz was thinking about conducting an LCA for motor vehicles. But at first a more simple product, namely a vacuum cleaner of the formerly associated AEG Hausgeräte GmbH should be analysed. Because the vacuum cleaner also turned out to be too complex (see AEG 1994, p. 106), the LCA was restricted to the vacuums cleaner's tube. The LCA was finished in April 1993 and was all in all rather a pilot and learning project than an LCA that actually influenced the company internal activities (see Grotz/Scholl 1997, p. 6f.). In the course of the carrying-out of the LCA the LCA-software „CUMPAN" has been developed[6].

Through this project AEG made the first experiences with LCA. In recent years different LCA-studies have been commissioned by the AEG Hausgeräte GmbH, inter alia the LCA that is underlying this case-study. Within the company the central technical department co-ordinated the conduction of the LCAs, but was never intended to be exclusively responsible for the company's LCA-activities. The department had the function to test the instrument and to spread its LCA-knowledge into other departments.[7] However, the internal LCA-know-how does not enable the company to carry out LCA-studies without support from external experts.

Additionally AEG has participated in numerous co-operation projects on LCAs. Especially one project that was carried out together with the University of Cottbus has to be mentioned. In this project approximately 25 software-tools have been tested, in order to find out whether they met the needs of the AEG Hausgeräte GmbH. After three to four systems had been analysed in detail, one of them should be bought to enable the company to independently carry out LCAs. But due to the company's restructuring and the dissolving of the central technical department, this was not realised; no software-tool has been purchased.

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6 CUMPAN (Computer aided environmentally oriented product analysis) is a software-tool that has been developed by Daimler Benz in co-operation with the University of Hohenheim (see Zürn/ Diener 1995).

7 In the course of AEG's stronger integration in the Electrolux Group, the central technical department was dissolved in mid 1997. The employees were distributed over the company and thus transported their LCA-knowledge to other departments.

Moreover, AEG participated in a study of the industrial association of the branch, the ZVEI. This study dealt with a comparison between one-way and return packagings for household appliances and was conducted by the ifeu Institut, Heidelberg.

Activities for building up a branch specific data base are neither undertaken by the AEG Hausgeräte GmbH nor the ZVEI.

Currently LCAs play a certain role within the company's product development. Although LCAs are formally integrated in the „product development process organisation" (please refer to chapter 3.2), they are only carried out, if developers and designers actually see a need for an LCA.

2.3.1.2 General description of the business external context

2.3.1.2.1 The political and legal context

With respect to household appliances, reducing their energy consumption is in the centre of public efforts. The European Parliament and the EU-Council have adopted a regulation (96/57/EG) encompassing „Requirements regarding the energy efficiency of electrical household refrigerators and freezers". The regulation defines limits for the energy use of new appliances in dependence on volume and cooling temperature. If the appliances meet the standards of the regulation, they get the CE-conformity-label and may be sold in all European countries.

In §1 (3) of the German Washing and Cleansing Agents Act (Wasch- und Reinigungsmittelgesetz) the following requirements are set up: „Technical appliances that serve for cleansing with washing and cleansing agents have to be designed in such a way that during their correct use they need as little washing and cleansing agents and as little water and energy as possible."

Moreover, public authorities strive for a better information of consumers on the ecological properties of products. Thus the companies can also be pressurised by the demand side. For example, the European Regulation 92/75/EWG that was enacted in 1992 prescribes that data on the energy consumption of household appliances has to be given in the form of standardised labels and product information. In this context the implementing regulation 94/2/EG was adopted. It contains energy-efficiency-classes which reach from A (low energy use) to G (high energy use) and have been created in consideration of the customary energy use of the different groups of appliances. Although the EU regulation has not yet been implemented in German Law, a lot of suppliers already indicate the energy-efficiency-class of their products voluntarily.

Ecologically oriented product labels serve similar purposes. In the course of European Eco-labelling (Euro-Flower) criteria for washing machines and dishwashers (96/431/EU and 93/430/EWG) and for refrigerators and freezers (96/703/EU) have been developed. For the latter the German Eco-label, the „Blue Angel", is available as well (RAL-UZ 75).

Since the German Waste Management Act was passed in 1994[8], household appliances producers increasingly deal with the after-use disposal of their products. § 22 (1) of the Waste

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[8] The Waste Management Act came into force in October 1996.

Management Act prescribes that, in accordance with their product liability, the companies are obliged to design their products in such a way that the amount of waste coming up during production and use is minimised and that an environmentally sound disposal of waste and products is secured. The LCA that is underlying this case-study has also been conducted against the background of an expected obligation of producers to take back end-of-life appliances

2.3.1.2.2 The branch/sector context

The Electrolux Group is the biggest producer of household appliances worldwide. With respect to the so-called white goods the group holds the leading position in Europe and is on third position in the USA. In South America and Asia the company is growing fast. Besides household appliances, Electrolux belongs to the leading companies also on the markets for industrial appliances and outdoor products.

The German market for electrical household appliances is dominated by few well-known brands which all hold a similar share in the market. Siemens (15%), AEG Hausgeräte (12%), Bosch (11%), Miele (11%), Quelle (10%) and Bauknecht (7%) all hold market shares in the range of 7-15%. The market shares presented in figure 2.2 result from mergers of some suppliers. With 31% BSH (Bosch Siemens Hausgeräte) holds by far the biggest share, followed by Electrolux with 16%.

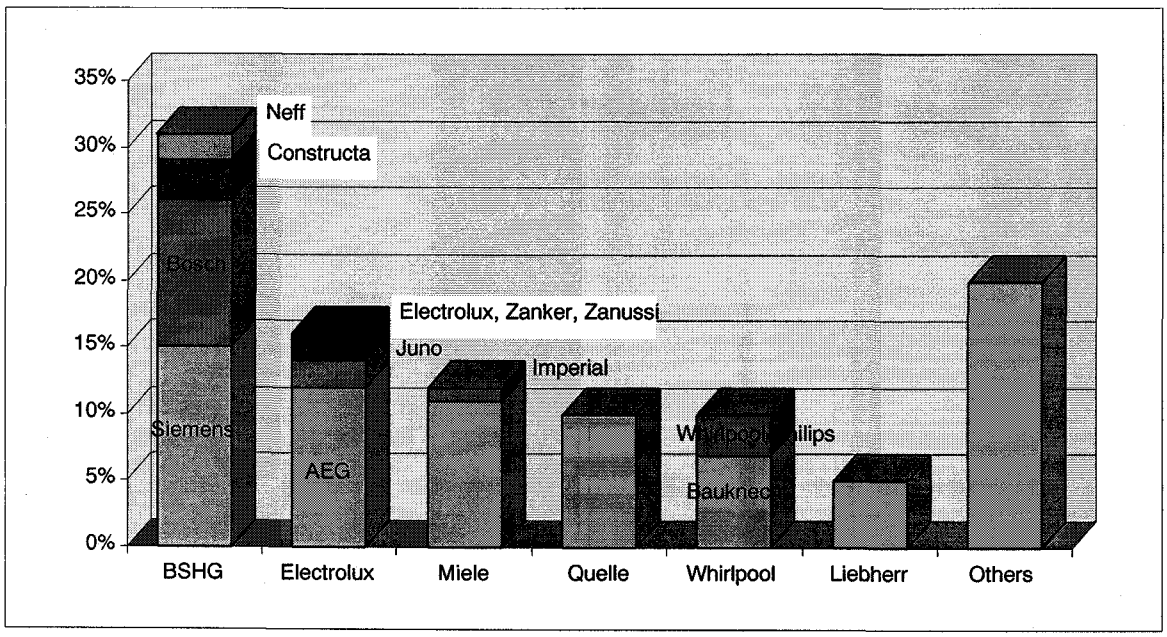

Figure 2.2: Market shares on the German market for electrical household appliances in 1993 (AEG 1995e, p. 10)

All of these brands are almost equally well-known to consumers in Germany. But among retailers AEG could stand out against other suppliers as the brand that is „mostly related to ecological ideas" (AEG 1993, p. 74). And AEG tries to enhance this image of an „eco-pioneer". But AEG is not the only supplier of household appliances that managed to build up an „eco-image". Its competitors also show an increased environmental engagement, BSH, for example, even applies LCA as well.

In total the branch shows a positive - in recent years significantly weaker - sales performance. After exports were slightly declining in 1993, also the exports develop in a positive way again (see AEG 1995c). For 1997 the electrical household appliances industry expects domestic sales to decline by 1% (see ZVEI 1997).

But the market for washing machines is regarded as relatively satisfied. In 1995 94 of 100 German households possessed a washing machine. Thus no remarkable increases in sales can be expected, purchases are only made to substitute old machines.

2.3.2 The selected LCA-study

This case-study is based on an LCA that deals with the weight in washing machines that prevent the appliances from vibrating and moving while spinning the laundry. In the LCA weights made from four different materials were compared, in order to identify the ecologically superior alternative. We have chosen this LCA, because it was intended to be used in the product innovation context and because it was regarded as relatively easy to follow up.

2.3.2.1 The LCA-process

2.3.2.1.1 Motives and objectives

The weights that are integrated in washing machines in order to prevent the machines from moving and vibrating while spinning the laundry weigh more than 20 kilograms. Thus they are responsible for roughly one quarter of the appliances' total weight. Because they are placed inside the machines directly around the soap container, it is difficult to remove them before disposing off the machines (see Gensch/Andreä, 1996, p. 19).

Thereto (and against the background of the Waste Management Act) the development department of the WET division (washing machines, dryers, and dishwashers) has thought about replacing the so far used weight from concrete by one from an alternative material. These considerations were integrated in the general product optimisation process. But before taking a decision, the ecological consequences should be analysed. And an LCA seemed to be the appropriate instrument for this purpose.

But, according to AEG, the decisive trigger for conducting the LCA has been a publication of a competitor. After the Waste Management Act was enacted, the competitor declared to take back and to recycle every washing machine. For this service DM 13 per washing machine were charged for the products of the competitor and DM 26 for appliances of other suppliers. The reason given for this price difference was that the products of the competitor can be recycled in a more efficient way, because they contain steel weights that need not be removed before shredding the machines. AEG wanted to check this argumentation with the help of an LCA-study.

All in all the conduction of the LCA resulted from the following mix of company internal and external motives:

- reaction to the German Waste Management Act and the resulting possibility to oblige manufacturers to take back and to recycle or to dispose off their appliances,
- considerations in the course of the product optimisation process, and

- publication / activity of a competitor.

When the idea of performing an LCA came up, the central technical department was contacted, because it already had some experience with this instrument. Subsequently the suggestion to conduct an LCA was discussed within the product team[9]. Here the decision was taken, to commission an external institute with carrying out the LCA-study.

The invitation to tender contained a rough description of the goals of the LCA. But the applicants were expected to specify the goals on the basis of the chosen methodology and in co-ordination with the relevant AEG department.

Finally, with conducting an LCA the following goals have been pursued:

- the ecological (and economic) analysis of the four different weights,
- checking the possibility to refute the arguments of a competitor respectively to reject them with the help of marketing strategies,
- looking for potentials for a continuos optimisation of AEG washing machines, especially regarding their disposal.

2.3.2.1.2 Chronology and organisation of the LCA-study

The central technical department asked about ten institutes to make an offer, five institutes followed the invitation. After looking at the different offers, the Öko-Institut, Freiburg, has been commissioned with carrying out the LCA.

The LCA was performed between October 1995 and February 1996. In the course of the LCA-conduction, the necessary decisions were commonly taken by the development department of the WET division and the central technical department (as co-ordinator) on the side of AEG and employees of the Öko-Institut. In order to co-ordinate the co-operation between AEG and Öko-Institut meetings were held at least every two weeks.

The LCA is based on primary as well as on secondary data. Data from public sources of information like data banks or publications of the business association were primarily used to depict extraction and processing of raw materials and energy supply.

The other stages of the life-cycle were covered by data that were collected specifically for the LCA. But the collection of detailed information turned out to be quite difficult. Data regarding preceding stages were often non-existent or the suppliers were not willing to provide them. Unsolved technical question posed additional problems. For example, it was not clear how the alternative weights should be attached to the soap container or how the technical design of the polypropylene-tank could be managed (see Gensch/Andreä 1996, p. 19).

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9 The product team was an AEG internal decision-making committee that existed for each product related company division. Normally, it consisted of the heads of the departments for development, controlling, marketing/distribution, and production. From case to case representatives of the environmental department were included as well. In the course of the company's restructuring the product team as a formalised committee was given up, instead teams are formed in case a need is seen.

To be able to assess the validity of the data additional scenario-like analyses have been carried out: for every weight variant best-case and worst-case scenarios have been juxtaposed.

The results of the LCA-study were presented by the Öko-Institut on an AEG internal final meeting.

All in all, especially AEG employees from the departments for product development and construction, the central technical department, and the departments for controlling and marketing/distribution were involved in the LCA-process. The environmental officer of the Nuremberg location was only informed about the LCA-study, but did not play an active part. External stake-holders were neither integrated; a critical review did not take place.[10]

The costs that incurred for the external experts were assigned to the development department of the WET division as the main initiator, but the amount were not made known to us. With respect to the internal costs, a former employee of the central technical department stated that during the conduction of the LCA he spent about 50% of his working time on the LCA-project.

2.3.2.2 Methodological choices

2.3.2.2.1 Type of LCA

Since the LCA underlying this case-study analyses the ecological properties of washing machine weights of four alternative materials, it is obviously a comparing study. The different variants of the component are juxtaposed in order to identify the one to be used in future. Thereto the LCA had a prospective function, but it also served defensive purposes, that is to oppose arguments and activities of a competitor.

By its author the LCA has been characterised as an „orientating LCA-study", because the collection of detailed information turned out to be difficult for various reasons, as described in chapter 2.1.2.

From the next two sections it follows that the LCA reveals characteristics of a streamlined LCA, with respect to both, the regarded life-cycle stages and the conducted LCA-steps.

2.3.2.2.2 Detailed description of the products subject of the LCA and their life-cycle stages

The LCA analyses the weights that are integrated in washing machines in order to prevent the machine from vibrating and moving while it is spinning the laundry. The weights are placed inside the machines directly around the soap container. On average they weigh more than 20 kilograms and can be made from different materials. The LCA compared the following alternatives from four different materials:

- weights made from concrete (so far used by AEG),
- steel weights,

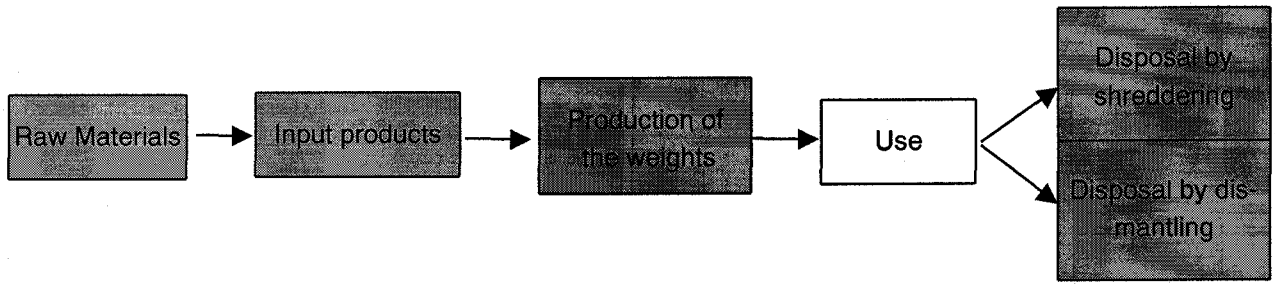
[10] For information about the organisational integration of the LCA-activities please refer to chapter 3.1.

- weights that consist of recycled glass, and
- a polypropylene-tank that is filled with water just before the washing machine is brought into service.

The LCA describes the production of the weights, the necessary transportation (distribution and supply relations only partly) and two alternative ways of disposal (shredding and dismantling) for each of the weight variants (see AEG 1997, p. 154).

Figure 2.3 shows the stages of the product life-cycle; the grey boxes mark stages that were considered in the LCA. Due to the difficult data collection the preceding stages, that is the extraction of raw materials and the manufacturing of input products, were regarded only partly (light grey boxes).

Figure 2.3: Stages of the product life-cycle



Because it was very difficult and sometimes impossible to consider the distribution and supply relations, the environmental impacts caused by transportation were reported only partly. But with the help of relevance assessments it has been checked, whether and to what extent these restrictions have influenced the results of the LCA.

Complementary products and substances that are used in the production of the weights were not traced back to the extraction of the particular raw materials, because this would have led only to marginal additional findings, but would have caused high costs and time efforts.

2.3.2.2.3 LCA-steps

The LCA-study encompasses the following steps:

- goal and scope definition,
- inventory analyses, and
- interpretation.

The first step encompasses the definition of goal, scope, and functional unit[11] of the study. In the course of the inventory analysis the data are collected and presented systematically.

In a complete LCA[12] the step of interpretation would be preceded by an impact assessment which associates the inventory data with specific environmental impacts (impact categories).

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[11] The functional unit describes the unit to which all LCA-data are related.

This step is missing in the described LCA, because the validity of the data was regarded as insufficient. Moreover, a comparing interpretation of the different weights was possible already on the basis of the inventory analysis.

In the course of the interpretation some data have been aggregated similar to an impact assessment, in order to obtain less complex results. If no reliable quantitative data were available, the data have undergone a qualitative interpretation.

2.3.2.3 Results and recommendations

In the following selected results of the LCA are presented (see Gensch/ Andreä 1996, p. 19ff.).

- By comparing the four alternatives with respect to their **use of primary energy**[13] the following results were obtained: the weight made from concrete turned out to be the best alternative. With 36 megajoule (MJ) (respectively 44 MJ, depending on the form of disposal) it revealed the lowest consumption of primary energy. Only the polypropylene tank comes near these results. If disposal by dismantling and use of secondary materials is assumed, it reaches the still relatively low energy consumption of 75 MJ.
- Regarding **atmospheric emissions**[14] only the glass weight came off better than the weight from concrete. But this holds only for emissions of dust, sulphur dioxide, nitrogen oxide, and (only in case of disposal by shredding) carbon monoxide emissions. This result can be deduced to the use of low-emission natural gas for melting the glass. But this advantages are accompanied by process related emissions of hydrogen chloride and hydrogen fluoride.
- Looking at the **amount of waste and residuals**, it was revealed that through dismantling the appliances after their use the amount of waste and residuals could be reduced considerably for all four alternatives. Independent of this general result it came out that the polypropylene-tank caused the lowest amount of recyclable and non-recyclable waste.

Additionally the carrying-out of the LCA revealed that the thermal conductivity of the weights so far has not been subject to research at all. Thus it could hardly been considered in the LCA. Because it is technically necessary to place the weights directly around the soap container, heat is given off from the soap container to the weights, especially at washing temperatures between 60 and 95 degrees centigrade. The alternative materials analysed in the LCA show a different thermal conductivity respectively thermal absorption. These different thermo-dynamic properties influence the heat loss and thus the amount of energy that is consumed during the stage of use.

In the LCA the use of primary energy was compared to the energy consumption during the stage of use for all four alternative weights. This was done in the form of a relevance assessment: the energy consumption was fictitiously increased by one, five, and ten percent.

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[12] According to the current state of standardisation at DIN/ISO.

[13] A figure for the consumption of energetic resources.

[14] With respect to air emissions the following substances have been regarded: carbon dioxide, carbon monoxide, organic compuonds, hydrogen chloride, hydrogene fluoride, sulphur dioxide, nitrogene oxide, dust.

These calculations have shown that already a slight change in the energy consumption during the stage of use, e.g. resulting from the different thermal conductivity of the alternative materials, leads to a significant alteration in the use of primary energy and the related emissions.

The main result of the LCA was, that the weight made from concrete came off as the ecologically most desirable alternative. But this holds only for the assumption that the appliances are dismantled after their use and that no significant differences between the alternatives are discovered with respect to their thermal conductivity. Moreover, the LCA clearly lead to the conclusion that, independent of the alternatives, dismantling the appliances and using secondary raw materials could reduce the amount of waste and the environmental impacts related to the production stage.

In case it is not possible to dismantle the appliances, the polypropylene-tank is superior with respect to non-recyclable waste, but shows an increase in other ecologically relevant figures.

In the final evaluation priority was given to the option „continued use of weights from concrete by dismantling appliances after their use." (see Gensch/Andreä 1996, p. 22).

The results of the LCA thus can be summarised as follows:

- The weight made from concrete is, especially in regards to the energy consumption, the ecologically superior variant.
- By dismantling the used appliances the ecological performance of all alternative weights could be enhanced.
- The thermal conductivity of the different weight materials has not been sufficiently investigated, but decisively influences the energy consumption during the stage of use.

2.3.2.4 Decisions and applications

2.3.2.4.1 Realisation of the LCA-results and recommendations

The decisions about a realisation of the LCA's findings and recommendations mainly refer to the three results summarised above. Measures that were only indirectly triggered by the LCA are described subsequently.

- Since the weight from concrete seems to be the ecologically most desirable variant, the LCA-results were regarded as a confirmation of the status quo at AEG Hausgeräte GmbH. Weak spots or optimisation potentials of the concrete weight were not identified and thus no optimisation measures were taken.
- The conclusion that dismantling the appliances before disposing off them would improve the ecological performance of all weight variants, lead to the decision to enhance the dismantling-ability of the washing machines in the course of the next general product reworking. Due to the reconstructions taking place in the context of a stronger integration of AEG into the Electrolux Group, so far no measures have been taken to change the attachment of the concrete weights, but are still kept in mind for the next product redesign.
- Although detailed information about the thermal conductivity of the different materials were not available, its influence on the energy consumption during the stage of use could be assessed through experiments and sensitivity analyses. Further tests regarding the

thermal conductivity have not been carried out. Considerations to reduce the giving-off of heat to the weights by changing the construction of the washing machines were not pursued. The main reason for this is the fact that the necessary stability of the washing machines leaves relatively little leeway for reconstructions.

The LCA also had a certain strategic importance for AEG Hausgeräte GmbH, in so far as the sensitivity analyses regarding the energy consumption during the stage of use once again have stressed that more environmental impacts arise in the stage of use than during production. „Therefore the task of 'reducing the appliances' (energy) consumption remains of central importance for the AEG Hausgeräte GmbH" (AEG 1997b, p. 154).[15]

Subsequently to the LCA of the washing machine weights, a study on a complete washing machine is in progress. This project was initiated by a Danish University. Because the LCA-study is financed externally, the AEG Hausgeräte GmbH only has to bear the internal personnel costs. The company decided to take part in this project, because it was regarded as useful to have more ecologically relevant information about its products. When this case-study was finished results from the project were not yet available.

2.3.2.4.2 Information and communication

When the Öko-Institut presented the LCA-results on the AEG internal final meeting, the members of the product team, employees from the environmental department and the central technical department were present.

Depending on the LCA-study, the collected data and results are presented in different forms and are made available to different company internal actors. In this context the necessity to observe the secrecy of product development information plays an important role. That detailed LCA-data could enable competitors to follow AEG's product innovations, was also the reason why public information on the LCA of washing machine weights was only given in an aggregated form. The LCA-results were reported in an article published in a specialised journal and in the „AEG Green Book" (see Gensch/Andreä 1996 and AEG 1997b, p.154).

Although the carrying-out of the LCA was mainly triggered by a competitor's publication, it was hardly used for external communication purposes. It was felt that the ecological differences between weights from steel and concrete were not significant enough, and thus it was too likely to confuse consumers. Moreover, the reliability of the data was regarded as insufficient to base a marketing campaign. The risk that the company image suffered in case the LCA-results were disproved seemed to be too high. Another barrier for using the LCA in the marketing context was the general opinion that LCA-results are too complex and technical; sales arguments could be found easier elsewhere.

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[15] Translation by the authors.

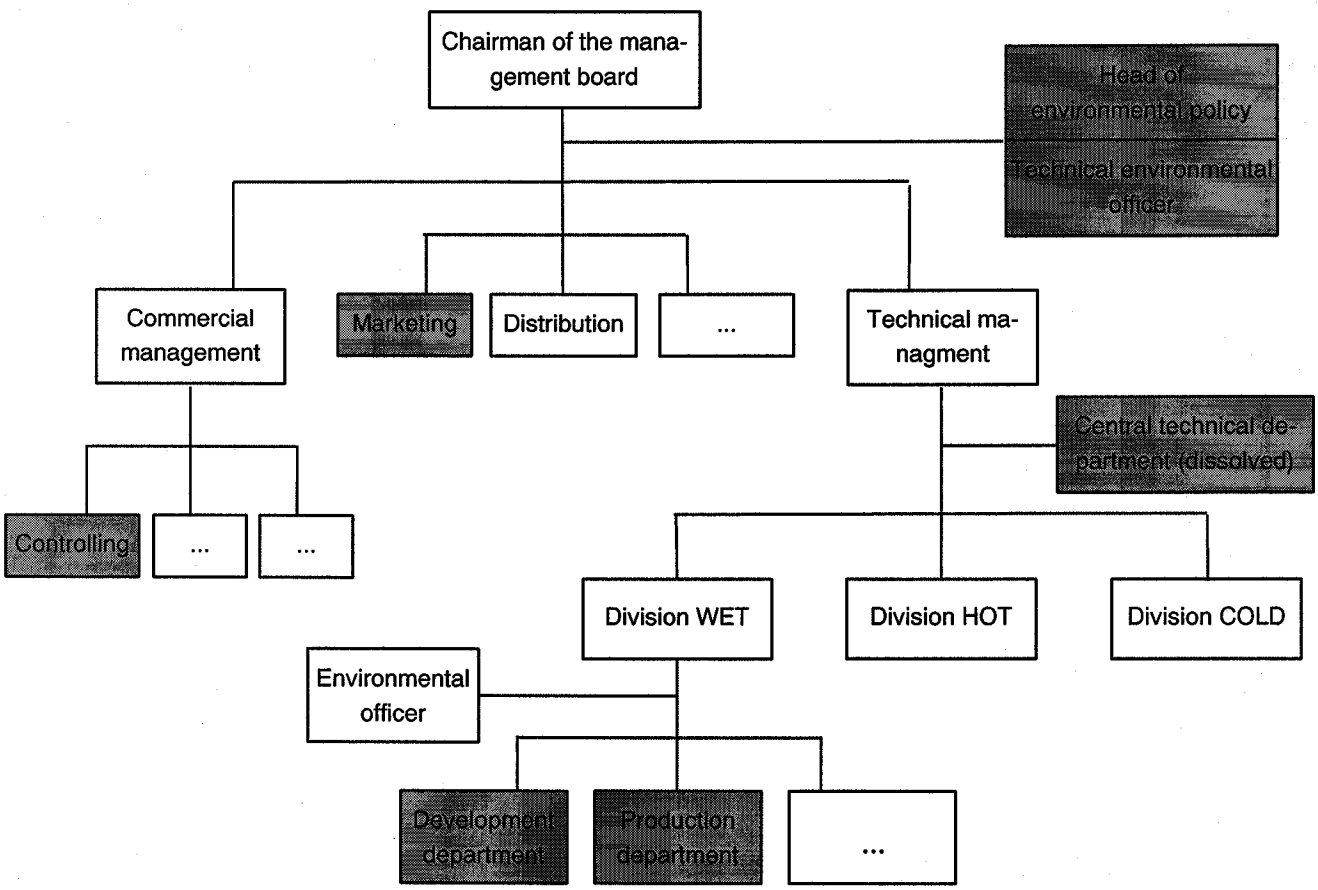
2.3.3 The role of LCA in the decision-making context

2.3.3.1 The decision-making culture

As already mentioned, the structure of the company's operative units follows the different product groups (WET, HOT, COLD). The organisation in form of product related divisions already equals the structure of the Electrolux Group. Here the divisions are called „Global Product Divisions" (GPD).

Figure 2.4 shows the organisational structure of the AEG Hausgeräte GmbH. Special emphasis is laid upon the departments which are relevant in the environmental management.[16] The light grey boxes mark the departments which were involved in the LCA-activities to a smaller or greater extent.

Figure 2.4: Organisational structure of the AEG location in Nuremberg (State: July 1997)



The organisational structure of the AEG Hausgeräte GmbH and thus the ways of decision-making have undergone remarkable changes over the year 1997. The process of restructurings became necessary in the context of a stronger integration of the AEG Hausgeräte GmbH in the Electrolux Group and was not finished by the time the data collection for this

16 For information on the environmental management see AEG 1997b, p. 135 ff..

case-study was completed. For this reason, the organisational structures depicted here reflect the situation of the time the LCA was conducted. The newly formed structures are described as far as they are known to us.

The decision-making culture of the AEG Hausgeräte GmbH seems to become more formalised in the course of the increasing integration in the Electrolux Group. But as the restructurings did not yet come to an end, it is currently impossible to draw final conclusions on this subject. All in all the decision-making culture of AEG is described as „typical for a big company". Although big companies tend to be organised in a rather hierarchical way, AEG respectively Electrolux try to avoid rigid structures. In order to keep the organisation flexible, decision-making processes and structures are explicitly hardly fixed in writing.

2.3.3.2 The product innovation process and the integration of LCA in this context

2.3.3.2.1 The „typical way" of product innovation at AEG Hausgeräte GmbH

The product development of the WET division (as of all other divisions) has been centralised for the whole Electrolux Group. The product development consists of various subdepartments: e.g. the basic development department which deals with general questions and the construction department that is rather dedicated to the concrete realisation of development ideas (on the drawing board). Furthermore, an evaluation department and various laboratories exist.

The product development process does not follow strict routines, but depends on the particular products and on whether it is the development of a totally new product or the optimisation of an already existing product. Because totally new product ideas are rare, in the following the product optimisation process is described.

Product changes are carried out in the course of a regular product redesign which takes place approximately every two to three years. In the meanwhile all planned product modifications are collected, in order to realise them altogether.

Innovation ideas can be raised by the basic development department as well as the internal proposal system or by anybody else. After the ideas have been worked out in detail, the construction department prepares concrete concepts and blueprints on the drawing board. Subsequently models are built, laboratory tests are carried out, and pilot series are run.

The framework of the product development process of the AEG Hausgeräte GmbH so far was set by an AEG internal guideline, the so-called „product development process organisation" (Produktentstehungsablauforganisation). It contains certain „checkpoints" that have to be considered while planning and constructing the products. At these points developers and constructors have to give written statements and must justify why they have decided in favour of particular options. With the help of the guideline it should be reached that all decisions in the product innovation process are taken carefully considered and can still be followed in future.

In order to construct products that are resource-saving and recyclable, „ecological checkpoints" have been integrated as well. The ecologically relevant parts of the guideline are:

- standard for recyclable constructions, following the Regulation 2243 of the VDI (Verein Deutscher Ingenieure, Association of German Engineers),
- standard on prohibited substances[17],
- occasional conduction of LCAs that compare different product alternatives respectively product parts alternatives, and
- investigation of the ecologically most desirable longevity of appliances (see AEG 1997b, p. 141).

The environmental management is responsible for controlling the observance of these „ecological checkpoints" and can, of course, introduce own ideas and suggestions regarding the ecological optimisation of products.

Due to restructurings taking place in the context of the firmer integration of AEG Hausgeräte GmbH in the Electrolux Group, the product development has become even more formally organised. Now it is called „integrated product development process", but is still very similar to the former AEG process.

To ecologically optimise products, not only LCAs are used. Other often applied instruments are ecological checklists and procurement standards which are also integrated in the „product development process organisation" respectively the „integrated product development process".

2.3.3.2.2 The integration of LCA in the product innovation process

LCAs are not regularly used in the product development of the AEG Hausgeräte GmbH. They are regarded as an instrument that assists decision-making processes and can be applied alternative to other ecological information instruments. LCAs are used, if a need for comprehensive life-cycle data is seen.

Since LCAs are explicitly mentioned in the „product development process organisation" guideline, they play a relatively important role in this context. To what extent LCAs are actually applied, depends on whether developers see a need for information provided by LCAs. In this context the environmental management has a supervisory and advisory function.

In case an LCA should be conducted, the then necessary decisions are not taken in accordance to any systematic structure. In this respect no determined routines exist. Somebody who sees a need to carry out an LCA, e.g. a product developer, constructor or employees from marketing or production, can address to the environmental department, especially to the technical environmental officer, in order to get more detailed information. But because the environmental department does not have a service function for conducting LCAs, the way of decision-making can also trace other paths. In former times the typical address would have been the central technical department, nowadays the company internal LCA-know-how is spread over various departments (and mostly lies dormant).

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[17] This is an internal standard that prohibits the use of certain materials and substances.

The LCA-know-how that was built up within AEG Hausgeräte GmbH was never sufficient to independently (without external support) carry out LCA-studies. Thereto all LCAs are performed in co-operation with external experts.

2.3.3.3 The future of LCA at AEG Hausgeräte GmbH

2.3.3.3.1 Weaknesses and strengths of the instrument and its future application

Generally AEG employees have stated various aspects that stand in the way of a widespread use of LCA within the company: the complexity of the LCA-methodology, the difficult definition of the scope, the collection of comprehensive data, and the lack of clear interpretation standards were mentioned as problems related to the carrying-out of LCA-studies. Although these methodological difficulties as well as indefinite LCA-results are regarded as important obstacles for the use of LCAs, AEG has not stopped its LCA-activities.

We learnt that the attitudes towards the future relevance of LCA differ within the AEG Hausgeräte GmbH. The head of the development department of the HOT division who was involved in the first LCA-study commissioned by AEG,[18] was of the opinion that, from a commercial point of view, LCAs are a controversial instrument. The reason he gave for this view was that carrying out LCA-studies is relatively demanding and takes a long time, while their benefits are limited. It was especially criticised that the LCA-methodology is too complex and that in the near future no commonly agreed concept for a streamlined LCA can be expected.

On the contrary, the head of the basic development department characterised the LCA underlying this case-study as very interesting and informative, because it provided comprehensive information on the ecological properties of the different materials. Thus it enabled conclusions that otherwise could not have been drawn. That in the case of the LCA underlying this case-study, only very few of the results and recommendations have been realised, has reasons that are independent from the instrument. On the one hand the LCA mainly confirmed the status quo. On the other hand, changes were delayed due to the restructurings taking place in the context of the firmer integration of AEG in the Electrolux Group. But the company claimed that these optimisation measures (e.g. the improvement of the dismantling ability of washing machines) are still kept in mind.

The representatives of the environmental department also see great potential for the business application of LCA. Potentials are especially seen in the context of product development and production. But the fact that electrical household appliances consist of a variety of different raw materials and input products seems to pose limits to the application of the instrument, because conducting LCAs for such complex products causes high costs and needs a lot of time. In order to simplify and to accelerate the carrying-out of an LCA, it is felt necessary to standardise the methodology and terms used and to build up public data banks.

Although public authorities could help to reduce some of the obstacles seen by AEG employees (see chapter 3.3.2), public LCA-activities were not explicitly mentioned as being responsible for the company's future application of LCA.

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[18] Thus he was not involved in the LCA on the washing machine weights that is underlying this case-study, but dealt with an LCA on a part of vacuum cleaner („pilot study").

2.3.3.3.2 Interrelations between the application of LCA and public policy

While the general LCA-engagement of AEG was not influenced by public policy, the LCA of washing machine weights was not least conducted against the background of the German Waste Management Act.

AEG employees would appreciate if public institutions or agencies, e.g. the German Federal Environmental Agency (Umweltbundesamt, UBA), supported industry, especially small and medium sized companies, in carrying out LCA-studies. Public authorities could supply financial aid or directly accompany the conduction of LCAs, by providing information, know-how or public data banks.

Because currently the LCA-instrument leaves too much leeway to manipulate the results, the company expects and welcomes public policy to further develop and standardise the LCA-methodology, especially the steps of goal definition and interpretation, respectively to participate in the efforts of the private standardisation organisations DIN/ISO.[19] Although the head of the environmental technology department who gave this statement mainly had the German government in mind, the standardisation could also be done by the EU, in order to establish the same standards in all EU member states.

2.3.4 Summary and conclusions

The history of AEG Hausgeräte GmbH dates back to the year 1883. At that time AEG was the only German supplier of electrical household appliances. Since 1994 the AEG household appliances division is a 100% daughter of A.B. Electrolux, Stockholm. The Electrolux Group is the biggest producer of household appliances worldwide. In 1996 the Group had 112,300 employees and its sales amounted to DM 26.2 billion.

Because AEG Hausgeräte GmbH showed a strong environmental orientation already in the mid 80ies, it can be regarded as one of the eco-pioneers in Germany. In the beginning of the 90ies LCA was added to the environmental management instruments the company applies. Potential application areas for LCA are rather seen in the optimisation of products and production processes than in marketing and sales.

The LCA underlying this case-study was also carried out in the context of the product optimisation process. It deals with the weights that are integrated in washing machines to prevent them from moving and vibrating while spinning the laundry. So far, AEG uses weights that are made from concrete. Against the background of the German Waste Management Act and the offer of a competitor to take back and to recycle end-of-life washing machines, AEG wanted to analyse whether using weight from alternative materials could make it easier to dispose off/recycle the machines. But the decision on the (ecologically) superior weights should not be based on the stage of disposal alone, but consider the whole life-cycle. Thus LCA seemed to be the appropriate instrument to use.

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[19] DIN (Deutsches Institut für Normung) is the German standardisation institute, and ISO (International Standardisation Organisation) is its pendant on the international level.

The main result of the LCA was that the weights made from concrete came off as the ecologically superior alternative. But this holds only, if the end-of-life washing machines are not simply shredded, but dismantled and recycled.

Because the LCA mainly confirmed the company in using weights made from concrete, AEG did not have to switch to weights from an alternative material. That the proposal to change some constructive details for easier recycling was not yet translated into action results from the restructuring of AEG taking place in order to stronger integrate the company in the Electrolux Group.

In the beginning of AEG's LCA-activities all LCA-know-how was concentrated in one central department. But since this department fell victim to the company's restructuring, many different departments know about LCA, but never enough to conduct whole LCA-studies alone - an external partner is always needed. The LCA of the washing machine weights, for example, was performed by the Öko-Institut Freiburg.

Although the company internal guideline for an „Integrated Product Development Process" proposes LCA as a tool to verify product development decisions, AEG does not intend to systematically carry out LCAs in the course of the product innovation process. Product decisions are actually based on an LCA only occasionally, i.e. in case developers or any other relevant decision-makers see a need for it. No fixed routines exist.

The opinion about the usefulness of the instrument varies considerably between the company's employees. Whether an LCA is carried out or not thus strongly depends on the persons who hold the decisive positions. AEG employees see the main impediments for a more extensive use of LCAs in the complexity of the instrument. Carrying out LCAs of heterogeneous products like electrical household appliances is regarded as needing too much time and money. Unless easier/streamlined LCA standards and public branch specific data-bases exist, other less comprehensive instruments like ecological check lists and procurement standards are likely to play a more important role.

However, the role of LCA as a decision-making tool at AEG will be strongly dependent on Electrolux in future and can not be foreseen at the moment.

2.4 Case-study Bosch und Siemens Hausgeräte GmbH

2.4.1 Company background

2.4.1.1 General description of the company

2.4.1.1.1 History and organisation structure of the company

The history of the Bosch and Siemens Hausgeräte GmbH (BSH)[20], company with limited liability, dates back to the mid 60ies. It was founded as a joint venture between two German enterprises, the Robert Bosch GmbH, Stuttgart, and the Siemens AG, Berlin and Munich, both holding 50% shares.

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[20] Until April 1, 1998, the name was Bosch-Siemens Hausgeräte (BSH).

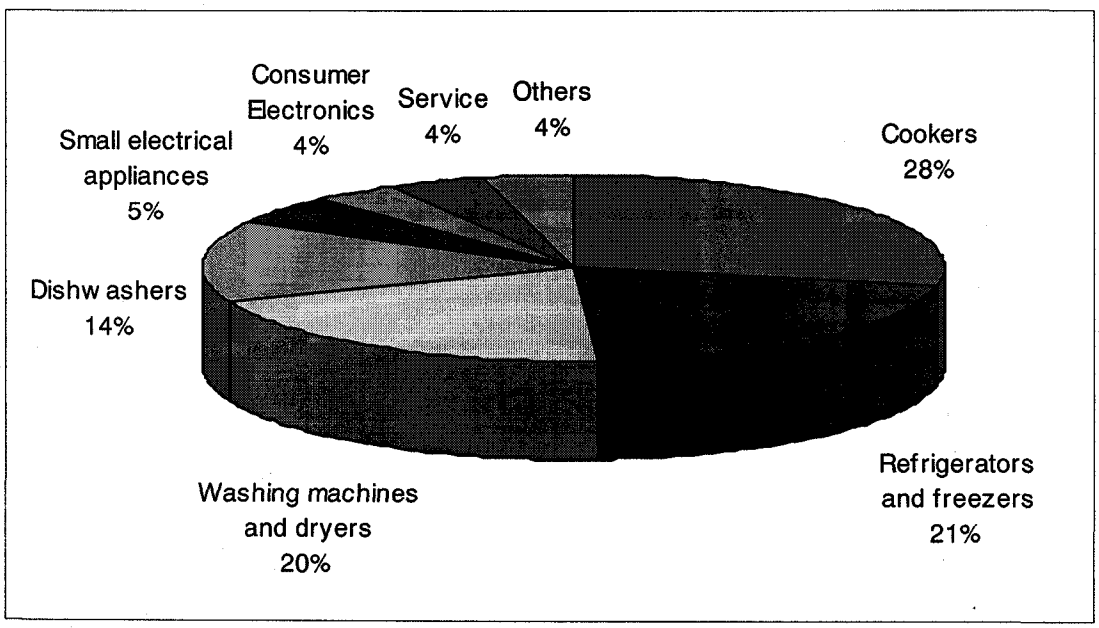
Both companies had already been on the market for „white goods". They merged their household appliances divisions, because they recognised that the increasing internationalisation of European and world markets required to join forces. By co-ordinating technical and commercial activities of the companies' consumer goods divisions, their competitiveness improved considerably. This strategy also lead to the full association of the German companies Neff GmbH and Constructa GmbH.

Since its foundation, about 30 years ago, the BSH has gradually developed from a German exporter into globally operating company group. With 30 production sites BSH is present in Europe, Northern and Southern America as well as in Asia. In order to realise economies in scale, the production works specialise in different products and regional markets. Also the general structure of the BSH Group follows product groups and regions (please refer also to chapter 3.1). The headquarters are still located in Munich.

2.4.1.1.2 Products, markets, turnover and employees

BSH manufactures a wide range of electrical household appliances for cookers, laundry,, refrigeration and dishwashers. The different product areas and their shares in the 1996 sales of the BSH Group are depicted in Figure 2.5.

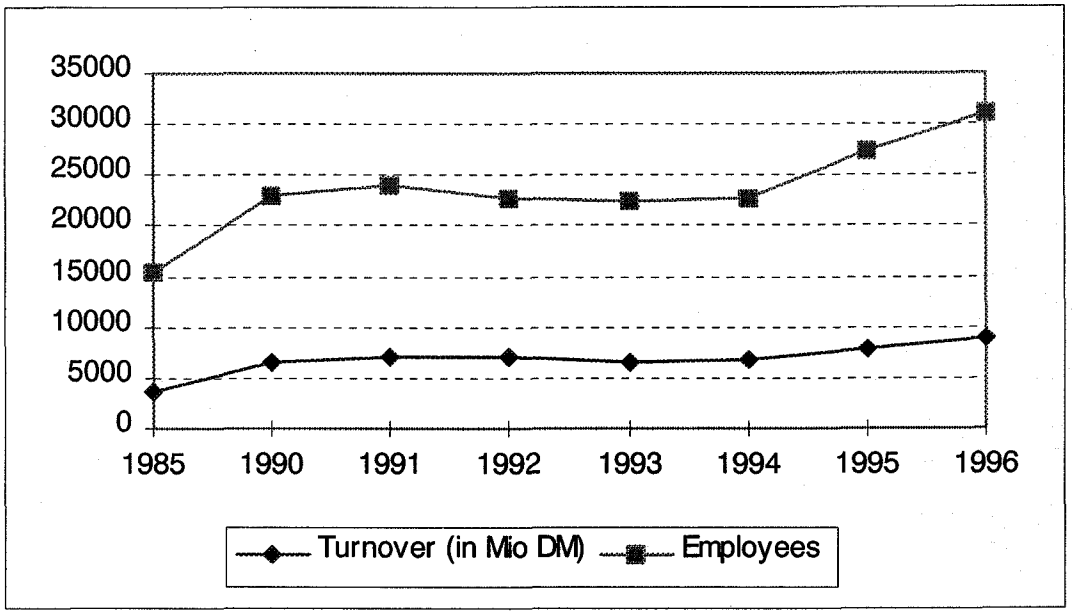
Figure 2.5: Shares of the different product groups in the 1996 sales of the BSH Group (total: DM 8.8 billion) (BSH 1996, p. 12)



Regarding the turnover, cookers, refrigerators and freezers, as well as washing machines and dryers are the most important product groups. Laundry products contribute a share of 20%.

In 1996 the overall turnover of the BSH Group amounted to DM 8.8 billion. At the beginning of 1997 the company employed about 31,100 people. 14,000 of them were working within Germany, and 17,000 abroad.

Figure 2.6: Turnover and employees of the BSH Group (see BSH annual reports of 1985, 1992, and 1996)



The turnover and the number of employees of the BSH Group developed parallel. 1996 was the first year in which more than 50% of the Group's turnover were made abroad. Extraordinary sales performances could be reached in Southern America (+28%) and Eastern Europe (+55%) (see BSH 1996, p. 4).

2.4.1.1.3 Environmental problems and activities

The most relevant environmental impacts of household appliances result from the energy and water consumption during their operation as well as from the high quantities of waste that occur, when the appliances have to be disposed off after the stage of use. The resource use and energy consumption related to production and transports are relatively less important. Accordingly BSH strives for reducing the water and energy consumption of its appliances; on average, both decreased by more than a half since 1970.

In 1988 BSH was the first producer of household appliances to have reduced the CFCs used in the insulation of refrigerators and freezers by 50%. From 1994 all appliances manufactured in Germany, Greece, and Spain are completely CFC-free.

Furthermore, obligatory ecologically oriented guidelines have been set up for procurement and product development. They prescribe, for example, which substances must not be used and that the appliances should be designed in a way that makes their recycling easier (only few different materials, easy dismantling). Since 1994 BSH offers to take back and to recycle end-of-life appliances.

In 1995 three BSH locations have been certified in accordance with the European Environmental Management and Auditing Scheme (EMAS) and in the following year the BSH location in Esquiroz was the first company to obtain the certificate in Spain. An annual environmental report is already published since 1993. In the meantime, all seven German production sites have been certificated according to EMAS.

By entering the environmental agreement that was initiated by the Bavarian government, BSH committed itself to contribute to an increased environmental orientation of companies.

Meanwhile, the environmental activities of BSH have obtained wide-spread public appreciation. In 1993 the company obtained an award of the US-American Environmental Protection Agency (EPA) for its engagement for protecting the ozone layer. Dr. Herbert Wörner, chairman of the executive board, was awarded the Bavarian environmental medal.

Also the environmental reporting of BSH has been acknowledged. In the seventh international competition „Ecology and Communication" of the Bavarian communication association BSH has won the first prize.

2.4.1.1.4 LCA-activities

Before BSH commissioned the LCA of soap containers, some other LCAs respectively LCA-similar studies have been conducted. BSH took part in a study of the household appliances industry that assessed the (ecological) consequences of introducing a return packaging for bigger appliances. The study was performed by the ifeu institute, Heidelberg. After the project was finished, the software developed by the ifeu institute (including transportation data) was made available to BSH. This enabled the company to carry out scenario-analyses of its own return packaging and thus to optimise it.

Environmental impacts related to BSH products have been assessed by conducting streamlined studies: the energy consumption of washing machines was analysed with the help of the KEA-concept[21] and selected material inputs and outputs of a new dishwasher were regarded in a diploma thesis carried out at the Technical University of Munich.

Subsequent to the LCA of soap containers, one further LCA was conducted which deals with the question whether BSH should carry on buying sheet metal fully painted from suppliers or better paint them itself. The study was carried out in co-operation with a painting company and is described as less comprehensive than the LCA of soap containers. So far, BSH has not conducted LCAs of whole appliances, but analysed single product components or packaging systems.

But in none of these projects internal capacities have been built up that would enable the company to independently, i.e. without external support, carry out LCA-studies. Because BSH does not plan to apply the LCA-instrument regularly, a need for comprehensive internal LCA-know-how is still not seen.

Basic LCA-knowledge exists in the central environmental department which functions as a co-ordinator of the studies and in the product development departments of the product divisions which were responsible for the actual carrying-out of the (LCA-)studies.

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[21] „KEA" stands for „Kumulierter Energieaufwand" which is the German expression for „accumulated energy need".

2.4.1.2 General description of the business external context

2.4.1.2.1 The political and legal context

With respect to household appliances, reducing their energy consumption is in the centre of public efforts. The European Parliament and the EU-Council have adopted a regulation (96/57/EG) encompassing „Requirements regarding the energy efficiency of electrical household refrigerators and freezers". The regulation defines limits for the energy use of new appliances in dependence on volume and cooling temperature. If the appliances meet the standards of the regulation, they get the CE-conformity-label and may be sold in all European countries.

In §1 (3) of the German Washing and Cleaning Agents Act (Wasch- und Reinigungsmittelgesetz) the following requirements are set up: „Technical appliances that serve for cleansing with washing and cleansing agents have to be designed in such a way that during their correct use they need as little washing and cleansing agents and as little water and energy as possible."

Moreover, public authorities strive for a better information of consumers on the ecological properties of products. Thus the companies can also be pressurised by the demand side. For example, the European Regulation 92/75/EWG that was enacted in 1992 prescribes that data on the energy consumption of household appliances has to be given in the form of standardised labels and product information. In this context the implementing regulation 94/2/EG was adopted. It contains so-called energy-efficiency-classes which reach from A (low energy use) to G (high energy use) and have been created in consideration of the customary energy use of the different groups of appliances. Although the EU regulation has not yet been implemented in German Law, a lot of suppliers already indicate the energy-efficiency-class of their products voluntarily.

Ecologically oriented product labels serve similar purposes. In the course of European Eco-labelling (Euro-Flower) criteria for washing machines and dishwashers (96/431/EU and 93/430/EWG) and for refrigerators and freezers (96/703/EU) have been developed. For the latter the German Eco-label, the „Blue Angel", is available as well (RAL-UZ 75).

Since the German Waste Management Act was passed in 1994[22], household appliances producers increasingly deal with the after-use disposal of their products. § 22 (1) of the Waste Management Law prescribes that, in accordance with their product liability, the companies are obliged to design their products in such a way that the amount of waste coming up during production and use is reduced as far as possible and that an environmentally sound disposal of waste and products is secured. On the basis of §24 take-back obligations can be enacted through ordinances. An ordinance for electronic waste is currently prepared. But so far the German government has refrained from putting take-back obligations into force, in favour of voluntary agreements.

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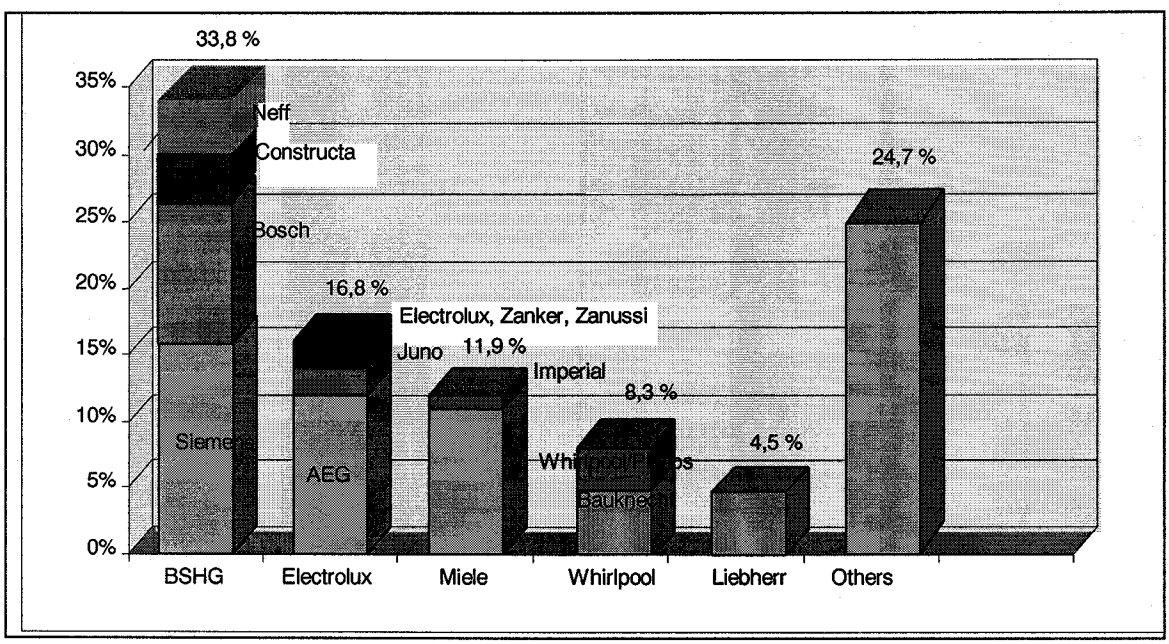
[22] The Waste Management Act came into force in October 1996.

2.4.1.2.2 The branch/sector context

BSH is the leading company on the German household appliances market (refer to figure 2.7) and holds the second position on the European and the fifth position on the world market (see BSH 1996, p. 3).

The German market for electrical household appliances is dominated by few well-known brands which all hold a similar share in the market: With 33.8% BSH (Bosch-Siemens Hausgeräte) holds by far the biggest share, followed by Electrolux with 16.8.

Figure 2.7: Market shares on the German market for electrical household appliances in 1997 (BSH 1997)



In total the branch shows a positive - in recent years significantly weaker - sales performance. After exports were slightly declining in 1993, also the exports develop in a positive way again. Sales potentials are especially seen in Eastern Europe, Latin America, and Asia. For 1997 the electrical household appliances industry expects domestic sales to decline by 1% (see ZVEI 1997).

Due to the longevity of the products, the demand of household appliances is highly related to the overall economic situation. Particularly on satisfied markets like those of Western Europe substituting purchases are postponed, in case of only moderate income expectations.

The ecological performance, especially the energy need, of household appliances gets increased interests not only from public authorities, but also from consumers. In its 1996 Environmental Report BSH claims to have recognised an increased ecological awareness of consumers. It is stated that 60% of consumers try to reduce the energy consumption in households and that even 80% consider the energy need while buying new household appliances (BSH 1996/97, p. 8).

Accordingly BSH showed an increase environmental orientation in recent years. But BSH is not the only supplier of household appliances that managed to build up an „eco-image". Some of its competitors also extended their environmental activities, AEG, for example, even conducts LCA-studies as well.

2.4.2 The selected LCA-study

This case-study is based on an LCA that deals with soap containers, i.e. it compares steel soap containers hitherto used by BSH to soap containers made from polypropylene, in order to identify the superior alternative. The LCA of soap containers is the first real LCA-study the company commissioned.

2.4.2.1 The LCA-process[23]

2.4.2.1.1 Motives and objectives

So far the soap container in BSH washing machines is made from steel. In 1994, in the course of the development of a new top-loader washing machine model, the product development department of the laundry product area thought of replacing the steel container by a polypropylene variant. These thoughts were not least stimulated by the fact that some competitors already used soap containers made from synthetic materials. The switch from steel to PP was beneficial for economic and technical reasons, but required completely different production processes and thus meant an important and hardly reversible change in the basic technology. Therefore the decision should not be taken without considering the ecological consequences related therewith.

The product development department contacted the person of the central environmental department responsible for product related environmental protection to ask for the best way and the most suitable instrument to get information about the ecological impacts caused by the two soap container alternatives. The central environmental department pronounced itself in favour of an LCA, as an instrument which provides comprehensive life-cycle data. The decision to carry out an LCA-study was taken by the environmental department of the laundry product area. But before the project could be started, the division management had to agree. Due to the company's general ecological orientation the management was easy to convince.

The carrying-out of the LCA was exclusively triggered by company internal motives, that is to support the decision on the soap container material. Following it was only intended for internal use in the product development. The LCA-study should analyse, if a technically and economically advantageous change in the basic technology, namely the switch from a steel soap container to a polypropylene variant, was also to be preferred from an ecological viewpoint.

2.4.2.1.2 Chronology and organisation of the LCA-study

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[23] Please refer to chapter 3.2 for the way of product innovation at BSH.

The responsibility for the conduction of the LCA-study was placed on the product development department of the division for laundry products. Since no sufficient internal LCA-know-how existed, support from external experts was needed. Some institutes, including the German Federal Environmental Agency (Umweltbundesamt, UBA), were asked for support. Finally the IKP was commissioned with carrying out the study, because they had already developed a software tool for the ecological assessment of synthetic materials.

In a kick off-meeting in which representatives of the management and the environmental department of the laundry product area, the central environmental department, and the IKP participated, goal and scope of the LCA were roughly defined and the time schedule agreed. For the environmental department of the laundry product area, as the promoter of the LCA-project, the meeting also served to secure the commitment of the other involved actors, especially the division management. After the kick off-meeting had taken place, the data collection began. Here the central environmental department and the division management did not play an active role, but were regularly informed about the state of the project.

The BSH intern data collection was organised by the environmental department of the laundry product area. The company, that is especially the production works in Berlin, provided data referring to production processes taking place at BSH as well as to transports and the stage of use. Because the information was spread over different departments, the data collection took about half a year. The data were put in some kind of self-made data bank based on EXCEL.

The remaining data were provided by the IKP. The preceding life-cycle stages were mainly depicted on the basis of average data. Particularly in the case of the polypropylene soap container specific data could not be used, because input suppliers were not yet known. Also the stage of disposal was covered by aggregated data. To provide these data and to carry out impact assessment and interpretation the IKP needed another three months. All in all the conduction of the LCA-study took about nine months and was completed in mid 1995. The external costs amounted to DM 50,000-60,000 and company internal costs came to about six man-months.

Despite the definition of goal and scope all methodological choices, were left with IKP, because the institute (and not BSH) had the necessary know-how. With respect to impact assessment and interpretation, BSH explicitly did not want to interfere, in order not to be involved in value judgements and weightings inevitably implied in this steps. The company intended to secure objectivity.

Although previous examinations of the economic and technical consequences showed that the PP-variant was superior to the steel soap container, economic and technical assessments were again included in the LCA, in order to carry out an integrated use-value analysis.

The results of the LCA were presented by IKP in a meeting in which the same persons took part as in the kick-off meeting, i.e. representatives of the management and the environmental department of the laundry product area, the central environmental department, and the IKP. Because the LCA was intended only for internal use, a critical review did not take place.

2.4.2.2 Methodological choices

2.4.2.2.1 Type of LCA

Since the LCA underlying this case-study analysed and juxtaposed soap containers of two different materials, it can obviously be characterised as a comparing study.

Because the information provided by the LCA-study influenced the decision about the soap container alternative to be used in future, the LCA was used in a prospective way.

The LCA regarded the entire product life-cycle and encompassed all LCA-steps required by the standardisation organisations[24] and therefore can be classified as a complete LCA. But because large parts of the LCA are based on aggregated data it also reveals characteristics of a streamlined study.

2.4.2.2.2 Detailed description of the products and subject of the LCA and their life-cycle

The soap container is an important part of the washing machine. It surrounds the washing drum and thus forms the container for water and detergents in which the washing drum rotates. In the LCA a soap container made from steel is compared to a polypropylene variant.

The LCA encompasses all stages of the soap containers' life-cycle. It begins with the extraction of raw materials, that is the extraction of mineral oil respectively the mining of iron ore, and their processing. The stages of production of intermediate products, production of soap containers, use, and disposal/recycling follow. While transports occurring within or between the stages are regarded as well, production and disposal of means of production, e.g. machines, remain unconsidered. The scope of the LCA is depicted in Figure 2.8.

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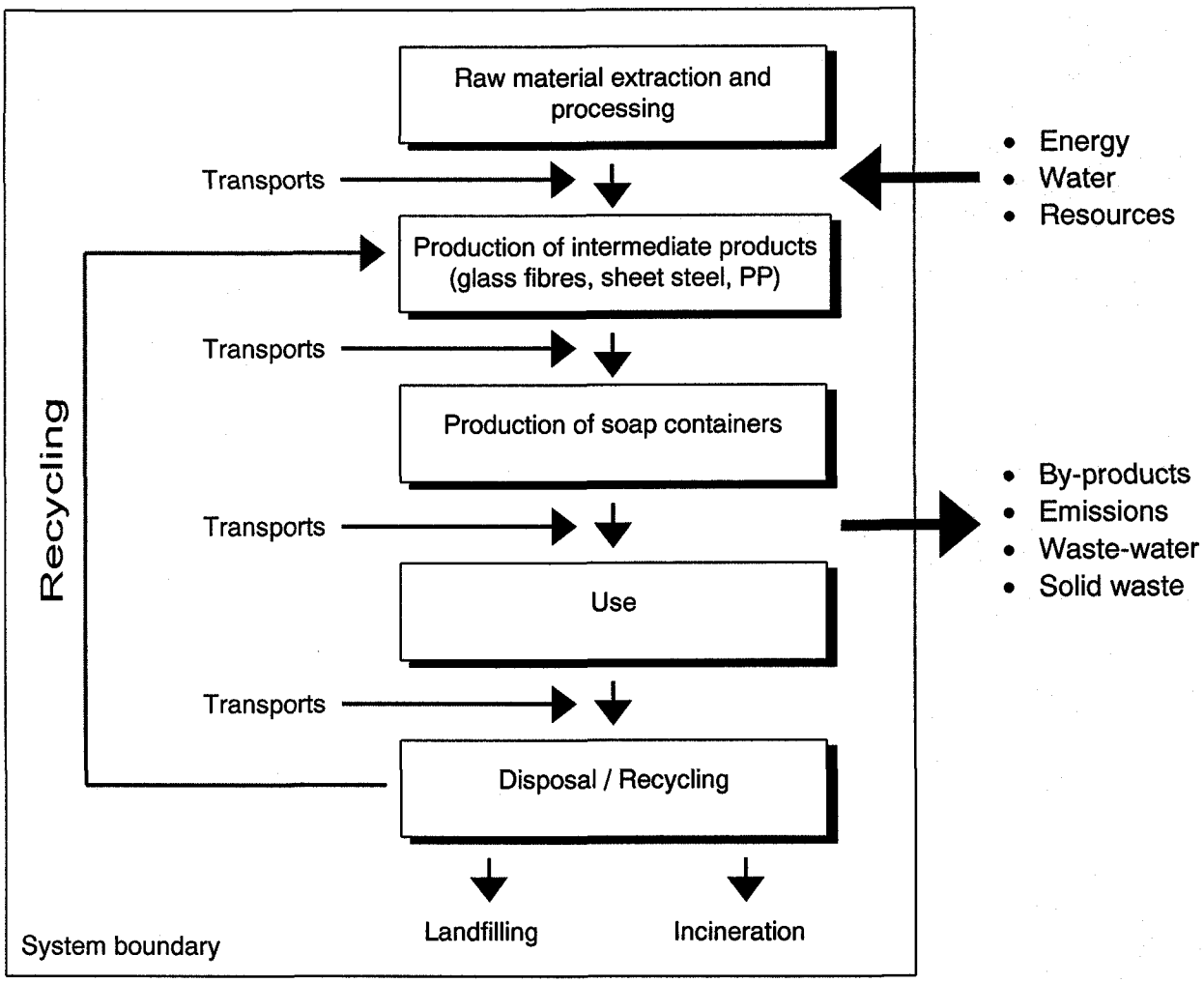
[24] According to ISO 14040 an LCA consists of the following steps: goal and scope definition, inventory analysis, impact assessment, and interpretation (see ISO 1997).

Figure 2.8: Scope of the LCA of soap containers (Saur 1995, p. 6)



The environmental impacts caused by the soap containers are recorded in the form of inputs (energy, water, resources) and outputs (by-products, emissions, waste-water, solid waste) related to the single life-cycle stages.

2.4.2.2.3 LCA-steps

The LCA followed the state of standardisation at DIN/ISO and the discussion within the SETAC (Society for Environmental Chemistry and Toxicology) at that time and therefore encompasses the following steps: goal and scope definition, inventory analysis, impact assessment, and interpretation.

Subsequent to goal and scope definition and data collection, the inventory data are associated with specific environmental impacts (impact categories) in the course of the impact assessment. The impact categories considered in the LCA are listed in table 2.3. Other possible impacts like ozone depletion, land use or noise emissions were not considered, because they were hardly influenced by the analysed soap containers or because detailed data were not available.

Table 2.3: Impact categories and weightings (see Saur 1995)[25]

Impact Categories	Weightings
Greenhouse Effect	30%
Acidification	5%
Nutrification	5%
Photochemical Oxidants (PCO)	5%
Human Toxicity	15%
Eco Toxicity	10%
Waste	10%
Resource use	20%

In the interpretation-step the figures obtained for the different impact categories are aggregated to an overall result. This was done by weighting the figures following the Dutch proposal of the VNCI-model of the VCI-group (VCI 1994)[26] which suggests to weight the environmental impacts according to their special extension (local, regional, global). The weightings actually used in the selected LCA-study were chosen by IKP and are depicted in table 2.3.

Subsequently, the LCA juxtaposes the ecological, economic and technical performance of the soap containers by means of an integrated use value analysis.

2.4.2.3 Results and recommendations

2.4.2.3.1 Comparison between the two soap container variants

With respect to economic and technical aspects the PP-container turned out to be advantageous compared to the steel alternative.

In regards to ecological questions the result came out less clearly. After inventory analysis and impact assessment were carried out no soap container variant was superior to the other: Whereas the steel container came off better with respect to acidification, photochemical oxidants, and eco-toxicity, the PP-variant achieved better results in regards to nutrification, greenhouse effect, human toxicity, resource use, and waste. Only after the impact categories were weighted, the PP-container revealed ecological advantages over the steel variant.

The decisive advantage of the PP-container was that due to its different construction the amount of water needed during the stage of use could be reduced by approximately two li-

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[25] The impact category has also been considered. However, the result of the inventory was that no emissions occurred which have to be allocated to this category; therefore it was neglected.

[26] The VCI is the official German branch association „Verband der Chemischen Industrie".

tres per washing. In connection with the applied weightings this led to a recommendation of the PP-variant. Diminishing the water consumption is especially important, because the amount of energy and detergents needed simultaneously decreases.

2.4.2.3.2 Other optimisation potentials

Besides the comparison between the soap container variants the LCA stressed the general importance of the stage of use. The other life-cycle stages caused comparably little environmental damage. By far the most impacts occurred due to energy, water, and detergent consumption related to the stage of use.

The data provided by the LCA would also allow for the identification of ecological weak spots and optimisation potentials of the single soap container alternatives. But because the goal definition did not (explicitly) contain such a weak spot analysis, the LCA-data were not used for this purpose.

2.4.2.4 Decisions and applications

2.4.2.4.1 Substitution of the steel soap container for the PP-variant

Due to the LCA the soap container made from PP seemed to be superior to the steel variant not only from economic and technical, but also from ecological reasons. The IKP presented the results of the integrated use value analysis implied in the LCA in a final meeting in which representatives of the management and the environmental department of the laundry product area as well as the central environmental department participated. After an intensive discussion the group expressed itself in favour of the PP-variant. Subsequently the product team[27] of the laundry product area has drawn the definite decision to switch the technology.

In 1996 the first top-loader washing machines equipped with PP-containers were placed on the market. Currently it is checked to what extent the LCA-results can be transferred to other washing machine models. In the long term it is aimed at using the PP-variants for all washing machines.

2.4.2.4.2 Realisation of other optimisation potentials

The LCA-study, once again, stressed the importance of the stage of use. Accordingly, through external communication measures BSH tries to convince its clients to operate the appliances in an environmentally sound way. For example, in the operation instructions users are advised how to reduce the consumption of energy, water, and detergents to a minimum. Subsequent to the LCA the operation instructions were critically reviewed in a study carried out by a student from Bayreuth University. Currently the central environmental department works on improving the instructions, whereby special emphasis is laid on ecological information.

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[27] Product teams exist for each product division. They consist of the division management and the heads of the division's development and marketing departments and are the decision-makers of important product related decisions (please refer also to chapter 3.2.1).

It is also aimed at developing „intelligent" appliances which can assist users in lowering the use of energy, water, and detergents: for instance, dishwashers which inform the user, if the machine is not fully loaded or washing machines which indicate the weight of the laundry and thereby enable the user to use the optimal quantity of detergents. Although these efforts were not triggered by the LCA, it clearly „served as a confirmation to be on the right track" (Criens on 10/15/97).

The LCA primarily served to compare the ecological performance of the two soap container alternatives. Although ecological weak spots and optimisation potentials could have been identified and realised, it was refrained from doing so. This was probably not least because the LCA revealed that the PP-soap container was already „environmentally friendly enough" not to interfere with the decision to take for economic and technical reasons. BSH claims that with respect to production processes taking place within the company, the LCA could not reveal new weak-spots, because the data were known anyway.

2.4.2.4.3 Information and communication

Because the LCA became an extensive study, an abridged version was written which still consisted of more than a hundred pages. But neither the long nor the short version of the LCA-study have been published. Information about the LCA, its methodology and results, was almost exclusively given in lectures on specialised conferences or meetings and thus primarily addressed experts.

By mentioning the LCA in the BSH environmental report its existence was made known to a wider public. But the report on the LCA was restricted to a few lines, providing the basic facts about background, motives, and results of the LCA-study.

The LCA was not applied in direct product marketing, mainly because it did not analyse a complete product, but only one part of the washing machine. Moreover the information provided by LCAs are generally regarded as too comprehensive and too complex to be used for public relations activities or advertising.

Due to the complexity of the LCA-study, even its company internal communication has been difficult. The IKP presented the LCA results in a meeting in which representatives of the management and the environmental department of the laundry product area and the central environmental department participated. Moreover the management of the BSH Group was informed about the LCA-process and its results.

Employees of the development and production departments of the laundry product area who were responsible for realising the LCA-results, i.e. the switch from soap containers made from steel to containers made from PP, of course, got notice of the LCA and its results as well.

In the BSH internal working group „Environmentally sound product development" (please also refer to chapter 3.1) details about motives, methodology, communication processes, and results of the LCA were given and discussed. Since the working group includes representatives of each product division, certain LCA-knowledge thus was widely spread over the company.

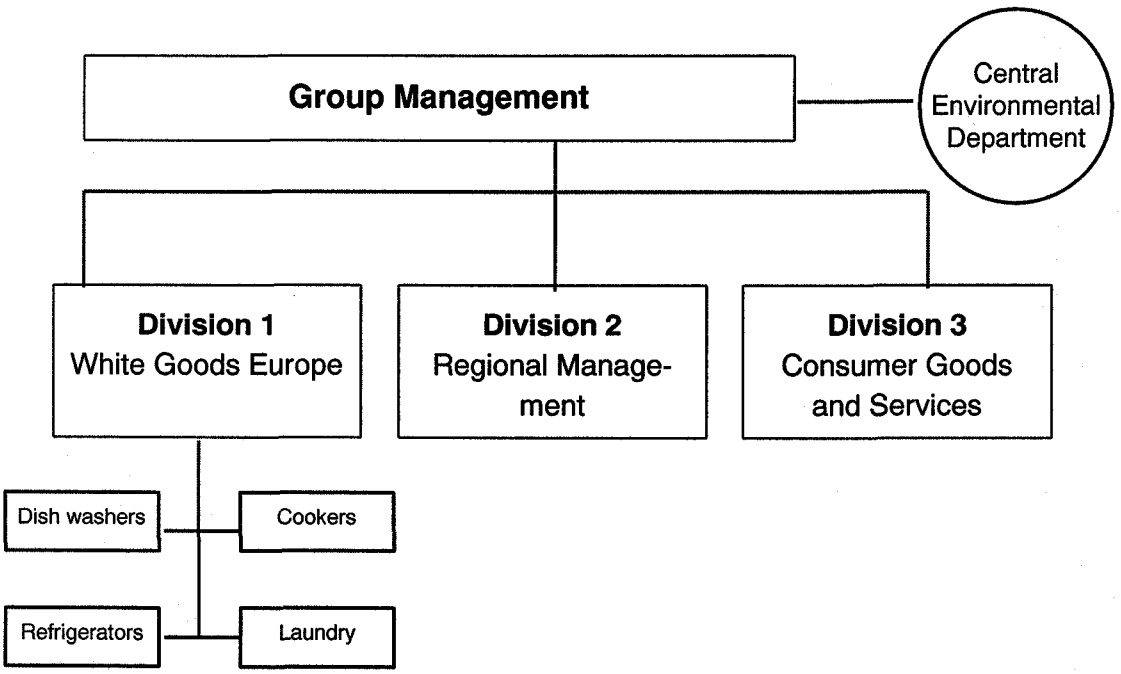
Employees that were neither directly involved in the LCA-process nor important decision-makers, were not informed. BSH explains that the LCA was rather intended to support a technical decision than to be used in the environmental oriented communication.

2.4.3 The role of LCA in the decision-making context

2.4.3.1 The decision-making culture

In recent years BSH more and more developed into an international company. Thereto the organisational structure changed considerably. Currently the BSH Group consists of three company divisions which are all on an equal level, only the group management is placed above (see Figure 2.9).

Figure 2.9: Overall organisational structure of the BSH Group



The company divisions have been established in accordance with product groups and regions in which BSH operates.

The decision making culture of BSH is characterised by flat hierarchies and intensive communication processes. An all levels within the single company divisions and on a super-divisional level committees have been founded in which important decisions are discussed and taken.

At the end of the 80ies BSH built up an environmental management system. As one part of the system the working group „Environmentally sound product development" was estab-

lished which co-ordinates the product related environmental activities of the BSH Group[28]. This working group consists of representatives of all product related company divisions and is lead by the employee of the central environmental department responsible for products.

The working group, for example, elaborates guidelines and checklists for an ecologically orientated product development, organises environmental trainings, and generally serves as a platform for discussions and exchange of information and experiences.

2.4.3.2 The product innovation process and the integration of LCA in this context

2.4.3.2.1 The „typical way" of product innovation at BSH

The responsibility for the development of new or enhanced products is with the single product divisions; each division has its own product development department. Inter-divisional exchange of information is secured by regular meetings of inter-divisional working groups, like the one for „Environmentally sound product development".

BSH strives for manufacturing integrally optimised products: „Every development takes place in an area of conflict between technical, economic, and ecological aspects. (...) Right from the beginning, all targets have to be considered, quantified, and monitored" (Criens 1997, p. 1-2).

At three mile-stones in the product development process a formal evaluation of the progress is prescribed. In the course of this so-called quality-assessments it is checked (with the help of checklists), to what extent technical, economic, and ecological goals are met. If a certain goal accomplishment was not reached, the development process is stopped. The last milestone is the admission of the product for large scale production (see Criens 1997, p. 5-6).

In order to generally integrate environmental aspects in the product innovation process ecologically oriented guidelines have been formulated: Since 1993 a binding guideline on the exclusion of hazardous substances exists which encompasses lists of substances that are forbidden or to be avoided. The lists partly go beyond legal standards. In the same year another guideline has been set which encourages developers to design products that are easy to recycle (only few different materials, easy dismantling).

The newly developed and also obligatory instrument „Product-Environment-Examination" (Produkt-Umwelt-Betrachtung) secures an early integration of ecological aspects in the course of the development of new product generations. Because totally new products are developed very rarely, the instruments focuses on the ecological optimisation of existing products and encompasses the steps that are depicted in Figure 2.10.

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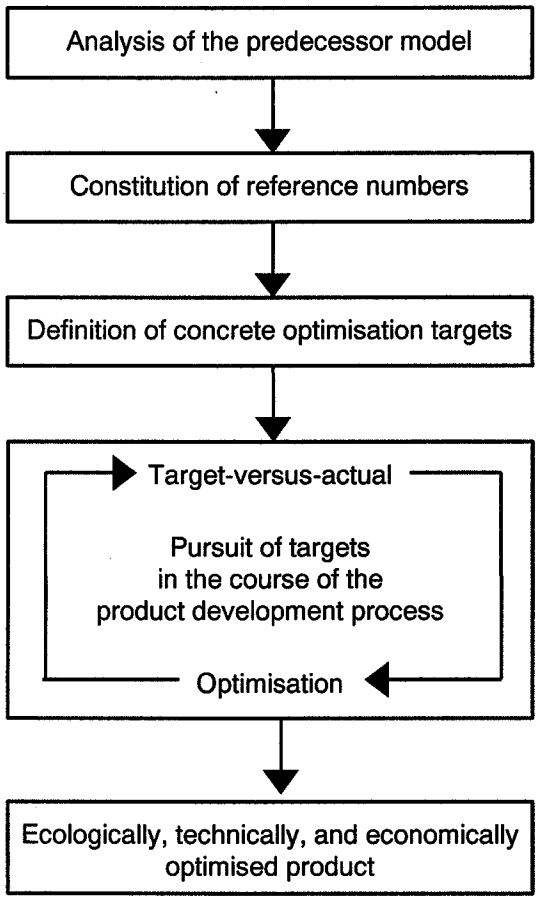
[28] When BSH built up its environmental management system at the end of the 80ies, seven subject related working groups were established: for environmental protection related to products, production, logistics, distribution, procurement, communication, and co-operation with industrial associations. Meanwhile five of these groups were replaced by environmental officers (co-ordinators) only the working groups dealing with products and production „survived".

Figure 2.10: The process of the „Product-Environment-Examination" (following BSH, 1996/97, p. 11)



The reference numbers, their actual and target values, as well as the extent of goal accomplishment are summarised in the so-called „Reference numbers-sheet". Considered are, for example, energy and water consumption, complexity, weight, and packaging of the appliances.

The reference numbers and targets are set by the product team which is responsible for the development of the particular product. Product teams exist in each product division. They are interdisciplinary filled and consist of employees from marketing, technicians, and cost accounting.

2.4.3.2.2 The integration of LCA in the process of product innovation

Since the „Product-Environment-Examination" should cover all life-cycle stages of the products, actual and target values could be identified with the help of LCA-studies. But so far BSH has refrained from firmly integrating LCAs in the process, because conducting LCAs of complex products like electrical household appliances is regarded as almost impossible. Thus the „Product-Environment-Examination" covers the products' entire life-cycle, but regards only selected energy and material flows (see Criens 1997, p. 3-4).

Moreover, BSH does not systematically integrate LCAs in the product development process, because this would require that LCAs accompanied the whole process and were continuously adjusted to its advances. But BSH regards the instrument as too comprehensive to be

used in this rather dynamic way. LCAs can only depict momentary situations, i.e. they are valid only for special scenarios set in particular studies.

BSH uses LCAs to identify ecological weak-spots and to support important product decisions. So far, BSH has not carried out LCAs of complete appliances, but analysed single product components or packaging systems.

2.4.3.3 The future of LCA at BSH

2.4.3.3.1 Weaknesses and strengths of the instrument and its future application

BSH has recognised the importance of life-cycle oriented examinations as the only way to find out in which of the life-cycle stages the most relevant environmental impacts occur. LCA is appreciated as an instrument that provides quantitative data on the ecological performance of products.

The company hardly uses LCA-studies to inform company internal or external stakeholders. To use LCAs for public relation activities or product marketing is explicitly avoided, because no commonly agreed rule for interpreting the data exists. LCAs are rather applied in the product development context, they serve to identify ecological optimisation potentials and to support product decisions. So far, BSH has not conducted LCA-studies of complete appliances, but analysed single product components and packaging systems.

Because BSH experienced the conduction of LCAs as very demanding, the instrument is not applied regularly, but only to support important product decisions. According to the environmental department of the laundry product area, „important" means that the appliance's technology, design or operation changes remarkably. Moreover the company regards LCA as not flexible enough to systematically accompany dynamic product development processes.

The central environmental department expects that LCAs will play a more important role in future. Possibly even whole appliances will be analysed, provided the methodology is standardised and the data availability enhanced, e.g. through public data banks. But in order to secure the necessary commitment, the central environmental department does not want to persuade anybody to carry out an LCA. It is preferred, that the idea to conduct an LCA-study comes from the product divisions themselves.

However, the laundry product area is still the only product area that shows interest in carrying out LCA-studies. The only study the company performed subsequent to the LCA of soap containers was also conducted here. Currently no LCA-project is in progress at BSH.

No urgent need for further comprehensive life-cycle studies is seen, because meanwhile it is well-known that most environmental impacts (about 80-90%) related to electrical household appliances occur in the stage of use. Thus focal points or BSH's research activities are already defined. Moreover the company claims that comprehensive data on the eco-performance of its products are already existing.

Public LCA-activities were not mentioned as a decisive factor for the company's future application of LCA. Nevertheless, BSH employees were very creative in providing ideas of what public authorities could do in the context of LCA (see chapter 3.3.2).

2.4.3.3.2 Interrelation between the application of LCA and public policy

Although public policy did not directly influence the conduction of the LCA of soap containers, the LCA-studies on packaging systems or detergents carried out by the German Federal Environmental Agency (Umweltbundesamt, UBA) helped to make the instrument known to the public and thus also to BSH.

But the head of the environmental department of the laundry product area is of the opinion that the UBA did not help LCA to good publicity, he regarded the reporting about the UBA's experiences as not encouraging. He was surprised that the UBA seemed to reduce its LCA-activities, when conduction and application of LCAs turned out to be more complicated than anticipated, instead of being an example to private actors.

He thinks that an important goal of product related public policy must be to establish a general product classification saying how environment-friendly the products are. This general classification could work similar to the energy-efficiency classes of electrical household appliances, but by taking all environmental impacts and the entire life-cycle into account. He regards LCA as the appropriate instrument to provide the information required and expects public policy and particularly the UBA to take an active part in this context.

With respect to LCA-methodology public authorities are demanded to standardise the impact assessment and interpretation step by prescribing impact categories that have to be considered in every LCA-study and by providing fixed weightings for the different environmental impacts. The BSH employee giving these statements did not explicitly mention certain public institutions, but addressed the state in general. Nevertheless, the remarks were obviously made against the background of the German situation.

2.4.4 Summary and conclusions

Bosch and Siemens Hausgeräte GmbH (BSH) was founded in 1967 when the Robert Bosch GmbH and the Siemens AG merged their household appliances divisions. The company produces a wide range of electrical household appliances like freezers, washing machines, and cookers and meanwhile developed into an internationally operating group. In 1997 the BSH Group made a turnover of DM 9.6 billion and employed about 32,000 people.

Traditionally the household appliances industry is relatively little related to ecological problems. Most environmental impacts result from the appliances' consumption of water, energy and detergents as well as from the high quantities of waste that occur, when they have to be disposed off after the stage of use. BSH made and still makes efforts to enhance the environmental performance of its appliances and in recent years uses LCAs respectively LCA-similar studies in this context.

But the switch from steel soap containers to containers made from polypropylene (PP) that is analysed in the LCA that underlies this case-study, was rather motivated by economic and technical than ecological aspects. But because this switch meant an important and hardly

reversible change in the basic technology, the laundry product area decided that it should not be realised without also considering the environmental consequences.

Thus in 1994 BSH commissioned an external institute to carry out an LCA that compared the two kinds of soap containers. The LCA confirmed that the container made from PP is superior to the steel variant for economic and technical reasons. With respect to ecological questions the result came out less clearly, but suggests that the PP-container is ecologically advantageous as well. Subsequent to the LCA BSH has begun to replace the steel soap containers. In 1996 the first washing machines equipped with containers made from PP were placed on the market.

All in all the company was content with the LCA-process and intends to further apply the instrument. But it is admitted that it was easy to be content, because BSH was lucky that the LCA-results did not interfere with the results of economic and technical analyses. However, currently the laundry product area seems to be the only product area that shows interest in the instrument. Here a further LCA-study has already been conducted.

BSH intends to use LCAs rather in the product development context than for public relation activities or product marketing. But the company does not plan to systematically integrate LCAs in the product development process, because the instrument is regarded as too complex to accompany dynamic innovation processes. LCAs are only carried out to support „important" product decisions. But no fixed routines exist that determine which decisions are important enough to be based on an LCA.

Otherwise, the ecological optimisation of products is secured through obligatory guidelines on hazardous substances and recycling as well as BSH's „Product-Environment-Examination". The energy need of appliances is examined with the help of KEA-analyses.

Since the company does not plan to regularly carry out LCA-studies, it neither intends to build up comprehensive LCA-know-how. The conduction of future LCAs will be laid in the hands of external experts again.

2.5 Case-study Henkel KGaA

2.5.1 Company background

2.5.1.1 General description of the company

2.5.1.1.1 History and organisation structure of the company

The company was founded by Fritz Henkel in Aachen in September 1876. The first product has been an all-purpose detergent. Two years after its foundation the enterprise moved to Düsseldorf due to better infrastructural conditions. The headquarters of the company are still located in Düsseldorf today.

Because the washing and cleansing agents turned out to be very successful, the company was growing soon. In the course of this growth the range of products was supplemented by a multitude of chemical products. Nowadays Henkel KGaA is the 48th biggest German company, according to the ranking published by the „Frankfurter Allgemeine Zeitung" (FAZ

1996). Moreover Henkel developed into one of the most internationally engaged German group of companies.

With 246 associated companies the Henkel Group is present in more than 60 countries. The leading company is the Henkel KGaA, public limited partnership, in Düsseldorf. Until 1996 all voting shares were owned by the Henkel family. Currently there exists an agreement which commits the Henkel family to hold at least 50% in the medium-term. The remaining voting shares and all non-voting shares are exchanged on stock markets.

2.5.1.1.2 Products, markets, turnover and employees

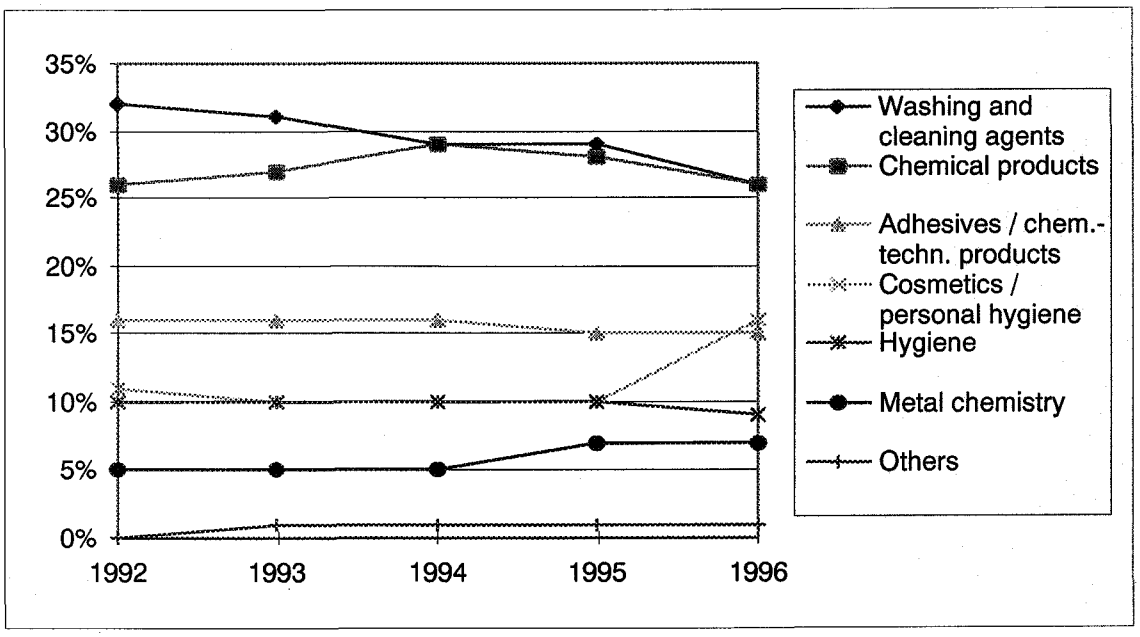
Henkel produces a wide range of chemical products. The almost 10,000 different goods are grouped into six segments (see table 2.4).

Table 2.4: Product groups of the Henkel Group (see Henkel 1997, p. 5)

Product groups	Products
Chemical products	• Oleochemicals: fatty alcohols, fatty acids, glycerine etc. • Fine chemicals: products for cosmetics and pharmaceuticals, food additives, aromatic substances etc. • Organic chemicals: ground substances and additives for synthetic materials, products for the textile, leather and paper industry etc. • Inorganic products: water-glass
Metal chemistry	• Chemical products for the treatment of metal surfaces
Adhesives / Chemical-technical products	• Products for building and renovating, e.g. sealing compounds • Industrial adhesives
Cosmetics / personal hygiene	• Soaps, deodorants, body lotions, tooth paste, shampoos etc.
Washing and cleansing agents	• Detergents, washing-up liquids, household cleansing agents etc.
Hygiene	• Products and services for cleaning, washing, rinsing, desinfection etc.

The washing and cleansing detergents and the chemical products are the most significant product groups. They each contribute 26% to the Henkel groups turnover. But in recent years their shares have been declining in favour of the cosmetics and personal hygiene as well as the metal chemistry. Because of important acquisitions in the field of adhesives the adhesives and chemical-technical products will move up to the top group in 1997.

Figure 2.11: The product groups' shares in turnover[29]



The products are manufactured in Henkel plants all over the world. At the Henkel location in Düsseldorf-Holthausen three product groups, namely chemical products, adhesives and chemical-technical products as well as washing and cleansing agents, are represented.

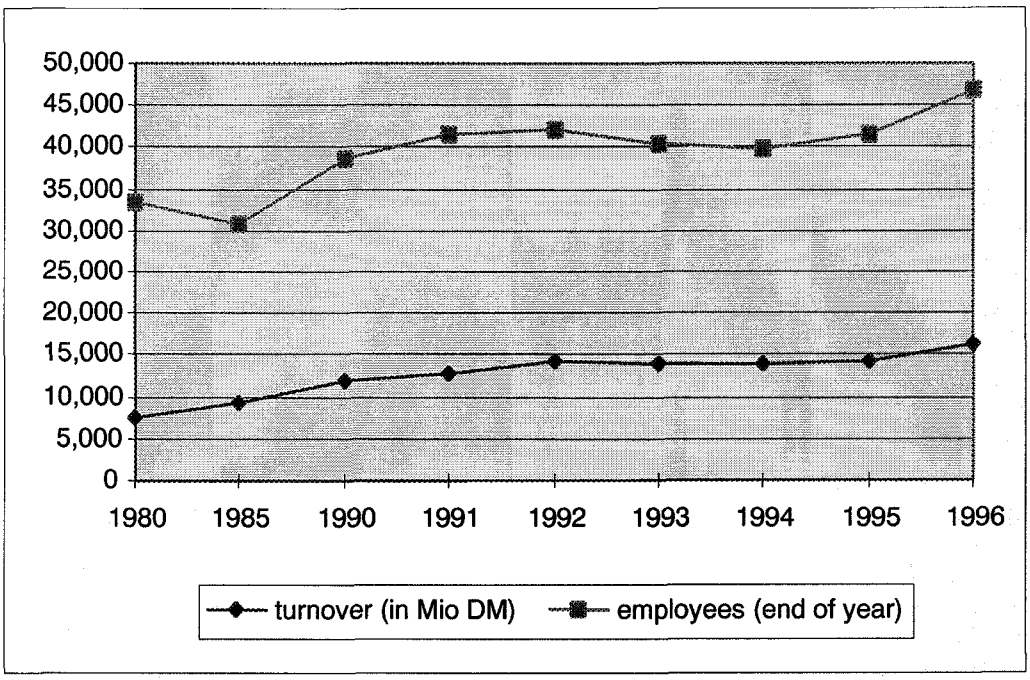
In 1996 the overall turnover of the Henkel Group amounted to DM 16.3 billion. In total 47,000 employees were working for Henkel; 31.000 of them abroad and 16,000 within Germany. The headquarters in Düsseldorf-Holthausen, also the company's biggest production site, employed 9,000 people (see Henkel 1997, p. 4).

In recent years the turnover of the Henkel Group rose steadily, apart from a slight decline in 1993. Between 1980 and 1996 the turnover of the concern more than doubled. The number of employees also increased, but at a much lower rate. The expansion of staff was slowed down by the personnel reductions in the early 80ies and at the beginning of the 90ies.

The Henkel Group's products are offered world-wide. But most of the products are still sold in Europe, especially in Germany. While 75% of the turnover is made in Europe, Germany alone holds a share of 28%. Further important markets lay in Northern America, Asia and, Australia. Hitherto Latin America and Africa do only play a minor role (see Henkel 1997, p. 4).

[29] The underlying figures have been taken from the Henkel environmental reports of the years 1993 to 1997.

Figure 2.12: Turnover and employees of the Henkel Group[30]



2.5.1.1.3 Environmental problems and activities

Henkel is convinced that a long-term market success can only be achieved with ecologically optimised products: „Who optimises products - and this holds especially for chemical products - only with respect to price and performance, belongs to the outdated. Today the environmental-friendliness counts as a new dimension of quality," (Henkel 1996, p. 11)[31].

Thereto Henkel reaches not only for quality-leadership, but also for „Eco-leadership". A few years ago Henkel has signed the charta for sustainable development of the International Chamber of Commerce (ICC) and moreover commits itself to the international initiative „Responsible Care" of the chemical industry.

The beginning of the ecological research at Henkel dates back to the 50ies. Since then numerous ecological product optimisations have been carried out. Regarding the division of washing and cleansing agents the development of detergents free from phosphates and the use of surfactants on the basis of renewable resources are to be mentioned.

To get an overview of the environmental situation of products and production sites, Henkel has built up a comprehensive environmental information system. In 1988 a first company-wide environmental audit has been decided; world-wide 140 production sites in 53 countries have been analysed. In 1996 the first three locations, inter alia Düsseldorf-Holthausen, were certified in accordance with the EU's Environmental Management and Auditing Scheme (EMAS). From the beginning of the 90ies Henkel regularly uses LCA in order to record the

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[30] The underlying figures are taken from the Henkel annual reports of the years 1980 to 1996.

[31] Translation by the author.

environmental impacts related to products. Information on the current environmental situation is provided in the annual environmental report that Henkel publishes since 1992.

The activities are integrated in a general ecologically orientated concept which prescribes guidelines for strategy development and management. In 1982 the „Principles for environmental and consumer protection in the Henkel Group" have been published. This company-wide binding code of conduct has been updated in 1995. At the same time it has been combined with the „Principles and measures for job security" order to form a holistic programme. Presently it is worked on incorporating the quality management as well. Concrete and quantified short-term environmental goals have been formulated in the 1995 environmental report for the first time.

The ecological engagement of Henkel gets increasing public resonance. In 1994 CAPITAL and WWF chose the managing director Hans-Dietrich Winkhaus as „Eco-manager of the year". The Hamburger Umweltinstitut (HUI) that tests the 50 biggest chemical companies worldwide with respect to their environmental performance[32] has ranked Henkel on second place both in 1994 and in 1996.

Despite the remarkable activities in the fields of environmental protection the chemical industry still uses or produces a lot of substances that can be harmful to nature and human health. Additionally, the chemical production processes are often connected to a high consumption of water and energy.

In the public Henkel is primarily identified with its traditional product group, the detergents. Along with the alteration of quantity, composition, and quality of its ingredients the environmental impact of washing agents also changed. While the nutrification caused by phosphates has been the main problem in the 70ies, nowadays the pros and cons of biotechnical enzymes and oleochemical surfactants are under discussion.

2.5.1.1.4 LCA-activities

Henkel uses LCAs, e.g. of detergents, detergent ingredients, adhesives, and packaging, from the beginning of the 90ies. Meanwhile every important product innovation is accompanied by an ecological assessment which is inter alia based on LCA (see section 3.2). Accordingly conducting LCAs is, especially in the division of washing and cleansing agents, regarded as a permanent task.

Although LCAs are firmly integrated in the product development[33], they are of varying importance for the different segments. In the segment of washing and cleansing agents as well as in the development of packaging they are used regularly. The field of chemical products is primarily concerned with obtaining the data for detergent ingredients. In the segment of adhesives and chemical-technical products difficulties in data collection stand in the way of a more intensive use of LCA (see Henkel (n.y.), p. 18-19).

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[32] Considered are inter alia environmental policy and goals, waste management as well as products and processes of the companies (see Krogh/Palaß, 1996).

[33] The term 'product development' encompasses not only the development of complete products, but also the development of new ingrediants.

In the beginning of the engagement in LCA Henkel was closely co-operating with external experts (e.g. Technical University of Munich) and consultants (e.g. Batelle, Chem Systems). In this way a comprehensive internal know-how of LCA-methodology was built up, so that Henkel was able to carry-out LCA-studies independently very soon[34]. Originally the WEQ-department was exclusively responsible for conducting LCAs. In the meantime LCA-studies are carried-out in the other segments as well. Furthermore The associated Institute COGNIS Industrial Consulting GmbH[35] is also involved in the LCA-activities. For instance, COGNIS can be commissioned to participate in collection of data, if the capacities within the different segments are not sufficient.

When the LCA-activities started, an extensive data bank was built up simultaneously. Because in the early 90ies there did not exist any suitable software in this field, Henkel developed its own system. Meanwhile some elaborated and easy to use LCA-programmes are available. Thereto Henkel plans to switch to one of these programmes.

The data bank is updated regularly and currently contains data modules of 250 different processes and more than 400 substances. In case of own processes and substances the data are provided by Henkel itself. To gather information on other stages of the product's life-cycle orders were placed with consulting firms, literature searches were conducted and estimates were made. Therefore each module includes an indicator which marks the quality of the data (see Klüppel et al. 1995).

Because data modules provided by the data bank can be used, the time needed for conducting an LCA-study has been reduced considerably, and currently varies between a few days or weeks. The data bank can be used intensively, because new products are rarely based on new ingredients, but result from new processing methods or new combinations of classical ingredients.

2.5.1.2 General description of the business external context

2.5.1.2.1 The political and legal context

In order to reduce the environmental damage that can be caused by washing and cleansing agents, a number of laws and regulations have been enacted in Germany. The most important one is the Law on Washing and Cleansing Agents (WRMG, Wasch- und Reinigungsmittelgesetz) together with its amendments on limits for the use of phosphates and the degradability of surfactants.

The latest version of the regulation on the degradability of surfactants from 1986 prescribes that surfactants have to be degradable to at least 90%. This requirement is fulfilled by the oleochemical (FAS) as well as by the petrochemical (LAS) surfactant.

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[34] The head of the WEQ-department is a member of the LCA-committees of DIN (German Institute for standardisation) and ISO (International Standardisation Organisation).

[35] COGNIS was founded in 1991 in order to concentrate the Henkel activities in the fields of bio- and environmental technology.

Moreover numerous voluntary agreements have been announced by the detergent industry. For example, in 1986 the non-use of APEO (Alkylphenolethoxylate)[36], a group of surfactants that degrade very slowly, has been agreed between associations of the detergent industry and the federal ministry of the interior.

Through voluntary covenants to provide information on the damage that ingredients of washing and cleansing agents can cause, industry has prevented legal regulations. According to § 7 WRMG the companies can be committed to declare all ingredients of their products on the packaging. § 9 WRMG which prescribes, that the suppliers of washing and cleansing agents have to transmit basic data on the environmental impacts of their products to the Federal Environmental Agency (UBA), also enables the government to enact regulations which go further. In its latest covenant of July 1997 the detergent industry has announced to provide comprehensive data on enzymes used in Germany (Müllmagazin 1997, p. 3).

2.5.1.2.2 The branch/sector context

Since the LCA that underlies this case-study deals with detergent ingredients, in the following only the market for this product group is regarded.

The German market for detergents is lead by the companies that are listed in table 2.5. They were able to defend their market shares, although the competitive pressure is rising, since big retailers have begun to install their own trade marks.

Table 2.5: Important producers of detergents and their trade marks

Producer	Trade marks
Procter & Gamble	Ariel, Lenor, Rei, Sanso, Dash, Vizir
Henkel	Persil, Weißer Riese, Spee, Fewa, Perwoll
Lever	Omo, Sunil, Coral, Skip (Baukastensystem)

[36] APEO is the generic term for a non-ionic surfactant group.

An outstanding position is held by „Persil" of Henkel on the one hand and „Ariel" of Procter & Gamble on the other hand. In 1996 „Persil" reached a market share of 34%, whereas the share of „Ariel" amounted to 22%. Henkel itself claims to belong to the leading producers of washing and cleansing agents not only in Germany, but also in Europe (see Henkel 1997, p. 4).

The German market for detergents is regarded as satisfied and is thereto characterised by a strong price and quality competition. Increases in turnover of single suppliers are only possible at the expense of the competitors and can primarily be achieved by product innovations. For instance, the rise in turnover of detergents that Procter & Gamble revealed in its annual report of 94/95 was based on the invention of „Ariel Futur". Henkel could strengthen its market position due to the introduction of „Persil Megaperls".

Although Henkel often is referred to as the Eco-leader of the branch, its main competitor is not passive in this field. Since 1989 Procter & Gamble has, for example, increased the use of recycled materials and reduced packagings remarkably. To assess the environmental profile of its products, also Procter & Gamble applies LCA for some years (see P&G Environmental Progress Report 1995).

Besides traditional and big suppliers like Henkel and Procter & Gamble, producers of detergents that aim at an ecologically orientated demand (e.g. „Frosch", „Storch") are in the market. But the market shares of their products are still very little. They are mainly restricted to ecological niches, and can therefore hardly be regarded as competitive products.

2.5.2 The selected LCA-study

This case-study is based on an LCA that compares an oleochemical (LAS) with a petrochemical surfactant (LAS). From the numerous LCAs conducted by Henkel we have chosen this one, because it is the first LCA the company carried out and thus enables us to describe how Henkel started its LCA-activities.

2.5.2.1 The LCA-process

2.5.2.1.1 Motives and objectives

The composition of detergents is very complex, they contain up to 25 different ingredients. The surfactants are an important component, because they are able to enhance the cleaning of the laundry.

Hitherto petrochemical surfactants (LAS) have been used. An oleochemical alternative on the basis of renewable oleo- and fatty substances is known for several decades. This so-called fatty alcohol sulphate (FAS) promises to save fossil resources and to be better degradable. Technical problems have prevented the substitution of FAS for LAS for a long time. Since they have been solved in the meantime, Henkel decided to switch to FAS at the end of the 80ies.

In 1991 the competitor Procter & Gamble published an LCA-study of FAS versus LAS in which LAS came off better than FAS (Franklin Associates Ltd. 1991). Subsequently a public discussion about the relative ecological desirability of FAS and LAS started. Thereto Henkel

postponed the market introduction of the first detergent based on FAS. Originally it was planned to promote the FAS based washing agents by an eco-marketing campaign. The company hoped for a success similar to that of the first phosphate-free detergents in the mid 80ies. In order to prevent reproaches for a not serious advertising Henkel wanted to be on the safe side and conducted an LCA of FAS versus LAS by itself. The results of the Procter & Gamble study were regarded as obsolete.

The decision in favour of the LCA has been taken by the management of the washing and cleansing agents division. The costs for carrying-out the study have also been overtaken by the division. Whereby the costs only encompass the expenditures for external services, the work done by Henkel employees was not calculated.

The commissioning of the LCA was triggered by external pressure through

- an LCA-study conducted by a competitor,
- the public discussion on the relative ecological desirability of oleochemical and petrochemical surfactants, and
- a possible loss in image and a resulting market failure.

Accordingly with conducting an LCA the following objectives have been pursued:

- Input of scientific evidence in the discussion about FAS versus LAS,
- use of the results of the LCA in the fields of public relation and consumer information, and
- review of a product decision, respectively carrying-out a weak spot analysis.

2.5.2.1.2 Chronology and organisation of the LCA-study

The responsibility for conducting the LCA was placed on the department WEQ-Quality and Environment in the division of washing and cleansing agents. The study has been carried-out in close co-operation with the division of chemical products, because important detergent ingredients are produced here. In order to co-ordinate the internal co-operation a working group of ten to twelve employees has been installed. Besides the divisions directly involved in the LCA, the division of adhesives and chemical-technical products has been represented in the group. Moreover employees of the fields of marketing, research and development, ecologists, biologists and representatives of COGNIS have participated. The working group primarily served as a platform for the exchange of information on LCA-methodology and possibilities for data collection. External experts and consultants also gave an input, especially on methodological questions (see chapter 1.3). The working group only existed in the beginning of the LCA-activities, when a lot of information was needed, that means approximately from 1990 to 1993.

Due to its exemplary character the LCA of FAS and LAS has been followed thoroughly by the working group. The decisions respecting the used methodology, the regarded life-cycle stages, and the realisation of the LCA-results have been taken within the group. Furthermore, it served the co-ordination of the gathering of data.

As long as the data referred to processes that were located at Henkel, the information has been given by the relevant Henkel divisions. Since the preceding stages of the life-cycle

have also been considered, co-operation of suppliers was necessary. Obtaining data for palm oil production in Malaysia turned out to be very difficult. They had to be supplemented by research on the spot. Although support was provided by Henkel subsidiaries in Malaysia, plantations (e.g. Golden Hope Plantation) and national associations and institutes (e.g. PORIM, Palm Oil Research Institute of Malaysia), Henkel employees from Düsseldorf have been to Malaysia in order to participate in data collection.

2.5.2.2 Methodological choices

2.5.2.2.1 Type of LCA

Since the LCA analysed and juxtaposed LAS and FAS, it can obviously be characterised as a comparing study. But because the decision in favour of a switch from LAS to FAS had been made before the LCA was conducted, the LCA is rather a retrospective documentational study which served to review a former decision.

The regarded LCA is the first LCA-study that was carried out by Henkel. Accordingly it was related with great efforts for data collection and learning the methodology.

Although Henkel has made enormous efforts, the company merely conducted the most important LCA-steps and regarded only the relevant life-cycle stages.

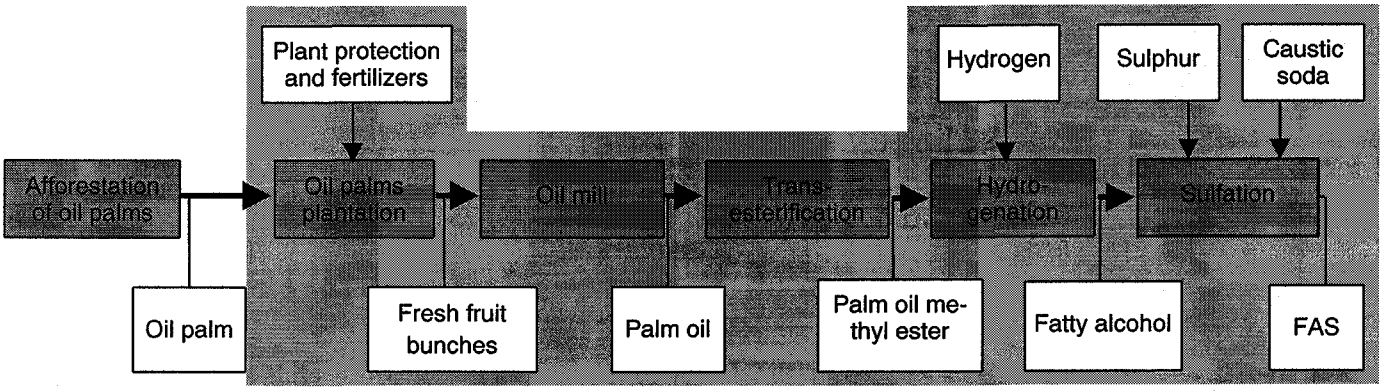
2.5.2.2.2 Detailed description of the products subject of the LCA and of their life-cycle

Surfactants are important detergent components, they serve to improve the cleaning of the laundry. So far petrochemical surfactants based on mineral oil, so-called linear alkyl benzol sulphate (LAS), are commonly used. Now Henkel considers to switch to an oleochemical alternative, the so-called fatty alcohol sulphate, that is based on palm oil as a renewable resource.

As already mentioned in section 1.2, the information published by Henkel almost exclusively covers the part of the LCA relating to FAS. For this reason the information given in the following also have to be restricted to FAS.

Figure 2.13 depicts the single stages of the production process of the oleochemical surfactant and the related outputs. The figure also reveals which inputs have been considered at single stages (e.g. caustic soda at the sulphation stage). The light grey area marks the scope of the LCA.

Figure 2.13: Life-cycle stages of fatty alcohol sulphate (FAS) and the scope of the LCA (see Klüppel et al. 1995)



Only the preceding processes and the production of FAS itself have been regarded in the LCA. The afforestation of the oil palms was excluded, because the authors of the LCA-study were of the opinion, that its contribution to the overall LCA is negligible (Klüppel 1993, p. 6). Also the following production of detergents, household use, and disposal remained unconsidered. Appropriate studies had been conducted already.[37] They came to the conclusion that FAS can be classified as ecologically harmless.

Whereas the planting and harvesting of the oil palms and the extraction of the palm oil mainly take place in Malaysia, the following processings are performed by Henkel. Sulphur and caustic soda as well as methanol used for transesterification are supplied by other companies.

The transportation of the palm oil from Malaysia to Germany, the related energy consumption and emissions are covered by the LCA. Expenditures required for manufacturing the means of transportation were not included. According to the authors of the LCA this was justified, because production expenditures for durable goods with large material throughput are very small compared to the overall results (see Klüppel et al. 1995, p. 647).

2.5.2.2.3 LCA-steps

The LCA of FAS versus LAS prepared by Henkel is restricted to the steps inventory analysis and interpretation[38]. The preceding step of goal and scope definition, especially the definition of the scope and the functional unit, has been dealt with, but it was not explicitly incorporated in the LCA. An impact assessment which serves as a basis for the actual interpretation step, has not been conducted. The data provided by the inventory have undergone a direct verbal evaluation.

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[37] Steber et al. (1988) have analysed the bio-degradability and eco-toxicological qualities of fatty alcohol sulfates. With respect to both parameters they have drawn the conclusion that this group of surfactants can be classified as ecologically harmless.

[38] According to ISO 14040 an LCA consists of the following steps: Goal and scope definition, inventory analysis, impact assessment, and interpretation (see ISO 1997).

At the Henkel company a lot of decisions that respect the field of goal and scope definition are taken independently from conducting a certain LCA-study, e.g. in the context of building-up data bank modules. Thereto this step is normally not included into single LCAs. Impact assessments are carried out only occasionally, because Henkel regards the uncertainties related to this step as too significant.[39] Furthermore the inventory data often were found to be sufficiently meaningful.

2.5.2.3 Results and recommendations

Henkel published the results of the LCA only in extracts. Thereto only the results regarding the olechemical surfactant FAS respectively its comparison to the petrochemical surfactant LAS can be reported in the following.

2.5.2.3.1 Weak-spot analysis of FAS

With respect to FAS the LCA identified several ecological weak-spots, but also ecologically less problematic fields. The LCA-study revealed that the fields of energy consumption and water pollution can be regarded as not critical. The results regarding air-pollution, consumption of resources and waste aspects were less positive (see Klüppel et al. 1995).

Besides the industrial chemical processes environmental damage was primarily caused by

- the use of agro-chemicals,
- the production of phosphate fertilisers and
- the palm oil extraction (burning of fibres and shells).

Because the analysed surfactant is based on renewable resources, the role of carbon dioxide emissions has to be stressed. They occur especially at the oil mills, when the fibres and shells are burnt in order to produce energy. [40] Due to the burning the carbon that is bound in the biomass (oil palm) is released, but it is of atmospheric and not of fossil origin. The authors of the LCA argue: „Carbon from renewable raw materials (...) does not contribute to an increased carbon concentration in the atmosphere, because only shortly before it had been taken up as CO_2 by the oil palm, i.e. in the final analysis, it is in circulation," (see Klüppel et al. 1995, p. 656). Thereto only the burning of fossil resources like mineral oil, natural gas, and coal contribute to the greenhouse effect.[41]

The LCA neither contains explicit recommendations nor target groups of optimisation measures. But nevertheless it is possible to identify ecological weak-spots and to assign the possible optimisation measures to the relevant actors along the considered life-cycle of FAS (see table 2.6).

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[39] For instance, in the course of the standardisation activites of DIN/ISO only two impact categories could be agreed as obligatory.

[40] The energy-intensive transesterification process also produces a lot of CO_2-emissions. But they are of a fossile origin.

[41] More detailed information on dealing with the CO_2-probem connected to renewable raw materials in the context of LCA is given by Hirsinger/Knaut (1993).

Table 2.6: Weak-spots of FAS, possible optimisation measures, and target groups

Weak-spots	Possible optimisations	Target groups
SO_2-emissions	energetic improvements of the processes of transesterification, hydrogenation, and sulphation	Henkel[42]
CO_2-emissions	zero-burning[43]	Oil mills in Malaysia
NO_x-emissions	Reduction of emissions caused by transesterification and sulphation	Henkel
	zero-burning	Oil mills in Malaysia
Emission of particulates	zero-burning	Oil mills in Malaysia
Solid waste	Reduction of waste caused in by the production of caustic soda	Henkel supplier
Consumption of non-renewable resources	Reduction of the use of artificial fertilisers	Oil palm plantation in Malaysia
	Optimisation of the sulphur extraction	Henkel supplier
	Optimisation of the production of caustic soda	Henkel supplier

2.5.2.3.2 Comparison between FAS and LAS

The results of the LCA of FAS are especially interesting in comparison to the results of the petrochemical alternative LAS.

According to Henkel the oleochemical surfactants not only need significantly less mineral oil, but also consume less energy and cause less air-pollution. But with respect to sewage the petrochemical surfactants came off better (see Henkel 1996, p. 12-13).

Thereto it can be said that the oleochemical surfactants are not superior to the petrochemical surfactants with respect to all impact fields. But all in all they are to be preferred for ecological reasons.

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[42] The only optimisation measure that could be taken by Henkel in this respect is a reduction of the energy consumption. But the emissions are primarily caused by the energy supply which cannot be inluenced by Henkel.

[43] Zero-burning means that in the course of replanting that takes place approximately every 15 years, the palms are mechanically chipped and the wood is then used as organic matter for mulching. The empty fresh fruit bunches are treated similarly after they have been used for the production of palm oil. They are used as organic fertilizers (see Hirsinger/Knaut 1994).

2.5.2.4 Decisions and applications

2.5.2.4.1 Ecological optimisation of FAS

The LCA of the production of FAS has identified some ecological weak-spots. They are mainly related to Henkel suppliers (palm oil, caustic soda, sulphur), and particularly to the oil palm plantations and oil mills. The processes located at Henkel contain certain optimisation potentials (energy consumption and emissions caused by transesterification, hydrogenation, sulphation). Appropriate measures are not explicitly mentioned within the LCA-study. Henkel does not plan any activities in this field either, because the processes had already been optimised before the LCA was conducted, so that a further enhancement would cause prohibitively high efforts.

The production processes of caustic soda and sulphur which are supplied by other companies reveal a similar situation. According to Henkel, these substances are standard products of the chemical industry which are, in accordance with environmental legislation, almost completely optimised, apart from the basic question of the environmental impact of chlorine chemistry. Thereto the demand for chemical ground substances is determined by the price.[44]

But Henkel did try to trigger off ecological optimisations of the palm oil production. To what extent the measures that have actually been realised in this field, e.g. the integration of filter systems in the oil mills, go back to the efforts of Henkel, cannot be said though. Because Henkel is a rather small purchaser of Malaysian palm oil,[45] its influence is quite small, it is exerted only indirectly by pointing the suppliers on the changing preferences on the European and especially the German market.

Accordingly a realisation of ecological optimisations has been prevented by:

- limited leeway for ecological optimisations of the chemical processes and
- lack of influence on suppliers.

2.5.2.4.2 Substitution of LAS for FAS

The comparison between FAS and LAS lead to the conclusion that FAS is the ecologically advantageous alternative, although it is not superior with respect to all impact fields. Accordingly Henkel propagated a complete switch from LAS to FAS: „This non-renewable resource (mineral oil, the author) is limited, and we do not want to use it further, if alternatives do exist. Therefore we replace the proven LAS by the evenly proven fatty alcohol sulphate (FAS) on the basis of natural oils and fats - which nature can plentifully supply," („Naturtalente", p. 12)[46].

Although efforts have been made, a complete substitution of LAS for FAS has not been realised so far (mid 1997). After the detergent version of 1993 exclusively contained FAS, in the

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[44] In the case of special input products, e.g. co-builder, Henkel influenced the product development. In the example of the co-builders Henkel called for a better bio-degradability (Klüppel 2.2.96, 16.4.96).

[45] Most of the oil is used for the production of food (e.g. margarine).

[46] Translation by the author.

version of 1995 a mixture of FAS and LAS was used again. Neither could an entire replacement of LAS be reached in the course of the innovation of „Persil Megaperls".

This was firstly due to technical problems. They could be solved in the meantime, but the costs aspect still remains. Due to a massive cut in prices of LAS, FAS simply became too expensive. Due to a very price-sensitive demand in the detergent sector, it could not be managed to induce the consumers to pay more for ecologically optimised products.

2.5.2.4.3 Information and communication

Ecological optimisation or substitution measures have hardly been taken. The LCA rather served to verify the assumed ecological advantages of oleochemical surfactants.

Within the company the results of the LCA have especially been transmitted to decision-makers responsible for product policy. The LCA influenced the product development in so far as it confirmed the company in its efforts to switch from LAS to FAS.

Since the results were introduced in the public discussion about pros and cons of FAS and LAS, the LCA was also used in the fields of external information and communication. Information on the LCA were distributed through lectures and articles in specialist journals as well as through environmental reports and brochures of the company. Thereby the following target groups were focused:

- competitors,
- (specialist) public as well as
- traders and consumers.

The publication of the LCA-conclusions particularly aimed at the main competitor. Procter & Gamble has conducted an LCA-study in which the petrochemical surfactant came off better than the oleochemical alternative. Henkel wanted to review respectively to refute this statement. In this respect the LCA served defensive communication purposes.

With the help of the LCA scientific evidence should be contributed to the discussion on LAS versus FAS that was going on in the (specialist) public. In this context it should also be mentioned that Henkel made available the LCA data for a surfactant study commissioned by European surfactant producers.

Of course, the relative ecological advantages of the oleochemical surfactant should be reported to traders and consumers. But because the LCA did not come to the conclusion that the oleochemical surfactants are superior to the petrochemical alternatives with respect to each impact field, a comprehensive eco-marketing campaign was not possible. It would have been necessary to make clear what exactly were the ecological advantages. Due to the complex ecological interrelations this could not be done in the form of advertisements. Thereto it was refrained from using the LCA in the marketing field. Instead it has been communicated in the context of public relations activities.

The decision not to employ the LCA for product marketing was also influenced by the fact that other attempts to increase detergent sales with the help of environmental orientated advertisements have not been successful.

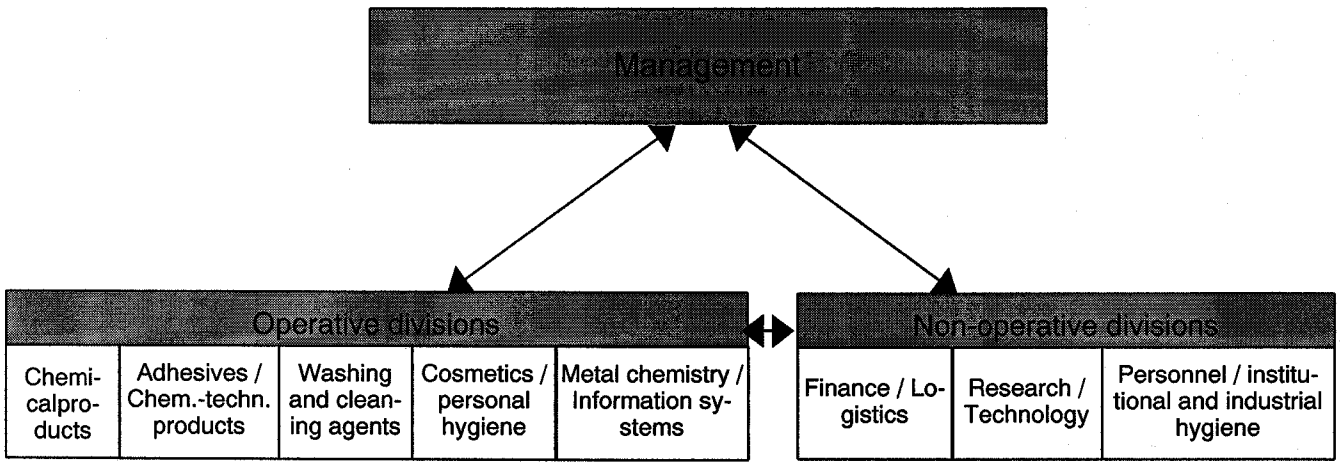
2.5.3 The role of LCA in the decision-making context

2.5.3.1 The decision-making culture

The structure of the Henkel KGaA is related to the different company divisions. These are the five operative divisions chemical products, metal chemistry/information systems, adhesives/chemical-technical products, cosmetics/personal hygiene as well as washing and cleansing agents. Moreover there are the three non-operative divisions finance/logistics, research/technology as well as personnel/institutional and industrial hygiene. The divisions are all on an equal level, only the management is placed above (see figure 2.14).

The decision-making culture of Henkel KGaA is marked by flat hierarchies and intensive discussion processes. This is particularly remarkable against the background of a large concern. Within the different company divisions important decisions are taken in division-internal committees. Questions that are of overriding importance are decided in super-divisional committees. It can be said that there exists a kind of hierarchy in committees up to the management board. But communication processes are not restricted to the vertical direction, they are also installed on the horizontal level, for instance through the so-called co-ordination circles. These are regular meetings of representatives of the different divisions which deal with special questions like environmental and consumer protection, research and development or investments.

Figure 2.14: Structure and communication processes of the Henkel KGaA



Henkel has recognised that effective environmental activities need engaged and creative employees. Thereto staff and factory committee are regularly informed about the current ecological situation. By the means of environmental training it is tried to enhance consciousness and knowledge of environmental aspects.

Because a co-operation with employees is promoted especially in the course of environmental activities, they can be regarded as an impulse for more participative decision-making processes.

2.5.3.2 The product innovation process and the integration of LCA in this context

2.5.3.2.1 The „typical way" of product innovation at Henkel KGaA

LCAs primarily serve weak-spot analyses in the course of developing products or substances. For this reason the process of product innovation and possible links for LCA are described in the following.

An idea for a new respectively enhanced product „can in principal be introduced by anybody," (Vogt on 10/24/97). Due to its importance the decision on whether a product idea is traced further or not, is taken by the product management of the relevant division, the division management or the company management. Thereby the decision-makers always take existing marketing strategies into account. If a positive decision is taken, a committee which includes employees of product development, product management as well as biologists and ecologists works out a concrete product conception. The concept not only regards technical properties of the product, marketing aspects and impacts on the environment and human health are also considered. With respect to costs no explicit instructions are given, but „it should not be lost sight of the costs aspect completely," (Vogt on 10/24/97).

On the basis of this conception the product management officially instructs the development of the product. The responsibility for the product development is with the single divisions. Here a close co-operation between researchers and employees of product development and application technology exists:

- In the chemical research laboratories new or enhanced substances are developed and produced in small amounts.
- The product development tests properties and possible applications. Moreover a large-scale production is prepared.
- The department of application technology further optimises products and application processes.

When the product idea has turned into a real product, this is comprehensively tested on its ecological, biological, dermatological, and toxicological properties. This examinations are carried out by the research field of biology and product safety. This research department belongs to the division of research and technology which exists besides the development departments of the operative divisions (see figure 2.14).

The analysis of these aspects is systematically conducted in the course of the „biological admission of products" which is part of the general product admission process. The biological admission is divided into two steps:

- In the first step the ingredients of the product are tested.
- In the second step the whole product is analysed, in order to secure that interactions between the substances are also considered.

The decision about the biological admission of products is taken in accordance with minimum criteria that are set by law, voluntary agreements or Henkel internal directives. Deci-

sion-makers are the product management of the relevant division, the division management or the company management, again due to the relevance of the product innovation.

The actual invention of a product is not exclusively dependent on ecological aspects. Costs, technical realisation or consumer acceptance play an equally important role. The corresponding information are provided by costs accounting and marketing departments. A determined hierarchy of goals does not exist, instead a case-to-case evaluation is carried out. But the minimum criteria of the biological admission have to be „clearly fulfilled, disregarding any economic aspects," (Klüppel on 07/31/97).

2.5.3.2.2 The integration of LCA in the process of product innovation

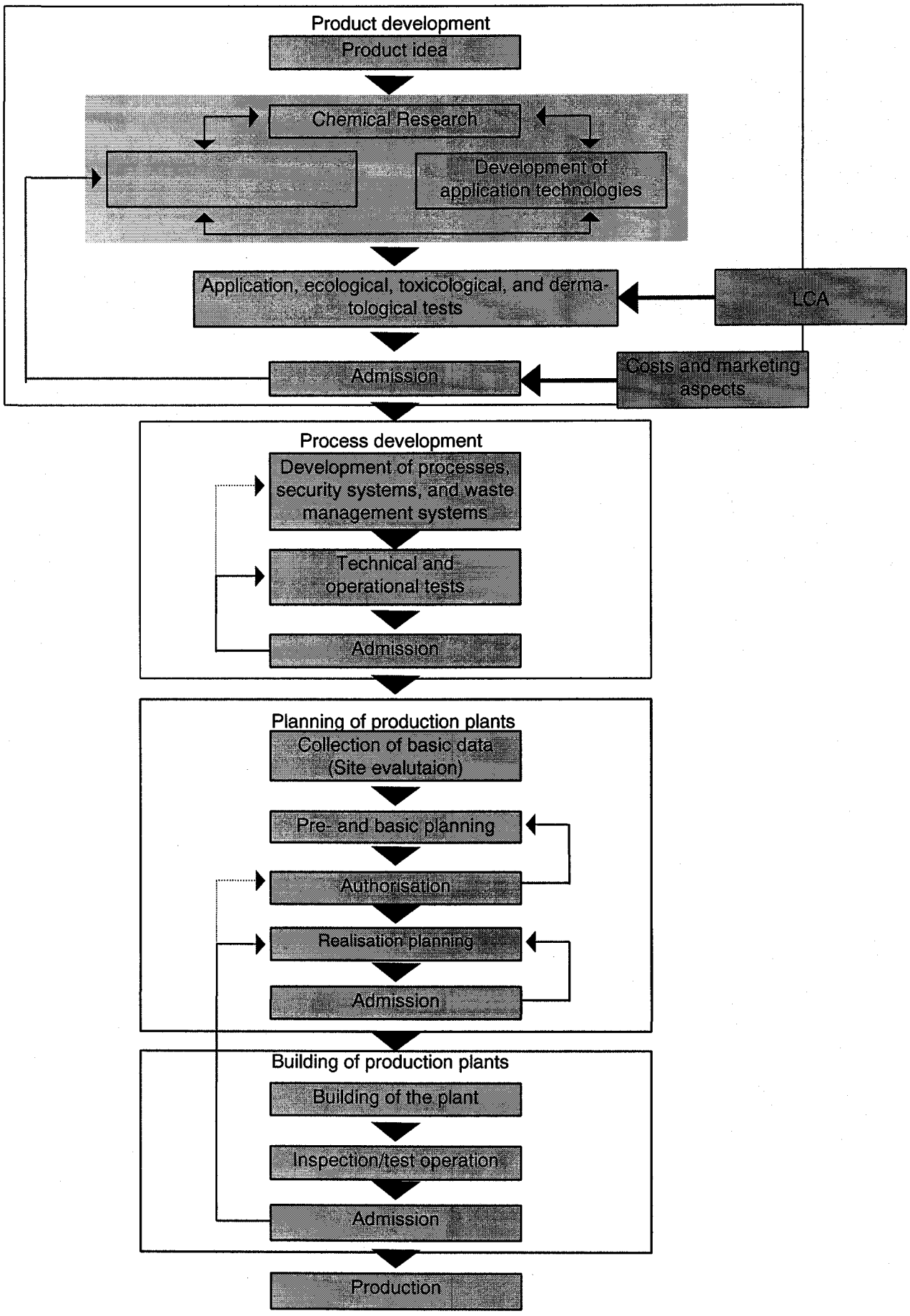
Whether substances and products fulfil the minimum criteria is analysed by means of negative lists, checklists and risk assessments. Additionally LCAs are used for analysing substances and single products or to compare different product alternatives. The relation between LCA and the other instruments is rather supplementary than competitive. As a relatively complex instrument, LCAs are not used before the tests with the help of the other instruments came to positive results. In the division of washing and cleansing agents the division management has given instruction to systematically carry-out LCAs for every „important" product innovation (Klüppel on 09/30/97).

Because the tests are conducted in the field of product development, the developers are the first to realise a need for an LCA. Staff members in charge for conducting LCAs, e.g. the WEQ-department in the washing and cleansing agents division, are informed or are sufficiently integrated in the product development to get active by themselves. Fixed routines do not exist so far.

The complex LCA-results are summarised and made available to decision-makers in management and product development. They are inter alia presented in form of the so-called „collection of substance data". This data sheet encompasses the most important substance related information in a very condensed form. Selected life-cycle data (cradle to gate-LCA), basic data of the ecological and toxicological analysis and other relevant data are depicted.

Measures taken in the field of product development are not the only activities combined with innovating a new product. Simultaneously production processes need to be developed and appropriate production plants have to be planned and built up. The entire process from product development to production is described in figure 2.15.

Figure 2.15: From product development to production (see Henkel (n.y.), p. 18)



2.5.3.3 The future of LCA at Henkel KGaA

2.5.3.3.1 Weaknesses and strengths of the instrument and its future application

Henkel uses LCAs from the beginning of the 90ies. The particularity of LCAs, that makes it different from other instruments, is seen in the consideration of all environmental impacts that occur along the entire life-cycle of products.

Therefore the most promising function of the instrument is seen in providing comprehensive ecologically relevant information for the process of product development. LCA-studies are described as „useful instruments for weak-spot analyses" (Henkel 1994, p. 8) and „valuable optimisation instruments" (Henkel 1993, p. 10).[47]

But the provision of extensive information is not only regarded as an advantage. Because LCA-studies reveal very complex and often indefinite results, they are regarded as not suitable for direct product marketing. LCAs are rather used in the context of public relation activities.

On the other hand the company claims that LCAs require (prohibitively) high quantities of detailed data. Some relatively complex products have not been analysed by means of an LCA, because the data collection has turned out to be too time-consuming or even impossible. For example, in the adhesives/chemical-technical products division the collection of data is impeded due to the fact that numerous substances from external suppliers are used (see Henkel (no year), p. 18-19).

Additionally, the fact that the LCA-study that was carried out by Henkel led to different conclusions than the one conducted by the competitor Procter & Gamble can serve as an example for indefinite LCA-results. If the data basis changes or if another assessment methodology is applied, the findings of LCA-studies can vary considerably. Of course, this also implies a certain manipulability of LCA-results.[48]

2.5.3.3.2 Interrelations between the application of LCA and public policy

According to Henkel employees neither the company's general engagement in LCA nor the conduction of the LCA of FAS versus LAS was influenced by public policy. Nor were public LCA-activities mentioned as a decisive factor for the company's future application of LCA.

But nevertheless it is claimed that public authorities could help to make the conduction of LCA-studies easier, for example, by contributing to the establishment of an international public data bank.

Moreover a need for further developing the LCA-methodology, especially the steps of impact assessment and interpretation, is seen. Although the necessary research has to be done by research institutes or universities, projects should be launched and financed by the state.

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[47] Translations by the author.

[48] Henkel claimed that its LCA-study came to different results than the one of Procter & Gamble, because meanwhile new data were available.

Besides an elaboration of the methodology Henkel regards it as equally important to further standardise the carrying-out of LCA-studies. The company welcomes that private institutions like DIN and ISO are responsible for the standardisation, but appreciates that public authorities participate in the process.

When public institutions or agencies[49] commission LCA-studies, Henkel expects them also to obey the standards and demands a more realistic view of the instrument's limits and perspectives. Because creating too high expectations that have to be disappointed in the end does not help LCA to positive publicity.

Last but not least it is seen as public policy's task to promote the instrument. Special emphasis should be laid on pointing out its advantages to small and medium sized companies and to support the conduction of LCAs, for example, by providing information, by initiating LCA-activities of industry associations, or by direct financial aid.

The above statements mainly address the German government. But with respect to standardisation activities or the establishment of international data-banks Henkel would prefer an engagement of the EU, in order to create equal conditions in all EU member states. However, currently the company does not expect public authorities to extend their LCA-engagement beyond the current activities.

2.5.4 Summary and conclusions

Henkel is one of the biggest producers of chemical products worldwide. Its range of products reaches from adhesives to washing and cleansing agents. Henkel has gradually developed into a globally operating group of companies which is present in more than 60 countries. In 1996 the group made a turnover of DM 16.3 billion by employing 47,000 people.

The company claims a leading position in the field of environmental protection. Accordingly it constantly works on an ecological optimisation of products and substances, in the sense of a comprehensive „product stewardship". In this context Henkel has been using LCA from the beginning of the 90ies.

The need and the willingness to carry out an LCA firstly arised in the division of washing and cleansing agents. In the late 80ies it was decided to substitute the customary petrochemical surfactant (LAS) for a surfactant on an oleochemical basis (FAS) which was supposed to be ecologically advantageous. But shortly before the market introduction, a competitor published an LCA in which LAS came off better than FAS. Subsequently Henkel planned to commission an LCA itself, in order to be on the safe side. The responsibility for conducting the LCA-study was placed on the department WEQ-Quality and Environment of the washing and cleansing agents division.

The (cradle to gate) LCA came to the result that the oleochemical surfactant has to be preferred for ecological reasons, although it is not superior to its petrochemical alternative with respect to all impact fields. Besides the comparison between the two surfactants the LCA identified ecological weak-spots of FAS, but triggered hardly any optimisation measures. The results of the LCA have rather been used to document and to communicate the existing ad-

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[49] In the past particularly the Federal Environmental Agency (Umweltbundesamt, UBA) has commissioned some LCA-studies.

vantages of the oleochemical surfactant. But it was refrained from using the LCA for direct product marketing.

While the first LCA resulted from external pressure and primarily served external information and communication purposes, nowadays the internal use of LCA is to the fore. Henkel, especially the washing and cleansing agents department, has firmly integrated LCAs in the process of product development. They serve to check whether new or enhanced products and substances fulfil the ecological minimum criteria that were set up by law respectively by Henkel intern directives. As a relatively complex instrument, LCA is used supplementary to other instruments like negative lists, checklists, and risk assessments. LCAs are conducted when comprehensive life-cycle data is needed.

The decision on the actual invention of a product is not only based on ecologically relevant information. Costs, technical realisation, and consumer acceptance are also considered. If conflicts of aims arise, the different aspects are weighted according to the concrete situation. Fixed weightings do not exist.

In the beginning of its LCA-activities Henkel closely co-operated with external experts and consultants, because the company internal LCA know-how was not sufficient. Meanwhile Henkel is well able to carry-out LCA-studies independently. For a company whose product innovations mostly result from new combinations of classical ingredients, it is relatively easy to systematically apply LCA. Because once the data for all ingredients have been collected and stored in a data bank, LCAs can be conducted almost „at a flick of a switch". The data bank Henkel has built up from the start of its LCA-engagement is continually updated and enlarged. Currently it contains data modules of 250 different processes and of over 400 substances.

Personnel capacities for conducting LCA-studies were not only built up in the washing and cleansing agents division. After the washing and cleansing agents division has made the first move, meanwhile LCA is of an increasing importance for the other operative divisions as well.

All in all LCAs constitute a useful completion of Henkel's environmental management instruments. Therefore the company has stated that LCA will, in the context of other instruments, play an even more important role in future.

2.6 Case-study Weleda AG

2.6.1 Company background

2.6.1.1 General description of the company

2.6.1.1.1 History and organisation structure of the company

The history of the Weleda AG, a Swiss public limited company, began in 1921 in Arlesheim (Switzerland). The company produces pharmaceuticals and products for personal hygiene. Its philosophy is rooted in the anthroposophic world view of Rudolf Steiner. Accordingly it was always aimed at producing in harmony with humans and nature. Steiner was decisively involved in the foundation of the company. For instance, the company name goes back to

his suggestion: „Viz Weleda was an Old Germanic individual, who not only knew curing, but a lot of other things," (Rudolf Steiner according to Daems 1991, translation by the author). The Weleda plant in Schwäbisch Gmünd (Germany) started up operations in 1924.

Today Weleda AG is an internationally operating group of companies. The parent company in Arlesheim, the site in Schwäbisch Gmünd, and the plant in Huningue (France) form the core of the group. All in all the Weleda Group holds majority shares in 17 European and Non-European companies, of which 16 have been fully consolidated. In another eight associated enterprises the Weleda Group's holding is less than 50%.

2.6.1.1.2 Products, markets, turnover and employees

Pharmaceuticals and cosmetics produced by Weleda are naturally based. The products are manufactured in accordance with the company's anthroposophical principles. While the pharmaceuticals aim at stimulating the human's self-curing abilities, the cosmetics should „support the various functions of the body, in order to keep the natural processes of the organism in equilibrium" (Weleda 1997, translation by the author).

Weleda supplies more than 8000 different finished pharmaceuticals which are available through pharmacies respectively on prescription. The range of products extends from cough drops to gum balm. Moreover about 200 preparations that are individually composed by doctors are produced a day. The cosmetics sector meanwhile encompasses more than 70 articles. Among them are as well shampoos and tooth-pastes as bath milks and sun-protection (see Weleda 1995).

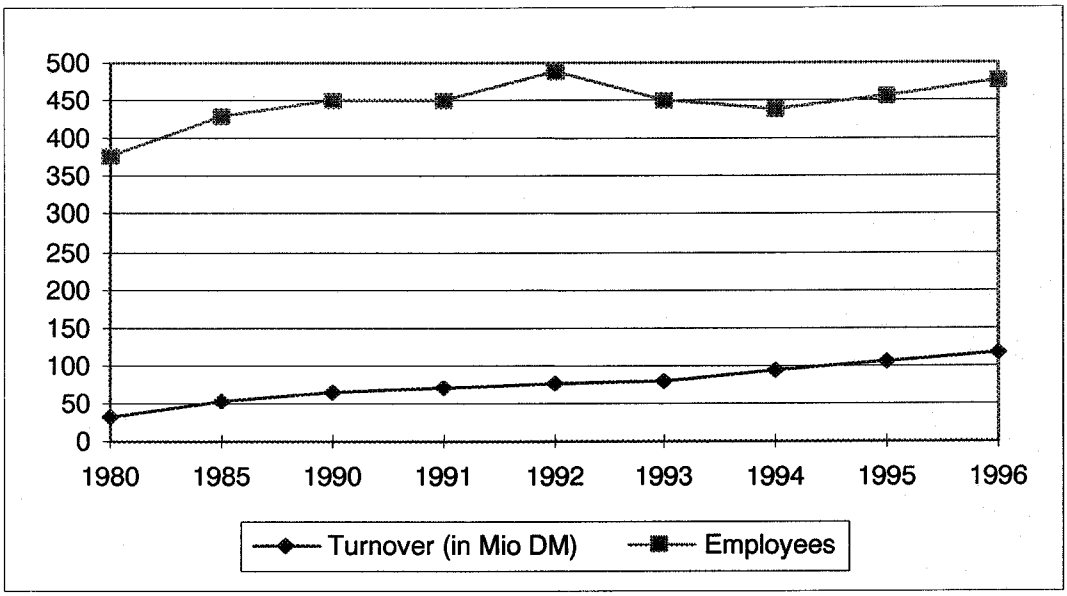
Traditionally the products are distributed through pharmacies, natural food shops, and health food shops. In recent years they were also sold in drug stores and ordinary department stores. The consequent intensification of this way of distribution had a positive impact on the turnover, without the sales through pharmacies suffering.

According to information given by the company the overall turnover is equally distributed to the fields of personal hygiene and pharmaceuticals.

In 1996 the Weleda Group reached a consolidated turnover of Sfr 160.9 millions (DM 190.3 millions). The site in Schwäbisch Gmünd contributed the biggest share, its turnover amounted to DM 118.3 millions.

Due to the positive development of turnover and results, the number of employees could be increased, contrary to the general trend, to 996. Especially in Schwäbisch Gmünd the staff was expanded remarkably, from 461 employees in 1995 to 476 in 1996 (see Weleda 1996b, p. 14-23).

Figure 2.16: Turnover and employees of the Weleda site in Schwäbisch Gmünd



In recent years the turnover of the Weleda site in Schwäbisch Gmünd rose steadily. The turnover reached in 1996 was more than three times higher than in 1980. The number of employees has developed less continuously. After it increased strongly until 1992, it has been reduced significantly. Thereto in 1994 less people worked for Weleda Schwäbisch Gmünd than in 1990. In the last two years an expansion of staff could be observed, again.

Weleda Schwäbisch Gmünd still sells most of its products in Germany. Of the DM 118.3 millions that were achieved in 1996, DM 106 millions were made on the German market which correspondents to a share of 90%.

2.6.1.1.3 Environmental problems and activities

Due to its philosophy Weleda has always put great emphasis on ecological aspects: „Since 1921 Weleda, as a producer of pharmaceuticals and cosmetics, reaches for a new understanding of the interrelations between humans and nature on an anthroposophical basis. Ecological thinking and acting are integral parts of the company's concept," (Weleda 1996a, translation by the author).

Since April 1997 the Weleda site in Schwäbisch Gmünd is certified in accordance with the EU's Environmental Management and Auditing Scheme (EMAS) and ISO 14001. In this context as well an environmental management system was built-up as a first environmental report was published. From 1996 the environmental impacts related to the production site are registered in an annual works balance. Although the first works balance has been completed in the course of the EMAS-certification, the systematic data collection was started a few years earlier. Meanwhile between 80 and 90% of all ecologically relevant data, e.g. energy and material consumption, are available through electronic data systems.

Because Weleda aims at manufacturing products which are in harmony with nature, the products are ecologically harmless. Weleda almost exclusively uses ingredients that are naturally, mostly vegetable, based. As far as possible they are obtained from plantations that use ecological plantation methods. All synthetic dyes, aromatic substances, or preservatives

are excluded. Moreover Weleda refrains from animal experiments and biotechnically manipulated substances. All inputs are systematically tested on ecological weak spots[50] and are evaluated due to their mass relevance.

Apart from the products, e.g. in the fields of production and packaging, still remains a need for ecological optimisation. In recent years, for instance the consumption of energy, particularly of electricity, has steadily risen. In its environmental report the company itself states: „With respect to an (...) energy management, exist deficits" (Weleda 1996a, section 7, translation by the author).

Most of Weleda's pharmaceutical and cosmetic products are filled in traditional aluminium tubes and glass bottles, although the „LCA of packaging systems" that was commissioned in 1995 revealed ecological advantages for the synthetic materials. Furthermore the general trend towards smaller packaging units has resulted in rising packaging intensities (see Weleda 1996a, section 4).

According to the experiences of „Stiftung Warentest", a foundation for product testing, cosmetics packagings are often oversized compared to their contents. But such „show-offs" were relatively rarely found in the field of natural products and does not hold for Weleda products. In a test that compared different face lotions, the packaging of the Weleda product was marked „good" (Stiftung Warentest 1997).

2.6.1.1.4 LCA-activities

Besides the „LCA of packaging systems" Weleda carried out some studies which show LCA-characteristics, but cannot be classified as complete LCA-studies. By means of such studies it was inter alia analysed, if preference is to be given to peanut oil or Vaseline, and which ecological impacts are related to the use of cardboard boxes for tooth paste tubes.

The studies never evaluated Weleda products, but inputs supplied by other companies. This leads to the assumption that LCAs are rather applied in the field of procurement than in the product development. Thereby the input products are not systematically evaluated by LCAs, but only when a concrete need is seen.

The co-ordination of data collection and presentation is the environmental officer's task. Further internal capacities for the carrying-out of LCA-studies, e.g. methodological know-how or special LCA data banks, have not been built up. The „LCA of packaging systems" has been conducted by external experts.

At the moment a company internal carrying out of LCA-studies is regarded as too demanding. Weleda hopes that performing LCAs becomes easier and quicker in future, because international data banks could be built up and made available through the Internet. By this means more companies, including Weleda, would be enabled to conduct LCAs independently.

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[50] This is done with the help of the ABC-method which is based on the following criteria: requirements set up by environmental legislation, public acceptance, harming potential, environmental costs, environmental impacts along the product's life-cycle, supply of resources (see Weleda 1996a, section 1).

2.6.1.2 General description of the business external context

2.6.1.2.1 The political and legal context

In recent years the German legislation has been increasingly engaged in the field of waste avoidance and disposal. The most important outcome of this process is the Waste Management Act (Kreislaufwirtschafts- und Abfallgesetz) of 1994. The Packaging Ordinance (Verpackungsverordnung) that has been enacted in the context of this law is of great importance for the field of packagings.

It prescribes that packagings have to be produced of materials that are environment-friendly and that do not impede recycling. Waste from packagings should be avoided by reducing the packaging to the „absolutely necessary extent" (§1 VerpackV).

Moreover the Packaging Ordinance commits retailers to take back the product packagings free of charge and to supply them to re-use or recycling (§5 VerpackV). Costs thereby arising mean an incentive to reduce packagings or to design them in such a way that they are suitable for re-use or recycling.

Besides it can be assumed that the law has sharpened the consumers' consciousness for the packaging problem, so that they can put appropriate pressure on industry as well.

2.6.1.2.2 The branch/sector context

As a manufacturer of products for personal hygiene and pharmaceuticals the Weleda AG belongs to the chemical industry. Weleda is not a chemical company in the true sense though, but produces only on the basis of natural substances. Accordingly the markets relevant for the company are in the segments of natural cosmetics and natural medicine.

Because no classification criteria is set by legislation, a definite demarcation of these markets is not possible. Thereto it can hardly be said which competitors the company faces and which market shares are hold by the Weleda AG. The company itself claims to have a „leading position" in this sector (Weleda 1995).

Although the market for conventional cosmetics is not the primary sphere of activity of the Weleda AG, developments on this much bigger market cannot remain totally disregarded. With respect to packagings it could be observed, that in recent years more and more aluminium tubes have been replaced by synthetic tubes. In the meantime especially tooth paste is almost exclusively supplied in tubes of synthetic material.

But this switch to synthetic tubes has not been motivated by ecological considerations. Synthetic tubes are preferred, because they can be printed better. By this means more information could be placed directly on the tubes. This made it possible to use the tubes as an advertising medium to an increased extent on the one hand, and to do without cardboard boxes and instruction leaflets on the other hand.

2.6.2 The selected LCA-study

This case-study is based on the „LCA of packaging systems", the only „real" LCA-study Weleda has commissioned. In the LCA glass bottles and aluminium tubes hitherto used by

the company were compared to synthetic packaging alternatives, in order to identify the ecologically superior packaging system.

2.6.2.1 The LCA-process

2.6.2.1.1 Motives and objectives

Since the packaging problem gained public interest, Weleda was confronted with many critical consumer questions about the packaging systems used and the environmental impacts related therewith. These questions revealed that in this field a lack of information existed inside the company as well.

For this reason in 1991 a dissertation was written which dealt with the subject „Tooth paste tubes with or without cardboard boxes". It considered the consequences for production, packaging, distribution, and ultimately for the environment. The study was mostly based on data provided by the Swiss federal environmental agency (BUWAL, Bundesamtes für Umwelt, Wald und Landschaft (BUWAL)[51].

Furthermore the environmental officer of Weleda Schwäbisch Gmünd has carried out a few „small LCA-studies" on the packaging subject together with colleagues from Switzerland. Because this studies were only based on BUWAL-data, at some time the wish to have „hard facts", that means to commission a real LCA-study, emerged. While in the Weleda plants in Switzerland and France a trend towards PET-bottles[52] could be observed, Weleda Schwäbisch Gmünd did not want to follow this trend before the ecological consequences were tested by means of a comprehensive LCA.

With the help of the LCA the environmental impacts related to different packaging systems should be registered, evaluated, and compared, in order to identify the ecologically most desirable alternative. Besides glass bottles and aluminium tubes traditionally used by Weleda, synthetic packaging alternatives have been analysed.

That Weleda Schwäbisch Gmünd was especially cautious, results not least from the fact that the German society sees the packaging problem more critical than this is the case in Switzerland and France.

All in all the carrying-out of the LCA was stimulated by the following mix of internal and external motives:

- critical questions of consumers,
- the public discussion about the packaging problem,
- pressure applied by the state through enacting the Packaging Ordinance, and
- company internal lack of information.

Accordingly with conducting an LCA the following objectives have been pursued:

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[51] The data were inter alia published in BUWAL (1991).

[52] PET stands for polyethylene terephthalate, a group of synthetic materials.

- providing comprehensive information for consumers and the public,
- avoiding costs that could arise due to the Packaging Ordinance,
- underpinning the decision about the packaging systems to be used in future, and
- obtaining scientifically based arguments for the discussion about the best packaging systems that was going on between the international Weleda sites.

2.6.2.1.2 Chronology and organisation of the LCA-study

To secure objectivity and professionality the LCA should be commissioned by external experts. At first Weleda addressed Dr. Ehrensperger, managing director of Neumarkter Lammsbräu, who referred the company to the IÖW. Early contacts between IÖW and Weleda were established at the end of 1994. The „LCA of packaging systems" was conducted from February to June 1995. The expenditures for carrying-out the study have been overtaken by the company.

The decision for carrying-out the LCA was based on a wide consensus. Besides the marketing and logistics departments who gave the impetus, the environmental officer has been integrated in the LCA-activities right from the beginning. Although the management did not have an active part in conducting and implementing the LCA, it has been informed regularly and has accepted and supported the whole process and concept.

The LCA-study was conducted by an external institute, namely the IÖW, with which all methodological choices were left. On the part of Weleda the environmental officer was actively involved in carrying-out the study. He co-ordinated the data collection within the company and was responsible for the communication with suppliers.

The stages from resource extraction to production of packaging materials, in case of the PET-bottle this is from mineral oil extraction to production of granules, was traced on the basis of literature data. The stage of processing the packaging materials to packagings, e.g. to a PET-bottle, was depicted on the grounds of information provided by suppliers. The suppliers were asked with the help of a questionnaire that was designed by the IÖW and distributed by Weleda. The data regarding the actual packaging process, this is filling the products into the packagings, were provided by Weleda itself. If necessary cardboard boxes and related material inputs have been considered as well. During the carrying-out of the LCA-study an intensive interchange with the colleagues in Switzerland and France took place. They partly contributed data concerning PET-bottles.

The LCA-results were presented by the IÖW at the Weleda company in Schwäbisch Gmünd. The findings and recommendations have been presented and discussed in a meeting in which participated only employees directly involved in the LCA-process, but also representatives of the management of Weleda Schwäbisch Gmünd as well as colleagues from Switzerland and France.

2.6.2.2 Methodological choices

2.6.2.2.1 Type of LCA

The „LCA of packaging systems" is the first real LCA-study that has been commissioned by Weleda. Since the company plans to carry out LCAs also in future, this first LCA can be regarded as a pilot study.

The LCA delivers a comparison between already existing (input) products. In this respect it is a descriptive study. But the LCA was not only used for a documentation of the environmental impacts related to the different packaging systems. It also served to identify the ecologically most desirable alternative that should be applied in future. In this respect the study had a prospective function for the company.

With respect to the regarded life-cycle stages and the LCA-steps that were carried out, the study can be classified as a complete LCA. Since large parts of the study are based on secondary literature, it also reveals characteristics of a streamlined LCA though.

2.6.2.2.2 Detailed description of the products subject of the LCA and of their life-cycle

In the LCA glass bottles and aluminium tubes traditionally used by Weleda have been compared to synthetic packaging alternatives. The regarded bottle and tube variants are listed in table 2.7.

Table 2.7: Regarded bottle and tube variants

Bottle variants	Tube variants
Green glass bottle 200ml	Aluminium tube 75ml
Light glass bottle 200ml	PE-tube[53] 75ml
Brown glass bottle 200ml	
Green PET-bottle 200ml	
White PET-bottle 150ml (projected to 200ml)	

The life-cycle stages that have been considered in the LCA were generally chosen in accordance with the „cradle to grave"-principle. But product transports to retailers and consumers have been excluded, because Weleda found it impossible to express the heterogeneous distribution structure in average figures. Since the packagings do not cause any environmental damages during the stage of use, this stage has neither been considered. The packagings' life cycle is depicted in figure 2.17. The light grey area marks the scope of the LCA.

[53] PE stands for polyethylene, a group of synthetic materials.

Figure 2.17: The packagings' life-cycle and the scope of the LCA

The production of packaging materials and packagings encompasses not only the manufacturing of bottles and tubes. „Accessories" that belong to the packagings like labels, lids, and cardboard boxes were included as well.

The transports that incur until the production of the packagings and the transport of the packagings to Weleda have also been regarded in the LCA.

2.6.2.2.3 LCA-steps

The LCA was conducted on the basis of the state of standardisation at DIN/ISO[54] at that time. Accordingly the LCA-study consists of the following steps:

- goal and scope definition,
- inventory analysis,
- impact assessment,
- valuation, and
- recommendations / optimisation analyses[55]

The first step encompasses the definition of goal, scope, and functional unit of the study.[56] In the course of the inventory analysis the data are collected and presented systematically. The regarded LCA depicts the data in the form of eco-accounts.

The impact assessment associates the inventory data with specific environmental impacts (impact categories). On the grounds of the current state of the methodology discussion the impact categories listed in table 2.8 have been regarded, either quantitatively or qualitatively.

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[54] DIN (Deutsches Institut für Normung) is the German standardisation institute, and ISO (International Standardisation Organisation) is its pendant on the international level.

[55] According to the standardisation discussion the last step is optional.

[56] The functional unit describes the unit to which all LCA-data are related. In the regarded LCA a 200ml bottle and a 75ml tube have been chosen.

Table 2.8: Considered impact categories

Quantitative impact categories	Qualitative impact categories
Greenhouse effect	Human toxicity
Resource scarcity (fossil resources)	Land use (at resources extraction)
Nutrification	
Acidification	

The evaluation process analyses and discusses results of the impact assessment as well as data directly obtained from the inventory. Data directly taken from the inventory concerned resource use, energy consumption, and waste production. The data were evaluated on the basis of a verbal discussion.

2.6.2.3 Results and recommendations

2.6.2.3.1 Regarding the tubes

The PE-tube came off better than the aluminium tube with respect to almost every impact category. The resource scarcity was an exception, because the manufacturing of the PE-tube that is based on mineral oil causes a high consumption of fossil resources. The aluminium tube achieved a better result also in the waste sector, because aluminium is recycled to a larger extent.

All in all the results speak so clearly for the PE-tube, that for ecological reasons it definitely has to be preferred to the aluminium tube.

Nevertheless the LCA revealed optimisation potential regarding PE-tubes. The tubes would be more suitable for recycling, for example, if they consisted of only one synthetic material, preferably PE, that means if it could be refrained from adding PP.[57]

2.6.2.3.2 Regarding the bottles

With respect to the bottles the vote was not that clear. The 200ml PET-bottle reached the best results in most of the impact categories, but the brown glass bottle was always near behind. That the brown glass bottle took the top position among the glass bottles, can be deduced to its lower mass.

On the part of the IÖW the brown glass bottle has been recommended. The reason given for this decision was that in the sector of glass a functioning recycling system has been established, which does not hold for synthetic materials.

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[57] PP stands for Polypropylene, a further group of synthetic materials. Currently there exist better recycling possibilities for PE.

If the existing optimisation potential was realised the result could change in favour of glass bottles. The main disadvantage of glass bottles is their higher weight. Therefore possibilities for material reductions should be researched.

2.6.2.3.3 Other optimisation potentials

Moreover the LCA-study has shown general optimisation potentials which concern as well the recommended as the other systems. For instance, it was suggested to give up the cardboard boxes or to intensify the use of recycled material, especially in the field of glass bottles.

Besides the recommendations included in the LCA, the ecological situation could be enhanced by installing return or refill systems. In the sector of glass bottles Weleda had already started corresponding activities before the LCA was commissioned.

2.6.2.4 Decisions and applications

2.6.2.4.1 Regarding the tubes

According to the LCA-results Weleda reaches for a switch to PE-tubes, but for reasons of product quality and preservation it cannot be done without aluminium tubes so far. During the stage of use, for example, they have the advantage, that they deform when they are squeezed out. Because thereto no air can get into the tubes, microbiologic pollution and related changes in colour and symptoms of decline are prevented. The judgement of Weleda that currently no synthetic alternative is available that has properties equal to those of the aluminium tube, has been confirmed by tests of the Swiss packaging producer Neopak.

That by the means of aluminium tubes a durable product quality can be secured, is of great importance to Weleda, because the non-use of preservatives takes precedence for the company.

Weleda has been working intensively on modifying the formula of products in a way that they become suitable for PE-tubes. But so far no significant progress has been made. Currently efforts are concentrated on the sector of daily-care products, that means on products for mouth and hair hygiene. This product group was chosen, because here the highest quantities arise and a „PE-tube-ability" seems to be at easiest achieved. Moreover a switch to synthetic tubes, especially for tooth paste, is strived for due to marketing aspects (see section 1.4.1). Since hardly any (conventional) tooth paste is supplied in aluminium tubes and cardboard boxes, „here the highest external pressure exists" (Beißwenger on 07/28/97, translation by the author).

In the environmental report of 1996 the following goal is established: „In 1998 Weleda wants to develop a new packaging concept for tooth pastes: switch from aluminium tubes to PE-tubes and no use of cardboard boxes" (Weleda 1996a, section 4, translation by the author).

2.6.2.4.2 Regarding the bottles

In the section of bottles the PET-bottles delivered the best result, apart from the waste disposal situation. Accordingly Weleda has begun to check the use of PET-bottles, in order to

switch to this type of bottle, as soon as the disposal situation improves. Until then it is hold to glass bottles

But a use of PET-bottles is not only prevented by an unfavourable disposal situation. Moreover Weleda faces the problem that ethereal oils that are contained in many preparations diffuse outwards through the PET-material, whereas air migrates inwards. Efforts for an adjustment of the product's formulas to the conditions of PET-bottles are currently concentrated on the sector of body lotions.

Since for the time being the products are filled in glass bottles, Weleda has partly switched to brown glass, according to the LCA-results. Aesthetic aspects stand in the way of a complete switch to brown glass bottles. Additionally it is worked on reducing the weight of glass bottles.

2.6.2.4.3 Realisation of other optimisation potentials

Within the LCA an increased use of recycled material and a non-use of cardboard boxes have been suggested.

With respect to aluminium tubes a use of recycled materials is not possible, because the production of the thin tubes requires pure aluminium. Such a high quality cannot be supplied by recycling. In the sector of glass bottles recycled materials are used, as far as permitted by the colour of the glass and processing techniques (currently 20-50%).

All packagings, including glass bottles, are obtained by suppliers. Thereto the use of recycled materials for glass production is beyond Weleda's direct sphere of influence. Nevertheless it is tried to induce suppliers to a more intensive use of secondary raw materials.[58]

The cardboard boxes are necessary, because otherwise it would not be feasible to equip the products with instruction leaflets. And Weleda does not want to give up this possibility to provide the consumers with comprehensive product information.

An installation of return or refill systems had already been checked before the LCA was carried out.

Weleda has discarded the idea of establishing a return system for several reasons. With respect to some (few) products legal regulations for pharmaceuticals prevented a re-use of packagings. The fact that primarily oils are filled in glass bottles poses another barrier, because the cleaning agents thus needed to clean the bottles are extremely ecologically harmful. Thereto environmental advantages reached through return systems would be compensated. This was revealed by a kind of LCA-study conducted by Weleda. Moreover providing logistics required by a return system would have been too demanding for a single and relatively small company like Weleda. Attempts to reach a co-operation with other producers have failed.

From building up a refill system was refrained, again on grounds of product quality and preservation. Because such a system is inevitably related to contamination through air or other microbiologic pollution.

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[58] An intensive use of recycled materials is in the self-interest of suppliers anyway, due to costs or obligations resulting from the Waste Management Act.

2.6.2.4.4 Information and communication

Within the company the results of the LCA have been transmitted to employees directly affected by their implementation, especially in the logistics and product development departments, and the management. A general information to all employees was not given.

The LCA has been commissioned to enable the company to give scientifically based answers to critical consumer questions on packagings. In this respect the LCA also serves for external information and communication purposes. Thereby the information are not provided in the form of advertisements, but in the course of public relation activities. LCA-information were made available in the Weleda-news (Weleda-Nachrichten) or upon concrete requests.

2.6.3 The role of LCA in the decision-making context

2.6.3.1 The decision-making culture

Weleda Schwäbisch Gmünd is structured in function related company units like logistics, production, or management. It is aimed at creating a lively, little hierarchic communication and discussion culture.

Important decisions are mostly taken in committees which are installed within the different company units or on higher levels, up to the management conference, which consists of management members and heads of departments. Additionally committees are existing that deal with special questions, e.g. the environmental committee.

With less than 500 employees Weleda Schwäbisch Gmünd is small enough to enable direct ways of communicating and personal contacts, besides the institutionalised forms of communication. An exchange between Weleda employees takes place on the international level as well. There are not only international management committees, but also subject related working groups in which, for instance, the company's position towards biotechnology is discussed.

2.6.3.2 The integration of LCA in decision-making processes

2.6.3.2.1 The integration of LCA in the product innovation process

So far no LCA has been carried out which analyses actual Weleda products. Therefore it cannot be said that LCAs are directly used for product innovations. The „LCA of packaging systems" has influenced the product development only indirectly, in so far as a switch from aluminium to PE-tubes requires modifications of the products' formulas.

In general Weleda regards LCAs as an useful instrument to include ecological aspects in the development of products. But with respect to its own products the company currently sees no need for action, because the Weleda products are based on natural substances and thus are mostly environmentally harmless anyway. In the product development of Weleda other information providing instruments like technical check lists, evaluations of suppliers, and market surveys play a more important role.

In the long run the company plans to carry out LCA-studies for its own, particularly new, products as well. Thereby it is aimed at a more systematic integration of ecological aspects

in the product development process. Although it was always tried to consider environmental impacts, so far this is done in a rather subjective way. But nevertheless presently not all parties involved see a necessity to commission LCA-studies regularly.

2.6.3.2.2 The integration of LCA in the procurement

The LCAs respectively LCA-similar studies so far carried out by Weleda all deal with products obtained from suppliers. Therefore the instrument is primarily used in the field of procurement.

An LCA based analysis of input products does not take place systematically, but when a concrete need is seen. That means, LCAs are conducted, if the environmental impacts related to new substances or products are totally unknown and/or environmental damages are suspected. Moreover LCAs are applied to give information about the relative environmental desirability of substances and products. Products which are regarded as environmentally harmless or whose relative environmental soundness is known, are not subjected to an LCA.

All substances used by Weleda are checked on ecological weak-spots by means of the ABC-method. Because the Weleda products are naturally based and hazardous substances are only used in small quantities, it is not regarded as necessary to systematically carry out comprehensive analyses on the basis of LCA.

2.6.3.3 The future of LCA at Weleda AG

2.6.3.3.1 Weaknesses and strengths of the instrument and its future application

The company stated that experiences that have been made with the „LCA of packaging systems" have been predominantly positive. The LCA „provides a useful information basis" (Beißwenger on 07/28/97, translation by the author) and is described as „illuminating" (Landensperger am 08/21/97).

According to Weleda it is the strength of LCAs, that they can provide a systematic overview on the environmental impacts related to products. That LCAs consider every impact along the entire product life-cycle is their advantage over other instruments. On the basis of the information thus provided, decisions in procurement and product development can be taken in view of ecological aspects.

The manipulability of results is regarded as the most significant weakness of the instrument which can be deduced from an immature methodology respectively unfinished standardisation processes. This is one reason why Weleda has refrained from using LCAs for product marketing. Moreover the company claims that the conduction of an LCA-study is too time-consuming, because of the comprehensive data collection and the complex methodology.

But despite of methodological problems in carrying out the LCA-study and technical difficulties in realising the LCA-results, the company plans to further apply the instrument. But Weleda would conduct LCA-studies more often, if the obstacles described above were eliminated (possibly, but not necessarily by public authorities).

2.6.3.3.2 Interrelations between the application of LCA and public policy

The conduction of the „LCA of packaging systems" was not least stimulated by the increasing engagement of the German legislation in the avoidance of packaging waste. The Packaging Ordinance commits producers to take back, re-use or recycle product packaging and thus sets a (financial) incentive to minimise packaging and to use environment- and recycling-friendly materials.

Public LCA-activities hitherto have hardly influenced Weleda's engagement in LCA and are thus seen neither as a hindrance nor as a help.

However, Weleda employees regard it as necessary to further standardise the LCA-methodology, because by reducing the leeway in scope definition and data interpretation the manipulability of results can be minimised. Furthermore, the data collection should be made easier, quicker and cheaper through establishing international public data banks.

Although it is not inevitably public authorities that have to provide these measures, they would be in charge, in case private actors fail. But the employees we have spoken with did not express clear expectations of future public LCA policy.

2.6.4 Summary and conclusions

The company philosophy of the Weleda AG is based on the anthroposophic world view. Therefore the company produces only naturally based pharmaceuticals and cosmetics. On the markets for these products Weleda holds a strong position. As an internationally operating group of companies, in 1996 Weleda AG employed 996 people and reached a turnover of DM 190.3 million. With sales of DM 118.3 million and 476 employees the Weleda location in Schwäbisch Gmünd contributed by far the biggest share.

Since Weleda uses naturally based ingredients, its products can be regarded as ecologically harmless. Thus environmental impacts arise only from production or packaging. Traditionally, Weleda has filled its products in glass bottles and aluminium tubes. In recent years the Weleda works in France and Switzerland began to switch to synthetic packaging.

The German public, consumers, and the state show a relatively critical attitude towards the packaging problem. For Weleda this gave cause for commissioning the „LCA of packaging systems" to analyse the ecological performance of the glass bottles and aluminium tubes traditionally used and to compare them to the synthetic packaging alternatives.

In 1995 an external institute, the Institut für ökologische Wirtschaftsforschung (IÖW), carried out the LCA. Since it was conducted in accordance with the state of standardisation at DIN/ISO at that time it can be regarded as a complete LCA-study. But because large parts of the LCA are based on literature data it also reveals characteristics of a streamlined study.

The LCA revealed significant ecological advantages of the PE-tube over the aluminium tube. With respect to the bottles the result turned out less clearly. Although the PET-bottle came off as the ecologically most desirable variant, the brown glass bottle has been recommended, due to the better disposal situation.

According to the LCA-results Weleda wants to replace as well the aluminium tubes as the glass bottles by the synthetic variants. But for product quality and preservation reasons a switch is not possible without adapting the products' formulas. This could not be realised so

far, although the product development department has made intensive efforts. The LCA-study served rather to improve the traditional packaging systems, for example, by reducing the weight of glass bottles or by non-using cardboard boxes and instruction leaflets.

Nevertheless Weleda describes its experiences with the „LCA of packaging systems" as predominantly positive. The provision of a systematic overview on all environmental impacts related to products is regarded as the main strength of LCA. The most important weaknesses of the instrument are seen in the comprehensive data-collection and the manipulability of the results arising from an incomplete standardisation.

So far, the „LCA of packaging systems" is the only „real" LCA that has been conducted by Weleda. Additionally some studies have been carried out which show LCA-characteristics, but cannot be regarded as complete LCA-studies.

All LCAs respectively LCA-similar studies conducted by the company did not analyse Weleda products, but input products obtained from suppliers. Accordingly LCAs are rather used in the context of procurement than in the product development. Currently LCAs are not systematically integrated in decision-making processes, but are used only occasionally.

Weleda seems to see LCA rather as competitive than complementary to other instruments. In the procurement context the company prefers to analyse the ecological properties of inputs with the help of the less comprehensive ABC-method. In the product development process environmental instruments are not important at all, because Weleda's products are ecologically harmless anyway. Here non-environmental instruments like technical check lists and market surveys predominate.

So far, Weleda has not built up internal LCA-know-how that would enable the company to independently carry out LCA-studies. But In the long run, when the data collection has become easier through the establishment of public data banks and when the standardisation is completed, Weleda intends to carry out LCAs without external support and probably not only for inputs but also for its own products.

2.7 Case-study YTONG AG

2.7.1 Company background

2.7.1.1 General description of the company

2.7.1.1.1 History and organisation structure of the company

About 70 years ago the Swedish architect Johan Axel Eriksson invented a new building material made from oil shist consisting of quartz and lime as well as aluminium-powder and water. By processing these raw materials a building material with numerous air pores, autoclaved aerated concrete (AAC), is provided. It was patented in 1924 and was named YTONG, a word combination of „Yxhult", the location of its development, and „betong", the Swedish word for concrete.

The industrial production of YTONG was started in 1929. Because building with YTONG became popular, the company was growing soon. In 1951 the first German YTONG-plant was

founded. Others were following, so that today a large number of production sites and also the headquarters are located in Germany. During the last years YTONG developed gradually into an international group. The activities do not only cover Western and Eastern Europe, but are currently also extended over USA and China.

The YTONG Group is present in 19 countries on three continents. Twenty-nine companies sign responsible for business operations, among these are five in which the YTONG Group's holding is less than 50% (YTONG 1996, p. 7).

The companies active in Germany are grouped within YTONG AG, Munich, under the roof of YTONG Holding GmbH which functions as the umbrella of the YTONG Group. Since 1996 the YTONG Holding GmbH is a virtually 100% subsidiary of the Readymix Concrete p.l.c., a large British producer of building materials.

2.7.1.1.2 Products, markets, turnover and employees

The YTONG building material is available in numerous different forms and all grades of strength. Blocks[59] or low-weight partition panels are used in house-building. Wall units with a steel reinforcement or roof slabs are suitable for industrial construction. The products can be divided into two main product groups:

- YTONG precision blocks
- YTONG reinforced elements

These „classical" YTONG products make roughly 95% of the company's turnover.

The remaining 5% are achieved by the other two business activities of the YTONG Group, namely selling of products from AAC granular materials and construction of production plants. More and more often the manufacturing of YTONG-products is organised in a license system in which licensees get ready for operating production works, whereas the responsibility for planning, implementation and start-up of operation of the plants remains at the YTONG Group.

While the reinforced elements are made to order and are transported directly to construction sites, the blocks are sold through specialist shops for building materials. The YTONG AG places great importance on the co-operation with the building-supplies industry. In Germany, the major market and testing ground for innovations, a Trade Advisory Board has been founded which introduces its empirical knowledge into the sales and innovation policies of YTONG.

In 1996 the turnover of the YTONG Group decreased by 3% to DM 867 million. Therefore the downward tendency that can be observed since 1995 continued, but slowed down. The number of employees developed in a different way. After a remarkable rise in 1995 it was reduced in 1996 by 13,8%, down to 2,985. That means that at the end of 1996 less people worked for the YTONG Group than at the end of 1994.

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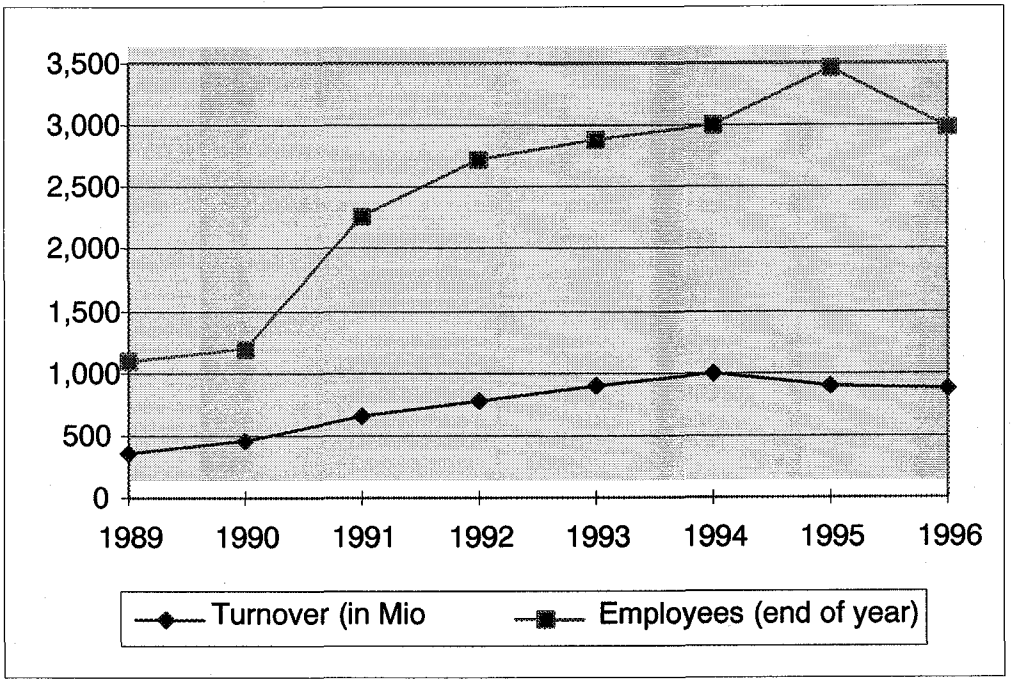
[59] The YTONG-blocks are a kind of large buildings stones.

Figure 2.18: Turnover and employees of the YTONG Group (YTONG 1993, 1996)



The YTONG Group's products are almost exclusively sold in Europe. The German business still holds the biggest share in the Group's turnover, although it declined from 56% of overall sales in 1995 to 51% in 1996 (YTONG 1996, p. 14). The markets of USA and China are just about to be penetrated.

2.7.1.1.3 Environmental problems and activities

YTONG claims a strong interest in realising and reducing the environmental damage caused by its products: „YTONG takes a holistic approach to its environmental responsibility, not merely addressing the production-related aspects of the problem, but taking the entire life-span of products and materials into account" (YTONG 1996, p. 23).

Environmental impacts connected to building materials are rather a question of quantities than of harmful substances: Extraction of great amounts of raw materials causes considerable damage to the landscape, transportation of resources and building materials leads to high energy consumption, and demolition of the buildings produces enormous quantities of waste. In Germany for example, in 1995 the amount of waste from reconstructing and pulling down buildings was 45 million tons (Böttcher-Tiedemann 1997, p. 99).

Regarding the whole life cycle, the use of buildings is the ecologically most relevant stage. The decisive factor is the energy consumption due to heating. Thereto the thermal insulation property of building materials is highly important for the environmental damage arising.

The YTONG material provides good thermal insulation. But, nevertheless, the company has been working on this field for years. As a reaction to the new German thermal insulation directive, the company has developed and constructed a „low energy house" in 1993. A similar project in which YTONG AG was involved is the „House of the future" which was built in Vilvoorde near Brussels and for which YTONG AG had been chosen as supplier of building

stones. Still the focus of the YTONG development centre is on further reducing the thermal conductivity of YTONG products (YTONG 1996, p. 23).[60]

The raw materials used in the production of Ytong are not regarded as hazardous substances. Due to its porous structure the YTONG material is of a relatively low weight.[61] This helps to keep energy consumption during transportation at a comparably low level.

The company has made great efforts in installing recycling systems and closed material cycles. During production almost 100% of the waste is re-used in subsequent manufacturing operations. Since the „no-waste" factory is nearly achieved, the „next step will be to implement recycling of broken materials in the manufacture of new products" (YTONG 1996, p. 23). Further attempts at re-using packaging materials like pallets and foils were made, because return quotas have not been sufficient. Although YTONG AG has even set economic incentives, it was impossible to get all the materials back from construction sites.

Although YTONG AG does not publish a regular environmental report, information on the environmental impact of its products is given in various publications. Especially the brochure „Building in Harmony with Nature" (YTONG 1994) deals with environmental and/or health questions, and stresses the advantages of YTONG in this field.

In January 1997 YTONG received the „DIN plus" quality seal. It is the highest award for product quality that is granted by the German Institute of Norms (Deutsches Institut für Normung, DIN). The labelled products have to meet criteria which are more stringent than those of the basic DIN standard. Despite a certification in accordance with ISO 9002, a number of ecologically orientated requirements have to be fulfilled, inter alia an eco-audit of products has to be submitted. Furthermore all packaging materials must be suitable for recycling, and wall-building materials must provide excellent thermal insulation (YTONG 1996, p. 20).

2.7.1.1.4 LCA-activities

Since the „LCA of typical YTONG products" has been conducted, it serves as a foundation of the ecological optimisation of products and processes. It is planned to update the LCA-study regularly. The responsibility for development and improvement of products and processes is with the YTONG research and development centre in Schrobenhausen. Therefore the LCA-activities are also located here.

The LCA-study has been carried out by a specialist institute, namely the Institut für ökologische Wirtschaftsforschung (IÖW). At YTONG AG no capacities for performing a full LCA have been built up, and it is still not intended to do so. But because the LCA software which had been developed by the IÖW was made available to YTONG, the company is able to update the existing LCA independently. Only when the basic LCA-methodology changes, support from external experts will be needed again.

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[60] The thermal conductivity of YTONG products varies from 0.11 - 0.24 W/mK due to the dry density.

[61] The weight of a pallet of YTONG blocks ranges from 500 - 1,400 kg, depending on volume and density.

2.7.1.2 General description of the business external context

2.7.1.2.1 The political and legal context

Although some of the motivation for environmental improvements came from the public respectively consumers, new laws have also made some changes mandatory. One example is the German Thermal Insulation Directive (Wärmeschutzverordnung) which has been enacted in the context of the Law on Energy Saving (Energieeinsparungsgesetz). The Thermal Insulation Directive was tightened in August 1994. The new standards, however, were a compromise between the even higher standards originally envisaged and the interests of the brick industry as well as the lime-sand-brick industry whose products insulate much worse than the competing material AAC. The YTONG products fully comply with the stricter standards.

Besides the energy aspect the waste problem has been in the centre of legislative activities. In 1994 the Waste Management Act (Kreislaufwirtschafts- und Abfallgesetz) was implemented. According to §22 that deals with product responsibility companies should ensure resource saving and low-waste production processes. Special emphasis is laid on an intensive use of recycled materials.

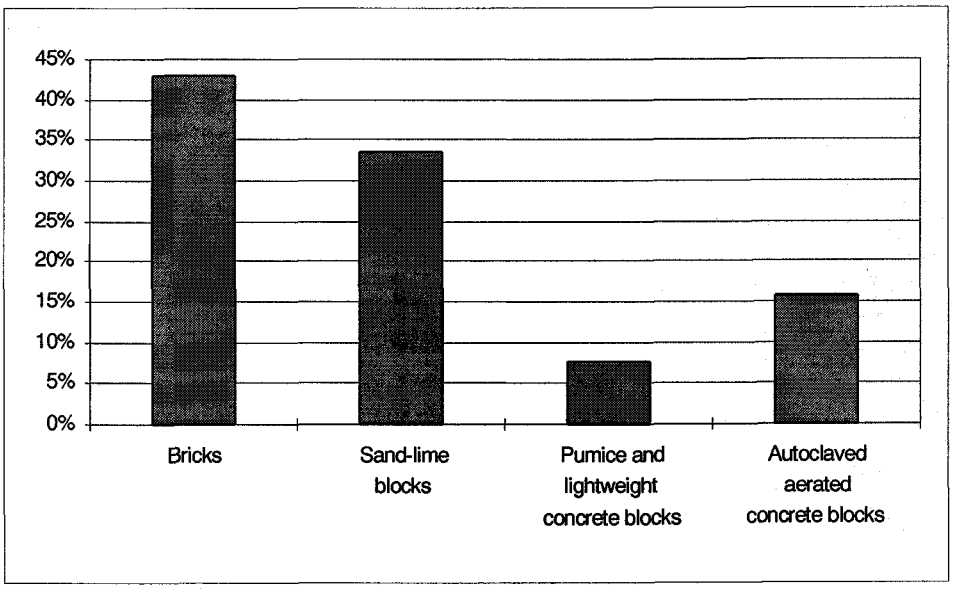
In June 1996 the German government presented a draft on the definition of goals regarding avoidance and disposal of building waste. Herewith the objectives pursued with the Waste Management Act are stated more precisely. The draft provides that unloaded soil must not be landfilled in future and that the landfilling of other non-recyclable building waste has to be reduced by half until 2005 compared to 1995. An implementation of corresponding regulations has been prevented by a voluntary covenant of the building industry which secures to realise the goals stated in the draft.

2.7.1.2.2 The branch/sector contex

Since the precision blocks and reinforced elements from autoclaved aerated concrete (AAC) are obviously the main business of YTONG, only the markets for these products are considered.

The AAC industry as a whole has consolidated its position in the market for building stones vis-à-vis its main rivals, the brick industry, which remains the largest supplier of building stones, and the lime-sand-brick industry. Figure 2.19 shows exemplary the position of AAC compared to other materials in wall-block production in Germany in 1993.

Figure 2.19: Shares of different materials in wall block production in Germany 1993 (YTONG 1993, p. 18)



1996 was characterised by difficult economic conditions, and a decline in building construction in important YTONG markets. Especially the main sales market of Germany showed a slack demand, the previous year's 16% decrease was followed by a renewed fall of 14%. The foreign markets as a whole developed favourably for the YTONG Group. This compensated partially for the market weakness in Germany.

The market for AAC in Germany is basically divided up between YTONG AG (Munich) and Hebel AG, Fürstenfeldbruck/D, whose products are regarded as equivalent to those of YTONG. According to the company's own estimation YTONG has a leading position not only on the German, but also on the European market (YTONG 1996, p. 8).

The building market has experienced a trend towards „ecological building" in recent years. The change was motivated by a risen public interest in the environmental impacts associated with building. The two specific factors - apart from generally increased environmental awareness - were negative effects on the environment and on human health which have been attributed to a number of materials such as asbestos or PVC, and the importance of energy consumption associated with construction and use of buildings.

At the time when the LCA at YTONG AG was prepared, the main competitor, Hebel, was not known to be especially engaged in environmental questions. In Hebel's publications ecological aspects did only play a minor role. Companies of the building industry had agreed not to carry out LCAs, because they didn't see a necessity and wanted to avoid that the firms had to conduct LCAs due to pressure from competition. After YTONG AG has violated the agreement by commissioning its LCA, Hebel AG felt forced to follow and conducted an LCA-study as well. Thereby the LCA of Hebel does not regard single building blocks or elements, but a complete house.

2.7.2 The selected LCA-study

This case-study is based on the updated version of the „LCA of typical YTONG products". The LCA analyses the ecological properties of building blocks and reinforced elements as the typical products supplied by YTONG. It is the only LCA commissioned by the company.

2.7.2.1 The LCA-process

2.7.2.1.1 Motives and objectives

When LCAs received increasing interest in the media in the early 1990s, the head of the sales and marketing department of YTONG AG[62] had the idea for an LCA of YTONG products, to supplement the rising involvement of YTONG in environmental questions linked to building and construction. In the sales and marketing department the relative environmental soundness of YTONG products (and AAC in general) was seen as an important advantage over the competitors which should be documented and communicated with the help of an LCA-study.

When it was tried to promote the LCA-idea within the company, criticism arose. There was reserve particularly from the R&D department which was asked to participate in carrying-out an LCA-study and from the parent company Readymix.

- The R&D department's argument was that an LCA was not necessary, because YTONG products had never been criticised as being particularly harmful to the environment.
- Readymix argued that the concept of LCA as such was not fully developed or even standardised yet and that therefore LCA was not a „serious" instrument.

Nevertheless, both parties could be convinced that, although YTONG had no need to defend itself, an LCA could be a valuable offensive marketing instrument and that an LCA should be done as soon as possible, while interest in LCAs was still vivid and a large publicity was sure.

Hence, at a meeting of members of the R&D department and of the managing board in December 1992, the decision in favour of an LCA was taken. It was agreed to look at three typical YTONG products: two building blocks of a different thickness and one reinforced element. The comparison between the two kinds of building blocks should provide information on the influence of wall thickness on the energy needed for heating purposes.

Primarily an LCA-study was seen as the appropriate means to make, already existing, environmental advantages of YTONG products known. Thereby the LCA was intended mainly to be addressed to the market, not to decision-makers inside the company, because no major changes were planned and no urgent decisions had to be made. The LCA was thus intended rather for external than for internal use.

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[62] The head of the sales and marketing department at that time, Mr. Dering, died in September 1993 and his successor has shown less interest in ecological questions.

2.7.2.1.2 Chronology and organisation of the LCA-study

The YTONG managers agreed that the LCA should be conducted by independent scientists, in order to be as impartial and scientific as possible. It was refrained from comparisons with competing products (of other firms), because the data needed for a thorough examination were not available to YTONG for other than their own products.

In April 1993 the Institut für ökologische Wirtschaftsforschung (IÖW) which had been commissioned to carry out the LCA-study presented a concept on organisational and methodological details. This proposal was accepted by YTONG without asking for any changes to be made.

According to the IÖW's concept, most of the data should be collected by YTONG and then be processed by the IÖW, according to the agreed methodology[63]. The IÖW worked out a questionnaire specifying the data needed, the units in which to measure, etc.. The questionnaire was given to the members of the project team which consisted of five senior research staff members of the YTONG R&D centre in Schrobenhausen. Each member of the project team was responsible for collecting data on one aspect of the products examined, each aspect corresponding to one stage in the products' life cycle.

Although some data were already known, large parts remained to be collected. Data related to processes taking place outside the company were covered through literature research. To obtain details on the production of raw materials, such as cement or lime, publications of associations of the AAC industry were used. Suppliers were not asked for data. Information on the typical life time of buildings and energy use during this time were obtained from publications of the Federal Statistical Agency (Statistisches Bundesamt).

Concerning the main fabrication process located at YTONG, information was provided by several YTONG production plants. As the data were varying for different plants, average figures had to be calculated in order to obtain typical values.

Data collection and preparation of an interim report took two month, and in July 1993, the interim results were presented on a meeting. At this point, some minor calculating mistakes were discovered and corrected. No other changes were made and, in September, the final version was presented. Also, a computer programme developed by the IÖW was given to YTONG, which enables the company to carry out similar LCAs for other products or with new data for the same products.

A first update of the „LCA of typical YTONG products" was conducted in 1995. Because not only the data base, but also the methodology had changed, again the IÖW was commissioned with carrying out the update.

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[63] All data are related to one square metre of a wall built of building blocks or reinforced elements (functional unit).

2.7.2.2 Methodological choices

2.7.2.2.1 Type of LCA

Since the „LCA of typical YTONG products" regards products which represent the whole range of products of the company, it can be regarded as a fundamental study which will form the basis of all future LCA-studies or updates commissioned by YTONG.

The LCA delivers an analysis of already existing products. In this respect it is a descriptive study. But ultimately the LCA was not only used for a documentation of the environmental impacts related to YTONG products. It also served to identify and to reduce ecological weak-spots. In this respect the study had a strong prospective function for the company.

With respect to the regarded life cycle stages and the LCA-steps that were carried out, the study can be classified as a complete LCA.

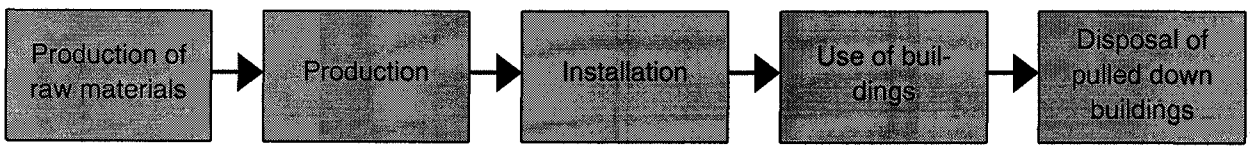
2.7.2.2.2 Detailed description of the products subject of the LCA and their life cycle

From the building material autoclaved aerated concrete (AAC) YTONG manufactures products in different forms and strengths. They can be divided into two main product groups, precision blocks and reinforced elements. To reflect the whole range of products of the company, by means of the LCA three YTONG products were analysed that were regarded as typical. These were:

- building block, 24 cm thick, density of 400 kg/m^3,
- building block, 36.5 cm thick, density of 400 kg/m^3, and
- reinforced element, 20 cm thick, density of 500 kg/m^3.

In the LCA all stages of the life cycle, including those not within YTONG's direct sphere of influence, were taken into account. The life cycle of typical YTONG products is depicted in figure 2.20.

Figure 2.20: Life cycle of typical YTONG products and scope of the LCA



Transports that incur between the different life cycle stages have also been regarded in the LCA.

With respect to the use of buildings it has been assumed that residential buildings have a life time of 80 years and that industrial buildings are demolished after 30 years. These assumptions are based on data of the Federal Statistical Agency.

Concerning the stage of disposal a mix of re-use, recycling, and landfilling has been presupposed which reflects the actual disposal situation in Germany in 1993.

2.7.2.2.3 LCA-steps

In its structure and method the LCA followed the discussion within the SETAC (Society for Environmental Chemistry and Toxicology) and the state of standardisation at DIN/ISO[64] Accordingly the LCA-study consists of the following steps:

- goal and scope definition,
- inventory analysis,
- impact assessment,
- valuation, and
- recommendations / optimisation analyses[65].

The first step encompasses the definition of goal, scope, and functional unit[66] of the study. In the course of the inventory analysis the data are collected and presented systematically. The regarded LCA depicts the data in the form of eco-accounts.

The impact assessment associates the inventory data with specific environmental impacts (impact categories). On the grounds of the current state of the methodology discussion the impact categories listed in table 2.9 have been regarded in a quantitative way.

Table 2.9: Considered impact categories

Impact categories
Greenhouse effect
Nutrification
Resource scarcity (fossil resources)
Acidification
Human toxicity

Other, not least important, impact categories could not be regarded, due to an insufficient data basis (land use), because no corresponding emissions occur (ozone depletion) or currently no agreed method exists (eco-toxicity, noise). They were partly considered qualitatively following the inventory analysis.

Other environmental impacts which were not covered via the impact assessment have been regarded on the basis of the inventory data as well, either quantitatively or qualitatively (see table 2.10).

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64 DIN (Deutsches Institut für Normung) is the German standardisation institute, and ISO (International Standardisation Organisation) is its pendant on the international level.

65 According to the standardisation discussion the last step is optional.

66 The functional unit describes the unit to which all LCA-data are related. In the regarded LCA one square metre of a wall has been chosen.

Table 2.10: Environmental impacts considered on the basis of inventory data

Quantitatively regarded impacts	Qualitatively regarded impacts
Energy consumption	Land use
Use of landfill volume	Scarcity of non-fossil resources
	Dismantling ability
	Noise
	Dust

The evaluation process analyses and discusses results of the impact assessment as well as data directly obtained from the inventory. The data were evaluated on the basis of a verbal discussion. That the different environmental impacts were not further aggregated, made it difficult to deduce overall results, but allowed a more differentiated interpretation.

2.7.2.3 Results and recommendations

2.7.2.3.1 YTONG blocks of 24 cm and 36.5 cm thickness

In the LCA the environmental impacts arising within the different stages of the products' life cycle are depicted separately for every impact category. This revealed for both, the 24 cm and 36.5 cm blocks, that in every impact category most of the environmental damages arise during the stage of use, that means through inhabiting and heating buildings. The production of raw materials, the manufacturing of the blocks and transportation follow in this order. The stages of installation and disposal are negligible in comparison. The only exception was the use of landfill volume, here the stage of disposal holds the overriding share.

The comparison between the two building blocks showed that the 36.5 cm thick blocks fared better regarding most environmental effects, significant exceptions being resource scarcity and use of landfill space. This result can be deduced to the better thermal insulation of the thicker blocks which leads to lower energy consumption during the use of buildings.

The 36.5 cm blocks cause a material use per square metre wall that is by 50% higher than that related to the 24 cm blocks. That means, although the resource use and all corresponding emissions are by 50% higher, over a life time of 80 years the advantage of a better thermal insulation predominates.

In the LCA no recommendations concerning the blocks were made, but with respect to their packaging. The blocks are stacked on pallets and then the whole pallet is shrink-wrapped in an LDPE-foil. The LCA has confirmed the company in its efforts for replacing this practice by protecting the blocks through impregnation. At the same time it has been advised to take the environmental impacts of the impregnation substances thus needed into account.

2.7.2.3.2 Reinforced element

Due to its different function the reinforced element cannot be compared to the building blocks. It is not used in the construction of housing, unlike the other two, but for industrial and factory buildings.

The results concerning the reinforced element are depicted in the same way as those of the blocks. And the findings follow the same tendency, that means the stage of use contributes by far most of the environmental damages. The production of raw materials, transportation, and the manufacturing of the reinforced element adjoin, generally, that means with respect to most impact categories, in this order. The stages of installation and disposal are comparably insignificant.

But the extent in which the environmental impacts arise within the particular stages varies from that related to the blocks. The production of raw materials and transportation come more to the fore. This results from the additional steel reinforcement on the one hand, and from the much shorter life-time of reinforced elements and the thereto reduced importance of the stage of use on the other hand.

With respect to reinforced elements it was recommended to replace the anti-oxidants currently used to protect the steel reinforcements by less toxic ones.

2.7.2.3.3 Other optimisation potentials

The LCA also revealed general possibilities to enhance the ecological situation, apart from particular products. It has been suggested to further reduce the use of substances that are harmful to humans or the environment and the amount of hazardous waste.

Since data for the LCA have been collected in various YTONG production plants, differences existing between the plants have been uncovered, especially in regards to energy consumption. Through comparing the different production methods, the least energy intensive processes could be identified and implemented in all works. By this means a significant amount of energy could be saved. The revealing of these differences has been the main benefit YTONG could reap of the LCA.

Most of the identified detrimental environmental effects occur during the stage of use. Thereto the highest potential for improvements lies in providing the customers with better information on the optimal use of YTONG products. For example, a better insulation could help to reduce the energy needed for heating and the environmental impacts related therewith.

2.7.2.4 Decisions and applications

2.7.2.4.1 Realisation of optimisation potentials

The marketing and sales department, although it gave the impetus for the LCA originally, has been disappointed at the results. They expected to obtain strong arguments for sales promotion. But the results were found to be too complex, because they were related to single environmental impacts and were not further aggregated to one statement saying how ecologically desirable the YTONG products really are. Especially the fact that the LCA does

not allow to compare YTONG products to those of the competitors gave cause for complaints. After all it was refrained from using the LCA in product marketing.

But on the contrary the R&D department, which rejected the project at first, was positively surprised by the LCA results. Therefore the LCA has rather been used to optimise processes and products than to advertise them. The LCA has changed as well the focal points of the R&D centre's research activities as the way they analyse products and production processes. Now the R&D team uses life cycle orientated data to detect potentials for ecological optimisation and has put the stage of use, especially the thermal insulation properties of YTONG materials, in the centre of its attention.

The LCA-study turned out to give a lot of valuable information helping to ecologically enhance production processes. As already suggested in the study, a comparison between different production plants revealed which plants did not work optimally and consumed more energy and materials or produced more waste than others.

According to the recommendation of the LCA environment-friendly, water based anti-oxidants for the steel part of the reinforced elements have been developed. They are already used in one plant and it is planned to gradually substitute them for the currently applied substances in all YTONG sites.

The LCA further demanded not to wrap the blocks in LDPE-foil, but to protect them with the help of an ecologically sound impregnation. Although corresponding efforts have been made, ultimately this has not been realised for different reasons. Through an impregnation the blocks were only protected from weather, but not from transport damages. Moreover, by wrapping the pallet and the blocks together, the foil serves stability purposes as well. If it was done without the foil, the blocks had to be hold together by metal bands. Even if an equal stability could be achieved, other ecological impacts and costs would arise. Last but not least, the foil, unlike the blocks, can be printed and thus be used as an advertising medium.

Since the energy consumption during the stage of use is responsible for most of the environmental impacts, the importance of thermal insulation has been stressed in the LCA. Insulation and use of buildings is beyond YTONG's direct sphere of influence. Thereto improvements can only be achieved by providing architects, builders, and users with information on this topic, in order to induce them to act accordingly. YTONG therefore has integrated environmental aspects into the communication with its clients. Furthermore the company could enhance the thermal insulation properties of its blocks by reducing their thermal conductivity by one third.

2.7.2.4.2 Information and communication

Before being published, the final version of the LCA was presented to YTONG staff members by the head of the R&D centre. Two meetings were hold on the topic, in the first one members of the sales department and in the second one members of the production department have been informed. At each occasion, 20 to 50 people were present. Additionally copies of the LCA were sent to each of the YTONG production plants. All YTONG employees were informed about the existence of the LCA. The managing staff was given detailed information.

Although it was refrained from using the LCA for product marketing, it should be presented to the public. YTONG therefore decided to organise a press conference. One of the authors of the study, a representative of the IÖW, gave information about methods and results of the LCA. The head of YTONG's R&D centre provided an assessment of the results and explained what consequences the company wants to draw.

Copies of the LCA-study have been distributed on this occasion, but were felt hard to understand. To make the results still accessible to the layman and to give an aid for their interpretation, a press item summarising methods and findings of the study was issued as well.

Moreover, YTONG included a simplified and carefully illustrated version of the LCA in a new edition of its publication „Building in Harmony with Nature" („Bauen im Einklang mit der Natur"; YTONG 1994). By this means the LCA was integrated into the „green" picture the company was drawing of itself. The booklet is extensively used in the course of public relation activities.

The LCA has met a wide interest mainly among the academic community concerned with LCAs. The marketing department frequently receives requests for copies from outside the company, most of which come from universities, architects, building societies, and the press.

2.7.3 The role of LCA in the decision-making context

2.7.3.1 The decision-making culture

YTONG is run in a very decentralised way. Independent companies do not only exist on an international level, but even within Germany. The German YTONG AG is divided into a number of regional companies. They form rather independent profit centres, that means they are responsible as well for producing and selling their products as for their results.

Only decisions which are also relevant for other YTONG companies are taken on the level of the YTONG AG respectively YTONG Holding. For example, decisions on the product programme or on general product quality standards are regarded as being of an overriding importance.

Decisions are mostly taken in groups. Committees have been installed on different levels within the YTONG companies and on the level of YTONG AG or YTONG Holding. On which level the responsibility for a particular decision is laid, depends on the importance of the topic.

2.7.3.2 The product innovation process and the integration of LCA in this context

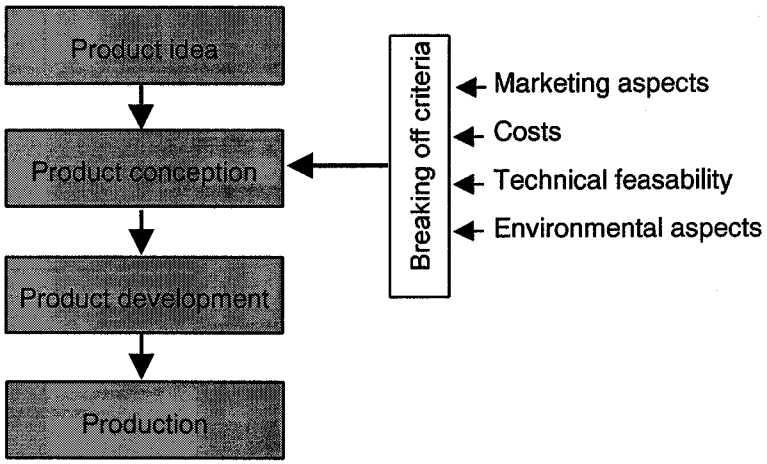
2.7.3.2.1 The „typical way" of product innovation at YTONG AG

YTONG AG uses LCAs primarily to identify potentials for ecological optimisation of products (and production processes). The process of product innovation is described in the following figure „From product idea to production".

If somebody in the company comes up with an idea for a new or enhanced product, the R&D centre in Schrobenhausen is contacted. It is responsible for the development of all YTONG products. If the know-how for realising the product idea is available, it is started with working out a detailed product conception. „Thereby it is mainly aimed at manufacturing products that are actually bought", (Hums on 10/16/97). This means, the products have to meet the clients' wishes concerning price and quality.

Costs and marketing aspects thus have top priority. Additionally, technical feasibility and ecological questions are considered right from the beginning. All aspects are transformed into breaking off criteria (see figure 2.21). If only one of these criteria cannot be fulfilled the whole process is stopped.

Figure 2.21: From product idea to production



In accordance with general guidelines the breaking off criteria are defined specifically for each product idea. They are agreed in a working group which consists of representatives of the marketing and sales department, the R&D centre, and the production sector.

If the product conception gets over all hurdles, the real product development begins. Production and market integration of the product are prepared simultaneously.

2.7.3.2.2 The integration of LCA in the process of product innovation

A systematic integration of LCA in the product innovation process is currently regarded as not feasible, because LCA-studies reveal results that are too complex. LCAs do not deliver one clear statement expressing how ecologically desirable products are, but reveal a number of results concerning single impact categories, because a further aggregation would require to weight different environmental impacts. YTONG finds it impossible to optimise individual products on the basis of an instrument that often ends in saying that an improvement in one impact category goes along with a deterioration in another. However, some changes in the production processes and the use of new anticorrosive agents have been initiated by LC-results.

Moreover LCAs try to consider every influence on the environment, including global effects like ozone depletion or comprehensive effects like ecotoxicity which are difficult to observe

and thus can hardly be quantified. YTONG prefers to regard only environmental aspects that can be measured, e.g. water pollution, emission of hazardous substances or compostability.

With respect to those aspects guidelines have been formulated that, for example, prohibit the application of certain substances or set limits to their use. These guidelines serve as a basis for setting up breaking off criteria (see section 3.2.1).

The LCA influenced the product development only in so far as it supported the definition of focal points of research activities. The instrument has been integrated in process optimisation. It was also used as a part of several other tools.

2.7.3.3 The future of LCA at YTONG AG

2.7.3.3.1 Weaknesses and strengths of the instrument and its future application

In contrast to the original intention, the LCA was rather used for optimising processes and products than for marketing purposes. The sales and marketing department found the results of the LCA-study too complex to be communicated via advertisements.

The most significant weakness of LCAs is seen in the fact that they do not allow one clear statement saying how environment-friendly the analysed products really are, but deliver a number of results related to different environmental impacts.

Problems arise especially, if different products are to be compared, because it is rarely the case that one product is obviously superior to the other. In most cases products reveal an advantage in one impact category while coming off worse in another.

This is not only likely to confuse clients, but also makes it difficult to base ecological product optimisations on an LCA. For this reason YTONG used the LCA-study to define general foci of its R&D activities, but did not and still does not firmly integrate the instrument in its product development.

Despite all difficulties YTONG found the information provided by LCA valuable enough not to want to do without the instrument in future. It is planned to update the „LCA of typical YTONG products" regularly. A first update was carried out in 1995, two years after the original LCA was commissioned.

2.7.3.3.2 Interrelations between the application of LCA and public policy

The „LCA of typical YTONG products" was not directly triggered by public policy, but was commissioned against the background of a risen public interest in the environmental impacts related to building.

YTONG does not expect public authorities to play a more important role in the context of LCA. Some kind of law that would force companies to carry out LCA-studies of their products is regarded as being as of no advantage. Because so far public LCA-activities did not have any influence on the company, YTONG sees public LCA policy neither as a help nor as a hindrance.

Although it is described as the main weakness of LCAs that they do not result in one clear statement about the environmental soundness of the analysed products, but in numerous

statements for single ecological impact categories, YTONG does not demand any public standardisation activities. The company does not want public authorities (nor anybody else) to provide obligatory weightings for the different impact categories in order to further aggregate the information, because nobody can say whether, for example, ozone depletion is of more importance than acidification.

2.7.4 Summary and conclusions

In the 1920ies a Swedish architect invented a new building material, autoclaved aerated concrete (AAC). From this material YTONG manufacturers blocks and other building parts. In recent years YTONG developed into an internationally operating Group of companies which is present in 19 countries on four continents. In 1996 the YTONG Group employed 2,985 people and its turnover amounted to DM 867 million.

When LCA received increased interest in the beginning of the 90ies, the head of the YTONG sales and marketing department raised the idea to carry out an LCA for YTONG products. With the help of an LCA-study the relative environmental soundness of YTONG products should be documented and communicated, especially to consumers. It was intended to use the LCA as an offensive marketing instrument.

In 1993 YTONG commissioned an external institute, the IÖW, to carry out an „LCA of typical YTONG products". The company provided extensive support, but did not build up internal capacities for carrying out complete LCA-studies. With the help of the software obtained from the IÖW, YTONG is able to adjust the study to new data situations. Only if the basic methodology changes, help from external experts will be needed.

When the study was finished the marketing and sales department refrained from applying the LCA in product marketing. The results were regarded as too complex and did not allow to compare YTONG products to those of the competitors. Thereto the LCA was communicated only in the course of public relations activities. In contrast the R&D department which did not promote the project at first, was positively surprised by the results. The LCA turned out to deliver valuable information for the ecological optimisation of processes and products.

The most important finding of the LCA was, that the stage of use clearly holds the biggest share in the environmental impacts caused by YTONG products. This can be deduced to high energy consumption for heating purposes. The comparison between the two blocks of different thickness additionally stressed the importance of thermal insulation. Thereto YTONG intensified the communication with clients on this topic on the one hand and concentrated its R&D efforts on the stage of use, especially on reducing the thermal conductivity of its products, on the other hand.

The LCA-study thus helped to identify general foci of the R&D activities and led to some product and process optimisations. Following LCA is taken account of in the process of product (and process) development. Nevertheless, no fixed routines exist which determine for which decisions LCAs are to be consulted and in what way. This means that a firm integration of LCA in decision-making processes could not be observed.

LCAs are regarded as not suitable to deliver useful information about indivudal Ytong products, because they lead to results that are too complex. LCAs do not deliver one clear statement expressing how environment friendly products are or whether the „old" or the

„new" one is ecologically superior, but reveal a number of general results concerning single environmental impacts.

To integrate environmental aspects in product development processes less complex instruments are preferred. Ecological questions are, similar to economic and technical ones, considered by means of general guidelines and breaking off criteria that are specifically developed for each product.

However, the „LCA of typical YTONG products" delivered information that were valuable enough to YTONG AG to plan to regularly update the study. A first update was carried out in 1995, two years after the originial LCA had been conducted.

3 Conclusions

3.1 General findings regarding the selected LCA-studies

3.1.1 Motives and objectives

In most cases, a mix of internal and external factors has driven the companies to carry out the LCA-studies, external factors being the more important ones. The market, that is competitors and/or consumers, has been the decisive impetus in four of five cases (AEG, Henkel, Weleda, YTONG). Public measures like environmental legislation never triggered the performance of an LCA directly. An internal interest to identify and to reduce or prevent product related environmental impacts often accompanied the external pressure. Four companies actually carried out the LCA, when a concrete product decision, e.g. a switch to another input material or packaging, had to be taken (AEG, BSH, Henkel, Weleda).

The objectives pursued with the conduction of the LCAs correspond to the motives. Three companies intended the LCAs for both, the information of consumers, competitors, and the public and the underpinning of concrete product decisions. Only one company each wanted the LCA exclusively for external use (YTONG) or internal use (BSH).

3.1.2 Actors

In all cases the carrying out of an LCA was suggested and promoted by employees like developers or people from marketing/public relations departments as the persons that directly needed the information and would be responsible for implementing the LCA-results. Thus all cases can be classified as bottom-up approaches. But nevertheless, „higher levels" like the division or company management had to agree, before the LCA could be realised. Consequently, the definite decision to carry out an LCA was usually taken on the management level.

The responsibility for the performance of the LCA was placed on development departments (AEG, YTONG) or environmental departments (Henkel, BSH) respectively environmental officers (Weleda). All LCAs underlying our case-studies were carried out in co-operation with external institutes. The companies usually participated in the goal and scope definition and supplied some data, primarily those referring to internal production processes. All other tasks, i.e. collection of remaining data and data processing, methodological choices, impact assessment and interpretation, were performed by external experts.

3.1.3 Type of LCA – methodological choices

Not all of the LCAs exactly followed the ISO-standards. Only two can be classified as complete studies in respect to both, LCA-steps and life-cycle stages. While every study dealt with the steps of goal definition and scoping, inventory analysis, and interpretation, an impact assessment was carried out only in three cases (BSH, Weleda, Ytong). Two of these LCAs (BSH, YTONG) also considered the entire life-cycle of the analysed products. In two of the others (AEG, Weleda) only the stage of use was excluded and one LCA (Henkel) merely provided a cradle-to-gate analysis.

All LCAs dealt with more than one product and thus are comparing studies. One company (YTONG) exclusively analysed its own already existing products. The other four companies compared their products, respectively parts of them, to alternatives they already knew, but not yet applied. In some cases, the alternatives regarded were those used by competitors.

In so far as all LCAs analysed already existing products, they were retrospective studies. But because they served not only documentation purposes, but were also used to identify and to reduce ecological weak-spots respectively to make out the product (component) alternative to be used in future, they also revealed a prospective character.

3.1.4 Realisation of results and recommendations

The extent to which the results and recommendations expressed in the LCAs were put into practice varies considerably between the companies. Only in the one case in which the LCA mainly confirmed the status quo (AEG), the company did not take any measures at all. Most companies realised some of the results and recommendations, while leaving others disregarded.

The reasons most often given for not translating the LCA-results into action were that their realisation would have reduced the products' quality and that they referred to life-cycle stages not in the direct sphere of influence of the companies. In some cases also aesthetic aspects or prohibitively high costs stood in the way of realising the findings. The companies put into practice preferably, but not exclusively, those results and recommendations that were related not only with ecological, but also with technical and/or economic advantages.

However, LCA supported some decision-making processes by providing additional information. LCA complements the „original" set of information, but does not automatically imply direct consequences. Besides directly influencing specific decisions, LCA contributes to indirect actions, e.g. future R&D activities. On the basis of the LCA-results YTONG, for example, decided to put the thermal insulation properties of its building materials in the centre of its future R&D activities.

3.1.5 Information and communication of LCA results

None of the companies applied the LCAs for direct product marketing. Some have explicitly stated that they regard LCA as not suitable to be used as a marketing instrument. Mainly the LCA-results are felt to be too complex to be transported through advertisements. LCAs normally do not end in one clear statement saying how environment-friendly the analysed prod-

uct really is. Especially if different products are to be compared, LCAs do not come to definite results.

Instead the LCAs served the information of and communication with company external stake holders in the context of public relations activities. All companies gave (brief) information in their environmental reports or brochures. Additionally, three companies (AEG, BSH, Henkel) actively participate in the expert discussion about LCA and thus provided detailed data in specialised journals or conferences.

Company internal the LCA-results were almost exclusively addressed to the management or other important decision-makers and the employees directly involved in the carrying-out or implementation of the LCA-studies. All other employees were only generally informed. None of the companies explicitly used LCAs for the staff's information or education.

3.1.6 Application fields

Not seldom the actual use of the LCA-studies differed from the initially intended application, because once the LCAs were completed, the companies discovered that they provide useful information also in the context of questions different from the original goal definition. In this context YTONG serves best as an example. Although the company exclusively intended the LCA to document and to communicate the ecological advantages of its products, the study was hardly applied for marketing/public relations purposes, but was used for further optimising production processes and products.

Generally the LCAs were rather applied for internal purposes than in the marketing/ public relations context. In four of the five cases the LCA-studies supported the product development, only one firm (Weleda) predominantly used the study in the procurement context.

3.2 General findings regarding the role of LCA in the decision-making context

3.2.1 Internal LCA-capacities

All LCA-studies were carried out in co-operation with external experts. Following, at the time the studies were conducted, in none of the companies internal know-how existed that enabled the firms to independently perform LCA-studies. In the meantime one company (Henkel) has built up comprehensive LCA-know-how. The others did not and still do not want to follow. Only two companies have extensive internal LCA-data banks at their disposal. In the one case (YTONG) the external experts commissioned with the conduction of the LCA-studies supplied the company with the software/data bank they developed. In the other case (Henkel) an extensive self-made data bank was established. But since in recent years a number of professional LCA-software-tools was placed on the market, the company plans to switch to one of these. The other firms do not have „real" LCA-data banks, but are thinking of purchasing software (AEG) or rely on some sort of computer based tools like EXCEL-data sheets (BSH).

3.2.2 LCA and other environmental management instruments

No company does exclusively rely on LCAs in order to integrate environmental aspects in the product development or procurement (Weleda) context. The companies also apply other environmental management instruments like checklists, „black lists", KEA-analysis, risk assessment or the ABC-method. Since these instruments are less complex, they are usually preferred to LCA. LCAs are performed only in case an extraordinary need for comprehensive life-cycle oriented data is felt.

Henkel is the only firm that uses LCA rather supplementary than competitive to other instruments. The products to be invented firstly have to „pass" instruments like checklists and risk assessment and are then subjected to LCAs.

3.2.3 Strengths and weaknesses

All companies appreciated that LCAs, in contrast to other instruments, are able to give a systematic overview on all environmental impacts that occur along the entire life-cycle of products.

But the comprehensive approach of LCA is not only regarded as an advantage. The companies claim that, on the one hand, the collection of the enormous quantities of data requires too much time and money and that, on the other hand, the instrument provides too complex and often indefinite results. Especially YTONG complained that LCAs do not allow one clear statement saying how environment-friendly the analysed products really are, but deliver a number of findings related to different environmental impacts.

The other aspect often mentioned as an important weakness of the instrument is the manipulability of results that arises from an immature methodology respectively unfinished standardisation processes. In this context especially the lack of clear scope definition and interpretation standards has been queried.

3.2.4 Future relevance and integration in decision-making processes

Although all companies discovered not only strengths, but also weaknesses of LCA, they all plan to further apply the instrument. LCAs are regarded more suitable for company internal than external oriented applications. The most promising use of LCAs is seen in the identification of ecological weak-spots in the product development context.

But so far, only one company (Henkel) regularly carries out LCA-studies and systematically integrated LCA in decision-making processes. In this company, i.e. at least in one of its product divisions, every important product innovation is accompanied by an LCA. Guidelines have been set up, which exactly prescribe at which development stage an LCA-study has to be performed.

All other firms carry out LCA-studies only occasionally, i.e. whenever somebody sees a need for comprehensive product related data. Whether an LCA is performed or not thus depends on the judgement of individual employees. Fixed routines which determine when and for what purposes LCAs have to be conducted do not exist.

3.2.5 Factors that support a systematic integration in decision-making prcesses

The only company which systematically integrated LCA in decision-making processes is the biggest one of our sample. Since carrying-out LCA-studies is (still) pretty time and cost intensive, this is presumably not by accident.

That the company belongs to the chemical industry is another, definitely positive factor, because in this industry product innovations mostly result from new combinations of classical ingredients. Thus, once the data for all ingredients have been collected and stored in data banks, LCAs can be conducted almost „at a flick of a switch".

In order to identify more detailed explanations and common patterns for the integration of LCA in business decision-making processes, we have analyzed the case-studies within the analytical framework of the „institutionalization theory". The conclusions we have drawn from this approach are presented in the following section 3.3.

3.3 The case-studies in the analytical framework of the institutionalisation theory[67]

3.3.1 The institutionalisation theory

How are new norms and methods – such as LCA – spread in industry? Before they can be used as a routine-tool for the solution of existing problems, a process going through certain stages has to take place. A possible theoretical background to explain this is the institutionalisation theory which analyses institutionalisation processes within an external control perspective.

Tolbert/Zucker (1996) present an overview of the state of institutionalisation theory. They describe that the process of adoption to new situations and requirements etc. pursues an institutional „script". They provide new insights into adoption processes within companies besides the model of rational choice. The *institutionalisation theory* describes the characteristics of *different phases* in the *introduction* of a new phenomenon *until it becomes something taken for granted and routine*. It also describes factors important for a complete institutionalisation. We have used and „translated" this theory to develop a framework for the process of the introduction of LCA into companies. The institutionalisation theory distinguishes four stages:

1. **Innovation**
2. **Habitualisation:** It involves the development of patterned problem-solving behaviour and the identification of signals determining when to apply this problem-solving behaviour.
3. **Objectification:** It involves the development of a consensus regarding the problem-solving behaviour.

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[67] This section is a part of the summary of the final report (Frankl/Rubik 1999). Interested readers are requested to study the long version of the final report for more details.

4. **Sedimentation:** Sedimentation is characterised by the cessation of promoting and accumulating evidence and by the existence of a formal structure spread across the group of actors theorised to be the appropriate adopters. When fully institutionalised, the use of LCA survives the generation of organisational members.

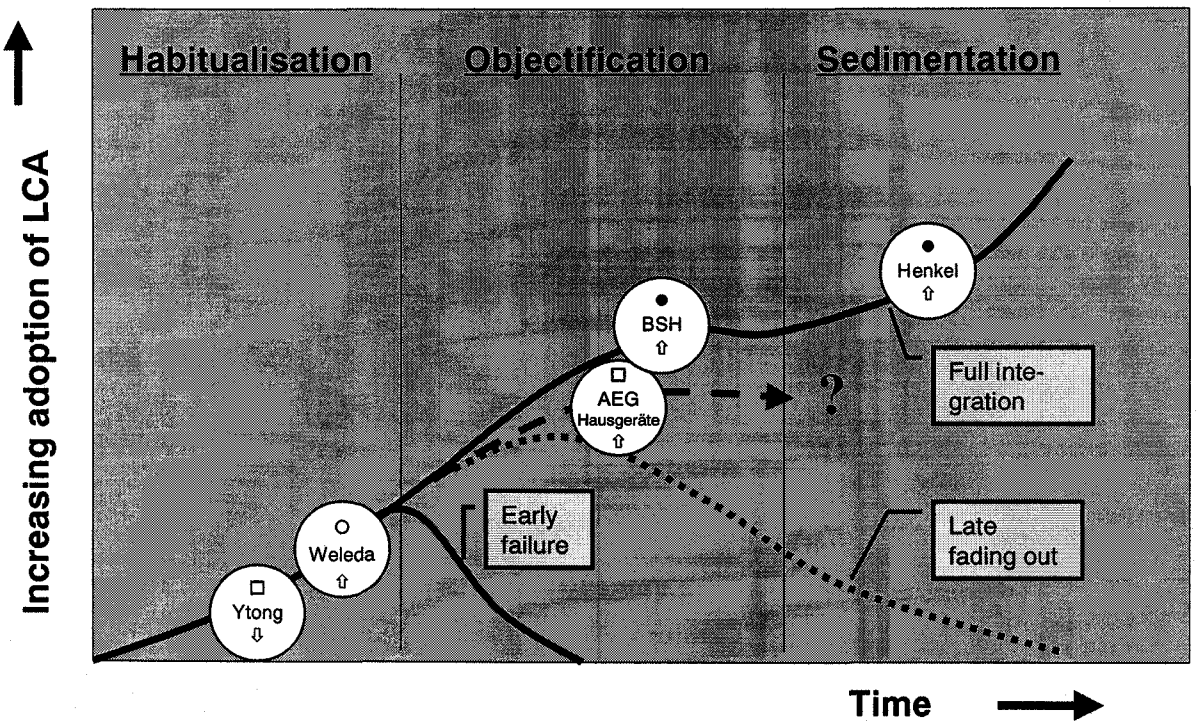
3.3.2 The application of the institutionalisation theory to the case-study companies

This general theoretical framework was applied by the project to the process of analysing the adoption of the new „phenomenon" of LCA. As mentioned, the detailed results have been published by Frankl/Rubik (1999).

Based on the institutionalisation theory, it was possible to classify the 20 different companies, which are the subjects of the case-studies, into several groups with similar behaviour and trends. To do this four main classification criteria were used, namely:

- Trend in the use of LCA (increasing or decreasing),
- institutionalisation stage,
- size of the company,
- top-down or bottom-up introduction of LCA in the company.

Figure 3.1 summarises the classification of the five German case-study companies according to the above criteria.



Explanation:

●	large companies	*	using a simplified and/or alternative methodologies
□	medium sized companies	⇧	bottom-up-approach
○	small companies	⇩	top-down-approach

Figure 3.1: Classification of the case-study companies according to the level of institutionalisation of LCA

3.3.2.1 From innovation to habitualisation

According to the institutionalisation theory, the adoption of LCA-activities within companies is determined by economic, technical and company-internal political arrangements. This is verified by our case-studies. Some of our case-study companies started LCA-activities because they intended to use the results in marketing. Another economic factor is the search for cost savings. Another observed external triggering factor is the environmental debate. According to our case-studies, policy as a driver for LCA possesses some influence in Germany, especially the German waste legislation.

Clear bottom-up or top-down patterns do not exist. That is, the type of approach (either bottom-up or top-down) is *not* a determining factor for success or failure within the institutionalisation process of LCA.

On the contrary, when looking at these different factors, the importance of the actors has to be highlighted[68]. The initiators are the persons who push the whole process and who are a must for this push. They need not be the entrepreneurs, but they might be. They are the initial driving force.

3.3.2.2 The semi-institutional development: the crucial stage of objectification

After the initial and successful adoption of LCA, it is necessary to develop a consensus regarding the use of LCA. The development of such a consensus concerning the use of LCA is probably the most crucial stage before LCA is applied routinely, and is the main characteristic of the objectification stage. The institutionalisation theory introduces two different mechanisms contributing to a consensus during this stage:

- Monitoring and information gathering and
- Champions who promote LCA.

Our case-studies showed that a monitoring of the competitors took place in all companies which still use LCA, i.e. in all successful cases.

Even more clearly, in all successful case-studies, an entrepreneur with a clear and reasonable strategy exists. The entrepreneur should have a „mission", that means a high personal commitment to push forward the LCA-activities. Even so the existence of an entrepreneur is not in itself sufficient. Even more important is his/her influential position within the company.

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[68] We identified three crucial *actors* within the institutionalisation process, namely the initiator, the promoter (or entrepreneur) and the set of champions. Their relevance changes throughout the process phases. The initiator is the central driver in the first phase. The importance of the entrepreneur (who might be, but is not necessarily, the same person as the initiator) is central in the objectification phase. His presence and influence are crucial factors for the overall success of the process. Finally, in the sedimentation phase, when consensus is needed, the set of champions involved in the diffusion of the tool has to expand within different sectors of the company. The set of champions generally includes the entrepreneur, however this is not strictly necessary, since in the full sedimentation phase the tool „survives" even if the people change.

Other actors involved in the LCA activities are the commissioner (the one who really gives the money) and the LCA analyst(s), who actually carry out the study. However, their role is less important, unless they coincide with the initiator and/or entrepreneur.

Whilst the existence and importance of an entrepreneur is a necessary, but not sufficient condition for the successful promotion of LCA, a good strategy with some appropriate objectives is also necessary. The objectives at the objectification stage are

- to get support within the company,
- to create links within the company and
- to enlarge the set of champions involved.

Company-internal co-operation and communication is necessary to make LCA known within the company and to obtain support on the path towards consensus. In all our successful case-studies, a good organisation (either already existing, or developed *ad hoc*) for the communication of the LCA results can be observed.

The entrepreneur needs to be persuasive, mainly by using sound arguments of a good justification, to introduce LCA within the company. This justification can vary, but a missing or insufficient justification will lead at least to an uncertain future for LCA. In all our case-studies, LCA failed if the justification was insufficient.

An appropriate strategy, communication and justification might make the creation of a large set of champions easier. All these elements might contribute to getting a mandate from top-management to go further and to implement LCA within the organisation.

3.3.2.3 The full-institutional development: sedimentation

After a successful objectification, during the sedimentation stage, LCA becomes fully implemented. At the end of this stage, a formal structure for working with LCA exists. The use of LCA is taken for granted, has become routine, is institutionalised and survives even if the people in the company change.

The success of the implementation is based on the strategy of the entrepreneur and company-internal-relationships. During a successful objectification, the entrepreneur should have gained some support from key persons and groups. The importance of opponents should be limited. To secure this political situation, the entrepreneur and the champion have to demonstrate positive experiences with LCA and a reasonable cost-benefit-relationship from LCA. Once again, different actors play the decisive role for success.

3.3.3 The role of LCA changes

The role of LCA changes over time throughout the institutionalisational stages. For instance, in many cases, LCA was expected to be used in marketing at the beginning. In all our case-studies, marketing expectations could not be satisfied. Either LCA failed generally or the adoption is now intended to be exclusively used for company-internal purposes. In general, companies realised that results of an LCA are too complex and disputable to be presented to the market[69].

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[69] This is due to methodological problems with respect to impact assessment and to the issue of availability and quality of data. Nevertheless they do not exclude that LCA could be used again in

LCA is first applied for learning purposes; this is an important characteristic of the habitualisation stage. We have also recognised that producers of complex products (e.g. automobiles, electric or electronic products) start with examinations of simple parts of these products. The view is on existing products, i.e. a retrospective environmental check.

During the crucial objectification stage internal purposes, both retrospective (especially bottleneck identification) and prospective (R, D & D), are important. LCA provides a very valuable information for learning. If the first institutionalisation stage passed successfully, and if external market drivers motivated the LCA, we observed that the expectations of the marketing department were disappointed, but the internal application became more and more important. However, this depended on two crucial factors: the openness of people to unexpected results and a good justification for LCA. Indeed, the shift from external expectations to an internal application of LCA only happens if the people within the company go through a learning process. This permits them to tackle unsatisfied expectations (marketing) and to appreciate highly enough the added value of LCA for other purposes (R&D, product development, learning, spin-offs, etc.)

If all the hurdles of this stage are overcome, then a clear prospective and company-internal application is preferred. The use of LCA can be diverse depending on several circumstances of a company, but the applications have to follow a clear and precise target-orientation. The use is a more prospective one looking to the future.

In addition to this, there is a clear trend among producers of complex products: They started their LCA-activities with simple products or compounds which are (relatively) easy to analyse; if the learning experience with the tool LCA has been positive, they consider more complex products and/or fit „simple" LCA-studies together (several compounds for a final complex product).

3.3.4 Are there any common application patterns?

The way of introducing LCA into a company might differ from country to country (clear examples: top-down in Italy and bottom-up in Sweden, with Germany and Switzerland somewhere in between). This might have something to do with specific different local management cultures. However, the type of approach has no real influence on the success or failure of the LCA institutionalisation process.

Another important factor, which might influence the application patterns of LCA, is the sector and also the life-cycle position to which a company belongs. According to Smith et al. (1998), the position in the life cycle is the key determinant in the approach taken in LCA adoption because the technological and market contexts differ along the life cycle. We cannot verify their adoption patterns[70]. Moreover, we only performed 20 case-studies and most companies belong to the group of downstream companies. However, our feeling is that the adoption of LCA is much more dependent on other parameters than on the life-cycle position (and

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the long-term as a marketing tool if (and only if) some codified procedures such as inventory assumptions, data quality and impact assessment procedures are agreed on in the future.

[70] An important distinction between Smith's analysis and our research is the approach: Whereas Smith et al. (1998) provided a static picture on the adoption of LCA, we developed a dynamic picture.

their characteristics as indicated by Smith). The business-internal adoption of LCA follows a specific logic of institutionalisation. During this adoption process, different characteristic elements influence the whole process. However, carrying out LCA does *not* seem to be influenced by the life-cycle position of the company.

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