

**CASE STUDY TETRA BRIK ASEPTIC® SLIM
1,000 ML WITH LIGHTCAP
BY TETRA PAK GMBH & CO. KG**

Documentation – 21.01.2009.

**Case Study undertaken within the PCF Pilot Project
Germany**

Content

1	Preface	1
2	Executive Summary	4
3	Company's Profile	6
4	Organisation and Procedures	7
5	Goals and Scope	7
5.1	Objectives of the Case Study	7
5.2	Product Selection and Definition of the Functional Unit	7
5.3	System Boundaries	8
5.4	Data Sources and Data Quality	10
5.5	Allocation	12
5.6	Treatment of particular emission sources	19
6	Inventory and Calculation.....	20
6.1	Extraction of Raw Materials.....	20
6.2	Converting	22
6.3	Secondary and tertiary packaging.....	22
6.4	Filling.....	23
6.5	Distribution	24
6.6	Shopping Tour	25
6.7	Product Use	25
6.8	Recycling and Disposal	25
6.9	Background data	25
7	Presentation of Results (best guess)	27
7.1	Overview	27
7.2	Extraction of Raw Materials.....	29
7.3	Production.....	30
7.4	Secondary & Tertiary Packaging	31
7.5	Filling.....	32
7.6	Distribution	33
7.7	Shopping Tour	34

7.8	Product Use	35
7.9	Disposal/Recycling	36
8	Assessment of the Results	37
8.1	Sensitivity Analysis	37
8.2	Handling of other Environmental Impact Categories	39
9	Interpretation and Perspectives	49
9.1	Challenges of the Case Study.....	49
9.2	Identification and Assessment for Further Reduction Options of the PCF..	49
9.3	Measures under Consideration to Further Reduce the PCF	49
9.4	Product Carbon Footprinting at Tetra Pak GmbH & Co. KG in the Future ...	49
10	Recommendations	51
10.1	International Methods for Calculation and Assessment of Product Carbon Footprints	51
10.2	Proposals for Product Specific Definitions and Rules (EPD, PCR).....	51
10.3	Reporting, Communication and Claims of Reductions to Customers and Consumers	52
	References	53
11	Annex	54
11.1	Documentation of the Data	1
11.1.1	Extraction of Raw Materials	1
11.1.2	Production	3
11.1.3	Secondary and Tertiary Packaging	4
11.1.4	Filling.....	5
11.1.5	Distribution	6
11.1.6	Shopping Tour.....	7
11.1.7	Product Use	8
11.1.8	Disposal/Recycling.....	9
11.1.9	Background data.....	10

1 Preface

The case study “Tetra Brik Aseptic® Slim 1,000 ml with LightCap” that follows was elaborated within the scope of the Product Carbon Footprint (PCF) Pilot Project Germany by Tetra Pak GmbH & Co. KG in association with Institut für Umwelt- und Energieforschung GmbH (IFEU). For the PCF Pilot Project, Tetra Pak GmbH & Co. KG joined nine other companies to pursue, together with the project initiators – WWF Germany, Öko-Institut (Institute for Applied Ecology), the Potsdam Institute for Climate Impact Research (PIK) and THEMA1 – the following project objectives:

1. *Gaining experience:* On the basis of concrete case studies, the project initiators and the participating companies gain experience with the practical application of current methods for determining carbon footprints and examine the efficiency of these methods (ISO¹ standards for life cycle assessment, BSI² PAS 2050).
2. *Deriving recommendations:* Based on the findings of the case studies, recommendations are derived for the further development and harmonisation of a transparent, scientifically founded methodology for determining the carbon footprint of products. The pilot project explicitly refrains from developing its own methodology.
3. *Communicating results:* Consumers must be informed of the product carbon footprint in a scientifically sound and comprehensible manner. To this end, the project stakeholders are holding discussions on reliable communication on a sectoral, company and product level to foster climate-conscious purchase decisions and use patterns. The relevance in terms of increasing the climate consciousness of consumer decision making is crucial to these considerations. The pilot project explicitly refrains from developing its own climate-related label since the current methodological conventions are not sufficiently consistent and are still under discussion, meaning that its significance in terms of possible courses of action would therefore be low.
4. *Standardising internationally:* The findings reached and the recommendations derived contribute to a situation in which the PCF Pilot Project Germany actively helps to shape the international debate on the determination and communication of carbon footprints.

¹ International Organization for Standardization.

² The British Standards Institution.

The definitions and uses of the term “product carbon footprint” differ internationally. Within the scope of the PCF Pilot Project Germany, the project stakeholders agreed on the following definition:

“Product carbon footprint describes the sum of greenhouse gas emissions accumulated during the full life cycle of a product (good or service) in a specified application.”

In this context, greenhouse gas emissions are understood as all gaseous materials for which a Global Warming Potential coefficient was defined by the Intergovernmental Panel on Climate Change (IPCC). The life cycle of a product encompasses the whole value chain – from the acquisition and transportation of raw materials and primary products over production and distribution to the use, recycling and disposal of the product. The term “product” is used as a generic term for goods and services.

The project initiators and participating companies regard the international standard for life cycle assessment (ISO 14040 and 14044) as the basic methodological framework for determining a product carbon footprint. Moreover, this standard is the most important foundation of the British PAS 2050 as well as of the above-mentioned dialogue processes of the ISO and the World Business Council for Sustainable Development/World Resources Institute³. Therefore, within the scope of the pilot project, ISO 14040/44 constituted an essential basis for the work carried out on methodologies and thereby for the case studies themselves.

Many of the basic methodological conditions of ISO 14040/44 can be applied in the case of the PCF methodology, but several have to be adapted. Some terms of reference of the ISO 14040/44 are loosely formulated, making it necessary to examine whether it is possible to develop less ambiguous terms of reference which have a comprehensive or product group-specific foundation. This would simplify the comparability of different PCF studies. In addition, within the course of the case studies, the significance of PCF compared to other environmental impacts in the product life cycle was analysed in varying detail. From the perspective of the PCF Pilot Project, this analysis is crucial to the securing of decisions and approaches to communication, which are made and developed on the basis of PCF. Furthermore, creating clearer terms of reference constitutes one of the greater methodological challenges in this context, also in respect of international harmonisation and all applications where public communication of the PCF is intended.

Each participating company selected at least one product from its portfolio for which a PCF was determined. In this way, methodological frameworks or rules of interpretation regarding the ISO 14040/44 could be practically tested using a specific case study. In turn, specific methodological issues also emerged from the case studies. The broad spectrum of products selected for the case studies made for a comprehensive discussion. The involvement of

³ With regard to the WBCSD/WRI process, a final decision has not yet been taken. However, it can be assumed, given the current status of the discussion, that a decision on the ISO 14040/44 will be taken in the coming weeks.

companies from very different sectors in the PCF Pilot Project was challenging but also fruitful, constituting an essential prerequisite for the development or optimisation of a methodology which could be used as broadly as possible. The case study “Tetra Brik Aseptic® Slim 1,000 ml with LightCap” by Tetra Pak GmbH & Co. KG constituted an important component of the project, on the basis of which – together with the diverse experiences gathered in terms of carbon footprinting – the findings and recommendations were developed according to the project objectives.

The most important results of the pilot project are summarised in a paper entitled “*Product Carbon Footprinting – Ein geeigneter Weg zu klimaverträglichen Produkten und deren Konsum? – Erfahrungen, Erkenntnisse und Empfehlungen aus dem Product Carbon Footprint Pilotprojekt Deutschland*“. This paper, along with much more information on product carbon footprinting and the PCF Pilot Project, can be found at: www.pcf-projekt.de

The work carried out within the pilot project should not be understood as the final word on the determination and communication of product carbon footprints. Therefore, the project partners are happy to receive intensive feedback from interested stakeholders, also with regard to the case study presented in the following. Based on this feedback and the project findings, the project initiators and partners wish to actively support international debates on the harmonisation of product carbon footprinting by virtue of their findings. Only in this way, with the help of an internationally accepted standard, can PCFs be determined, assessed and reliably communicated in a uniform and comparable fashion.

Hochheim a. M., 26 January 2009

2 Executive Summary

Tetra Pak is the leading supplier of carton packaging systems. The Tetra Brik Aseptic Slim 1000 mL with LightCap is an aseptic beverage carton used mainly for UHT milk and juices.

This study examined its Global Warming Potential to prepare a Carbon Footprint of this product. For this purpose the whole life cycle of the packaging system from “cradle to grave” has been assessed. The main life cycle steps are the production of raw materials, converting and filling as well as transports, use phase and disposal. For the modelling and assessment this study followed the official standards for Life Cycle Assessments: ISO 14040 and ISO 14044 and the methodical recommendations of the PCF Project. The function examined is the packaging and retail of UHT milk. The functional unit has been set to 1 L of packaged beverage available to the consumer.

Figure 2-1 shows the results of the best guess scenario of this study. The graph shows three bars for the packaging system under investigation, namely the following (as seen from left to right):

- sectoral results of the packaging system itself (stacked bar) “system results”
- credits given for secondary products leaving the system (negative stacked bar) “credits”
- net results (grey bar) as a result of the subtraction of credits from overall Carbon Footprint “net results”

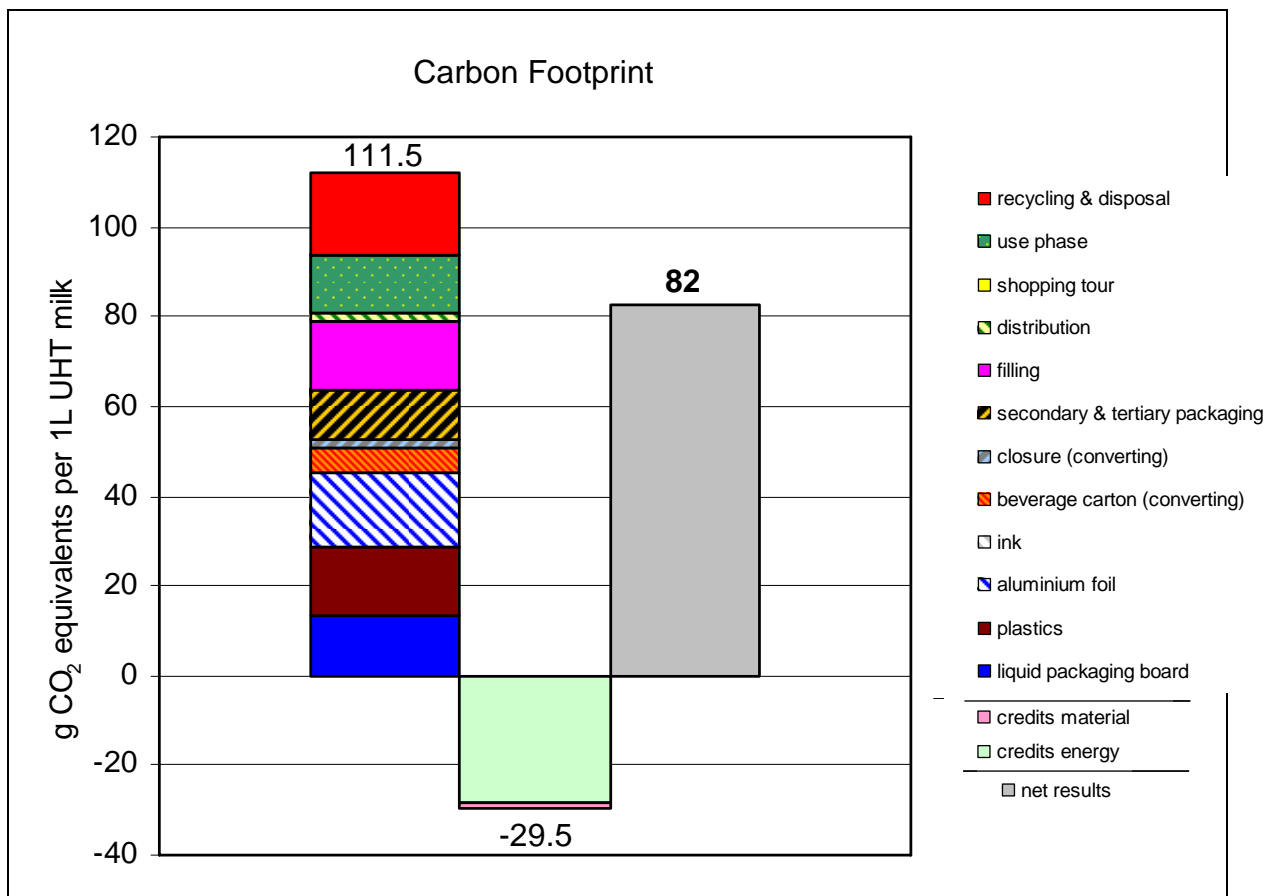


Figure 2-1: Carbon footprint of TBA Slim with LightCap

The overall Carbon Footprint of the TBA Slim with LightCap amounts to 82 g CO₂ equivalents per litre milk packaged. Life cycle phases showing the highest emissions are the production of the three main raw materials, the filling of the beverage carton and the disposal and recycling processes.

The highest potentials to further reduce the Carbon Footprint of the TBA Slim therefore lie in technical improvements in the field of material production and the use of alternative materials for the non-renewable materials used. A higher recycling rate and the adoption of more effective recycling techniques for the recovery of PE and aluminium will also lower the Carbon Footprint as more credits for secondary products can be attributed to the system.

In the course of this study other environmental impact categories such as Acidification, Eutrophication and Use of Nature were also considered. An exclusive focus on green house gas emissions involves the risk of missing other, possibly equally important environmental impacts.

3 Company's Profile

Tetra Pak is the world's leading food processing and packaging solutions company. Working closely with its customers and suppliers, Tetra Pak provides safe, innovative and environmentally sound products that each day meet the needs of hundreds of millions of people around the world. With over 20,000 employees and operations in more than 150 countries, Tetra Pak believes in responsible industry leadership and a sustainable approach to business. In 2007, around 69 billion litres of liquid food had been filled in a total of 137 billion Tetra Pak packaging worldwide. In Germany,

Tetra Pak has long been committed to reducing its emissions – first through its Energy Goal (established in 2000) and then the Climate Goal (established in 2005). Tetra Pak's global climate goal is the core of the company's climate programme: 10% reduction of CO₂ emissions in 2010 vs. 2005 in absolute terms. In absolute terms means that Tetra Pak will reach the absolute reduction of 10% even as they continue to have a strong production increase during the same period. The goal covers all Tetra Pak sites and includes the direct emissions from sites, as well as the indirect emissions from power suppliers providing electricity to Tetra Pak sites. The goal will be achieved through improved energy efficiency and increased use of green power, i.e. electricity generated from renewable energy sources. The green power must meet the ok-power standard for renewable energy recommended by the WWF. Among other criteria, part of the sources must be new and additional. Tetra Pak has qualified for and joined WWF's Climate Savers programme to reduce the company's carbon footprint absolutely.

Furthermore, Tetra Pak's potential impact on the climate is dependent upon its choices of raw materials, production technology and transportation. Consequently the company's climate programme focuses on three parts:

1. Increase the share of renewable materials and energy
2. Increase the recycling and recovery of Tetra Pak packages
3. Increase the efficiency of production and transportation

Through ensuring that 3/4 of the material feedstock is coming from living systems Tetra Pak ensures they work with nature - helping to keep the climate stable naturally. Tetra Pak works with suppliers and environmental groups such as WWF and its forest programmes (Global Forest and Trade Network, and Forest Stewardship Council) and the High Conservation Value Resource Network, to keep forests alive and healthy for the plants and animals that live there.

4 Organisation and Procedures

The responsibility for the PCF Pilot Project and the case study within Tetra Pak Germany-Switzerland was in the Communications and Environment Department, headed by Dr. Heike Schiffler, Director Communications and Environment. The operational coordination of the case study with the external partner, the data gathering within Tetra Pak as well as the communication towards the project initiators and project partners was under responsibility of Caroline Babendererde, Manager Environment at Tetra Pak Germany-Switzerland.

External partner of the case study are Andreas Detzel and Frank Wellenreuther, both from the Institute for Energy and Environmental Research (IFEU), Heidelberg. Within the PCF Pilot Germany, Mr. Detzel and Mr. Wellenreuther participated in the TF Methodology and did the entire modelling of the Tetra Pak beverage carton selected for the case study. They were also entitled to contact directly Tetra Pak responsables in the converting factories in Limburg and Berlin for detailed information.

5 Goals and Scope

5.1 Objectives of the Case Study

With the political importance of climate change the carbon footprint of packaging came into the focus of companies and consumers. Because of many years of experience with product Life Cycle Assessments (LCA) and the importance that LCAs mean for the status of packaging in Germany, Tetra Pak Germany-Switzerland participates in the PCF Pilot Project Germany to mainly work on the methodology for PCF measurement.

For the case study, a Tetra Brik Aseptic Slim 1,000 mL package with LightCap closure has been chosen. Almost 1.8 billion units of TBA Slim were sold in 2007 in Germany, mainly in the UHT milk segment.

5.2 Product Selection and Definition of the Functional Unit

The Tetra Brik Aseptic Slim is a carton packaging system used for the packaging of UHT food and beverages. According to Tetra Pak the TBA Slim 1000 mL with LightCap has the highest market share for the packaging of UHT milk on the German market. As this case study aims to examine a typical product of Tetra Pak's product range it was chosen for this study. It basically consists of a beverage carton compound made of liquid packaging board, low density polyethylene and aluminium foil. The closure consists of high density polyethylene.

The function examined in this case study is the packing, retail and utilisation of UHT milk. The functional unit has been set to 1 litre of packaged UHT milk available at the consumer's home.

5.3 System Boundaries

This case study is designed to follow a “cradle-to-grave” approach. It covers all relevant process steps from raw material sourcing to the final waste treatment or recycling of the used packaging. A general simplified process flow diagram including an indication of the system boundaries for the TBA Slim system is given in figure 5-1.

The studied system starts with the extraction of raw materials from their natural source, followed by production of package components such as polymer granulates or aluminium foil. The transportation of all materials to the subsequent process step is included in the system model. The package components are the starting point for the subsequent converting step, where the package as such is manufactured and then delivered to the milk manufacturer (filler). Again, the transport of the empty carton ready to be filled is included in the system model.

At the milk manufacturer, the UHT milk is filled in the package and undergoes a sterilization process before the actual filling. Whereas the impacts related to the manufacture of the milk itself are excluded from this study, the efforts required for the sterilization process are considered in order to cover packaging-type specific attributes. The filled packs are then distributed to the retailers (i.e. to the point-of-sale).

From the point-of-sale the TBA Slim is transported to the consumer’s home where the use phase of the product is taken into account.

After the consumer use phase the discarded packaging is collected for recovery and final waste treatment, respectively. Waste collection and waste treatment for post-consumer as well as for process waste is included within the system boundaries. For recycling and recovery routes the system boundaries are set at the point where a secondary product is obtained. A secondary product is defined here as a usable or saleable product.

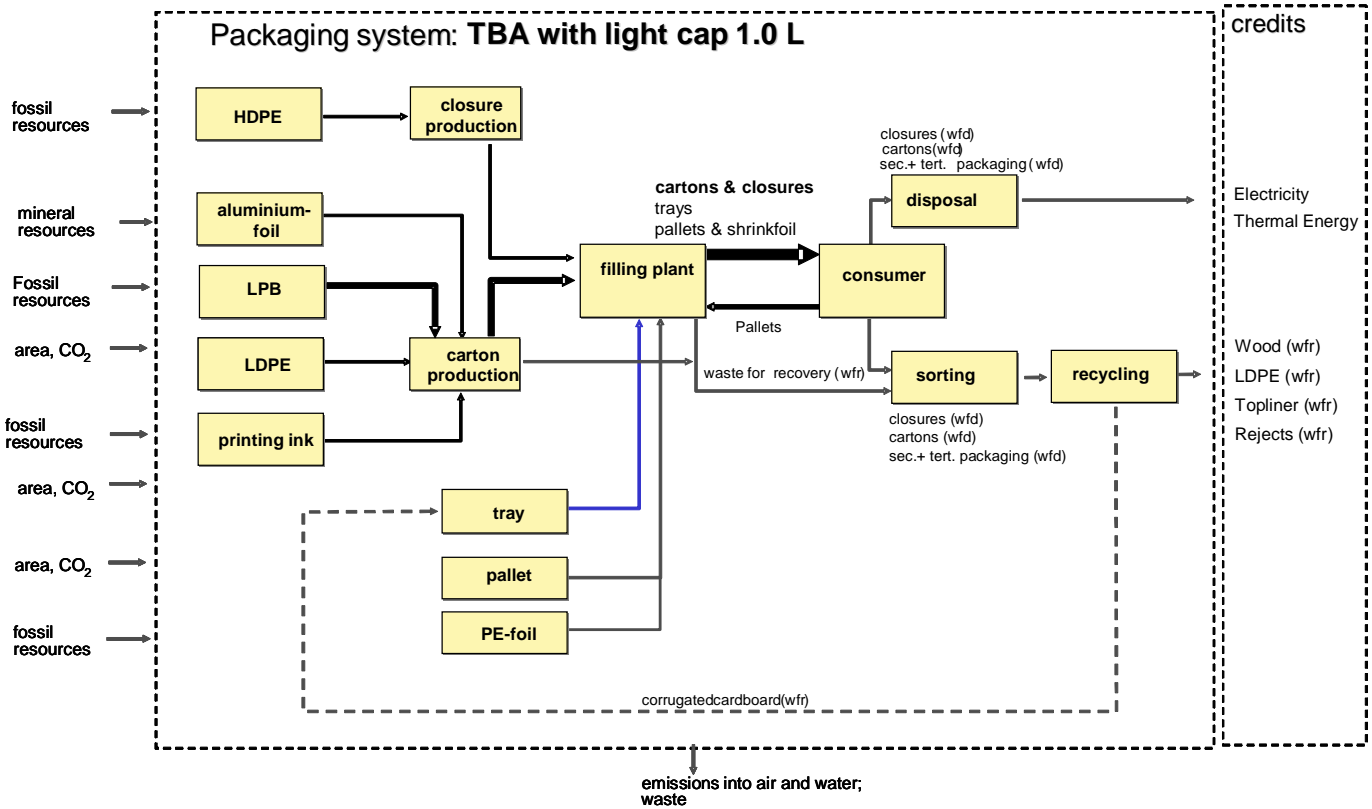


Figure 5-1: Simplified diagram, showing the most important life cycle processes of TBA Slim

Exclusion of food-related aspects

This study examines the TBA Slim as a packaging system; whereas the milk filled in the packs and its pre-chains is not within the scope of the study.

The distribution and shopping tour step respectively in this study consider only the GHG emissions related to the transport of package materials defined by package weight and pallet specification in case of lorry transports.

In general, the study covers the following life cycle steps:

- production, recycling and final disposal of the primary packaging materials
- production, recycling and final disposal of the secondary and tertiary packaging materials (corrugated cardboard trays, reusable crates, pallets, wrap foils)
- production and disposal of process chemicals, as far as not excluded by the cut-off criteria (see below)
- filling process
- distribution of packed milk to the point of sale
- transport of packed milk to the consumer's home
- storage of the packaging as part of the consumer's use phase

Not included are:

- production and disposal of capital goods and infrastructure (machines, transport media, roads, etc.) and their maintenance
- food production
- GHG emissions related to storage phases at central warehouses or the point-of-sale
- GHG emissions of food losses due to breakability of packages
- GHG emissions from accidents
- shelf efficiency
- losses of filled good at different points in the supply chain (losses might occur at several points in the supply and consumption chain, for instance in the filling plant, during handling and storage in the warehouses and in the retail outlets, at consumer homes etc. These losses would mostly be accidental. However, there is no robust data available which would allow for a consistent accountancy of food losses in the context of this case study).

The production of food is not included as the case study is confined to the packaging only. All other exclusions are assumed to be of minimal impact and result from a lack of robust data.

5.4 Data Sources and Data Quality

The datasets used in this study are described in section 6. The general requirements and characteristics regarding data gathering and data quality are summarized in the subsequent paragraphs.

Primary and secondary data

For the modelling of the product system predominantly primary data is used. For the most important activity data for processes in the life cycle of the TBA Slim carton like the production of raw materials, converting and filling, original data was collected from the respective producers like the paper industry, Tetra Pak or the dairy industry. In cases where no primary data could be obtained secondary data is used. These data mainly originate from the internal IFEU database as well as from publicly available databases likeecoinvent or GEMIS. This is also true for the used emission factors. Most of these are developed by IFEU on the basis of literature data like HBEFA [INFRAS 2004].

Geographic reference

The geographic scope of this case study is the German market, so most of the life cycle steps of the TBA Slim have been modelled in consideration of German basic conditions, e.g. German electricity grid mix.

Regarding packaging raw materials, relevant regional aspects and related transports were accounted for whenever data were available. For example the production of liquid packaging board takes place in Sweden and Finland and has been modelled with data from the Nordic suppliers.

Quotas and technologies related to disposal, recovery and recycling mass flows are representative for the average situation in Germany.

Time reference

The reference period of the study is 2000 - 2008. Most of the collected data refer to the period between 2000 and 2008 or overall as close as possible to this time period. The market data and recycling quotas for cartons are of 2007. The dataset for the manufacture of LPB and the converting is of 2007. Filling data is of 2008. A major part of the datasets taken from literature have a reference period between the late 1990s and 2005 (see section 12.1). The datasets for transportation, energy generation and waste treatment processes are taken from the IFEU internal database in the most recent version (time reference between 2002 and 2005).

Technical reference

The process technology underlying the datasets used in the study reflects process configurations as well as technical and environmental levels which are typical for process operation in the reference period.

Completeness and data symmetry

In general, all relevant information and data required for the assessment of the TBA Slim were available and gaps could be filled with good approximates. An exception is data for emissions caused by the storage of the beverage carton at central warehouses and retailers. These storage phases have been omitted from this case study (see section 5.3).

Data symmetry check of underlying datasets has revealed a good data symmetry regarding elementary flows.

5.5 Allocation

Allocation refers to partitioning of input or output flows of a process or a product system between the product system under study and one or more other product systems [ISO 14044, definition 3.17]. This definition comprises the partitioning of flows regarding reuse and recycling, particularly open loop recycling.

In the present study a distinction is made between process-related and system-related allocation. The latter wording refers to allocation procedures in the context of open-loop recycling.

Both approaches are further explained in the subsequent sections.

Process-related allocation

For *process-related allocations*, a distinction is made between multi-input and multi-output processes.

Multi-output processes

For data sets prepared by the authors of this study, the allocation of the outputs from coupled processes is generally carried out via the mass. For some data sets taken from the literature, the calorific value or market value is used as the allocation criterion. The respective allocation criteria are documented in the description of the data in case they are of special importance for the individual data sets. For literature data, the source is generally referred to.

Multi-input processes

Multi-input processes occur especially in the area of disposal. Relevant processes are modelled in such a way that the partial material and energy flows due to disposal of the used packaging materials can be apportioned in a causal way. The modelling of packaging materials that have become waste in a waste incineration plant is a typical example of multi-input allocation. The allocation for e.g. emissions arising from such multi-input processes has been carried out according to physical and/or chemical cause-relationships (e.g. mass, heating value, stoichiometry, etc.)

Transport processes

An allocation between the packaging and content was carried out for the transport of the filled package to the point-of-sale and the subsequent one to the consumer's home. Only the share in GHG emissions related to transport, which is assigned to the package, has been accounted for in this study. The allocation between package and filling good is based on mass criterion.

System-related allocation (open-loop recycling)

The approach chosen for system-related allocation is explained with the help of the graphs shown in figure 5-2. Both graphs show two exemplary product systems, referred to as

product system A and product system B. System A shall represent systems under study in this LCA.

In figure 5-2 (upper graph) in both, system A and system B, a virgin material (e.g. polymer) is produced, converted into a product which is used and finally disposed of via MSWI. A virgin material in this case is to be understood as a material without recycled content.

A different situation is shown in the lower graph of figure 5-2. Here product A is recovered after use and supplied as a raw material to system B avoiding thus the environmental loads related to the production ("MP-B") of the virgin materials, e.g. polymer and the disposal of product A ("MSWI-A"). Note: Avoided processes are indicated by dashed lines in the graphs.

Now, if the system boundaries of the study are such that only product system A is examined it is necessary to decide as to how the possible environmental benefits and loads of the polymer material recovery and recycling shall be allocated (i.e. accounted) to system A. In LCA practice several allocation methods are found.

General notes regarding the graphs 5-2 to 5-5

The following graphs (fig. 5-2 to 5-5) are intended to support a general understanding of the allocation process and for that reason they are strongly simplified. The graphs serve

- to understand the difference between the 0% allocation method, the 50% : 50% allocation method and the 100% allocation method
- to understand which processes are allocated⁴:
 - primary material production
 - recovery processes
 - waste treatment of final residues (here represented by MSWI)

However, within the study the actual situation is modelled which is for example the real recycling flow, the real recycling efficiency as well as the real substituted material including different substitution factors.

For reasons of simplification the following aspects are not explicitly documented in the graphs shown below; for example:

- Material losses occur in both systems A and B. They are of course taken into account and the final disposal of such losses is included in their respective systems.

⁴ according to ISO 14044 (2006) §4.3.4.3.2:

"reuse and recycling ... may imply that the inputs and outputs associated with unit processes for final disposal of products are to be shared by more than one product system"

- Hence not all material from system A is submitted to system B as suggested by the simplified material flow. Consequently only the life cycle steps of the effectively recycled material are allocated between systems A and B.
- Excluded from the graphs are therefore processes relevant for the packaging waste material flow of system A which ends up in the residual waste fraction and undergoes directly a final waste treatment process.
- Within the graphs a substitution factor of 1 has been applied for simplification. In the real calculations substitution factors smaller than 1 are used where appropriate. For example in this study a substitution factor of 0.9 had been used for beverage carton recycling because the material property of recycled carton fibre is slightly different to primary fibre material.
- Even if not relevant in this study the substituted material might be totally different (e.g. wood instead of plastic) which is also not addressed in the graphs below.

The allocation method used in this study is shown in figure 5-4. Figures 5-3 and 5-5 show the two other potential allocation methods. These graphs and the accompanying explanations are only included for better understanding.

In order to do the allocation consistently, besides the virgin material production (“MP-B”) already mentioned above and the disposal of product B (“MSWI-B”), the recovery process “Rec” has to be taken into consideration. This has been highlighted in figure 5-2 by placing these processes in between system A and B. Regarding the waste treatment process (here represented as MSWI-B), burdens or benefits are considered in a similar way as the avoided primary raw material production.

Furthermore, there is one important premise to be complied with by any allocation method chosen: The mass balance of all inputs and outputs of system A and system B after allocation must be the same as the inputs and outputs calculated for the sum of systems A and B before allocation is performed.

Allocation with the 0% method (figure 5-3)

In this method, the assessment of material flows ends with the recovery of post-consumer waste. The method implies that recyclates are not dealt with as co-products. Consequently the benefits of “MP-B” are completely assigned to system B, which also has to carry the full loads of “Rec” and “MSWI-B”. System A, from its viewpoint, receives a zero credit for avoided primary material production, but saves the waste treatment (MSWI-B), which is completely assigned to System B in this case.

The 0%-method could be regarded a simplified approach as it does not require any information, for example, about the quality of recyclates and their potential applications in follow-up product lives.

The 0% allocation method was chosen as sensitivity analysis regarding the choice of allocation method in this study.

Allocation with the 50%-method (figure 5-4)

In this method, benefits and loads of „MP-B“, „Rec“ and „MSWI-B“ are equally shared between system A and B (50/50 method). Thus, system A, from its viewpoint, receives a 50% credit for raw material production and is assigned with 50% of the burden or benefit from waste treatment (MSWI-B).

The 50% method has often been discussed in the context of open-loop recycling, see [Fava et al. 1991], [Frischknecht 1998], [Klöpffer 1996] and [Kim et al. 1997]. According to [Klöpffer 2007], this rule is furthermore commonly accepted as a “fair” split between two coupled systems.

The 50/50 method has been used in several LCA and carbon footprint studies carried out by IFEU and also is the standard approach applied in the packaging LCAs commissioned by the German Environment Agency (UBA). Additional background information on this allocation approach can be found in [UBA 2000].

Allocation with the 100%-method (figure 5-5)

In this method the principal rule applied is that system A gets all benefits for displacing the virgin material and the involved production process „MP-B“. At the same time, all loads for producing the secondary raw material via „Rec-A“ are assigned to system A. In addition, also the loads that are generated by treatment of product B in „MSWI-B“ is charged to system B, whereas the waste treatment of product A is avoided and thus charged neither to System A nor to System B.

One should be aware that in such a case any LCA focusing on system B would then have to assign the loads associated with the production process „MP-B“ to the system B (otherwise the mass balance rule would be violated). However, system B would not be charged with loads related to „Rec“ as the loads are already accounted for system A. At the same time, „MSWI-B“ is not charged to system B (again a requirement of the mass balance rule), as it is already assigned to System A.

The allocation factors have been applied on a mass basis (i.e. the loads of the recycling process are charged with the total loads multiplied by the allocation factor) and where appropriate have been combined with substitution factors. The substitution factor expresses to what degree the secondary material (the recyclate) substitutes a primary material. For example, if recycled fibre replaces virgin wood fibre, a substitution factor of 0.9 is applied, in other words, 1 kg recycled fibres receive a credit for replacement of 0.9kg primary wood fibres.

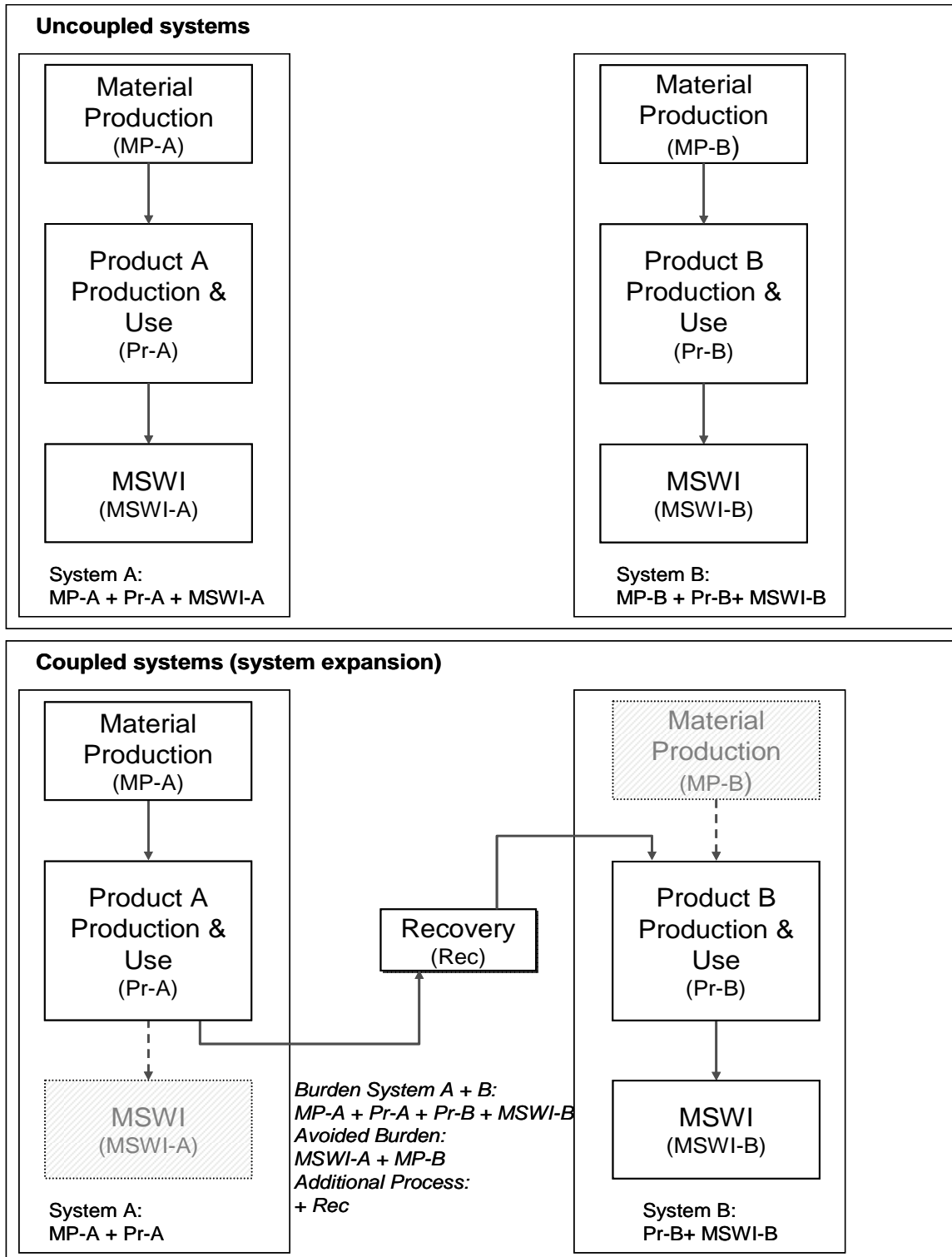


Figure 5-2: Additional system benefit/burden through recycling (schematic flow chart)

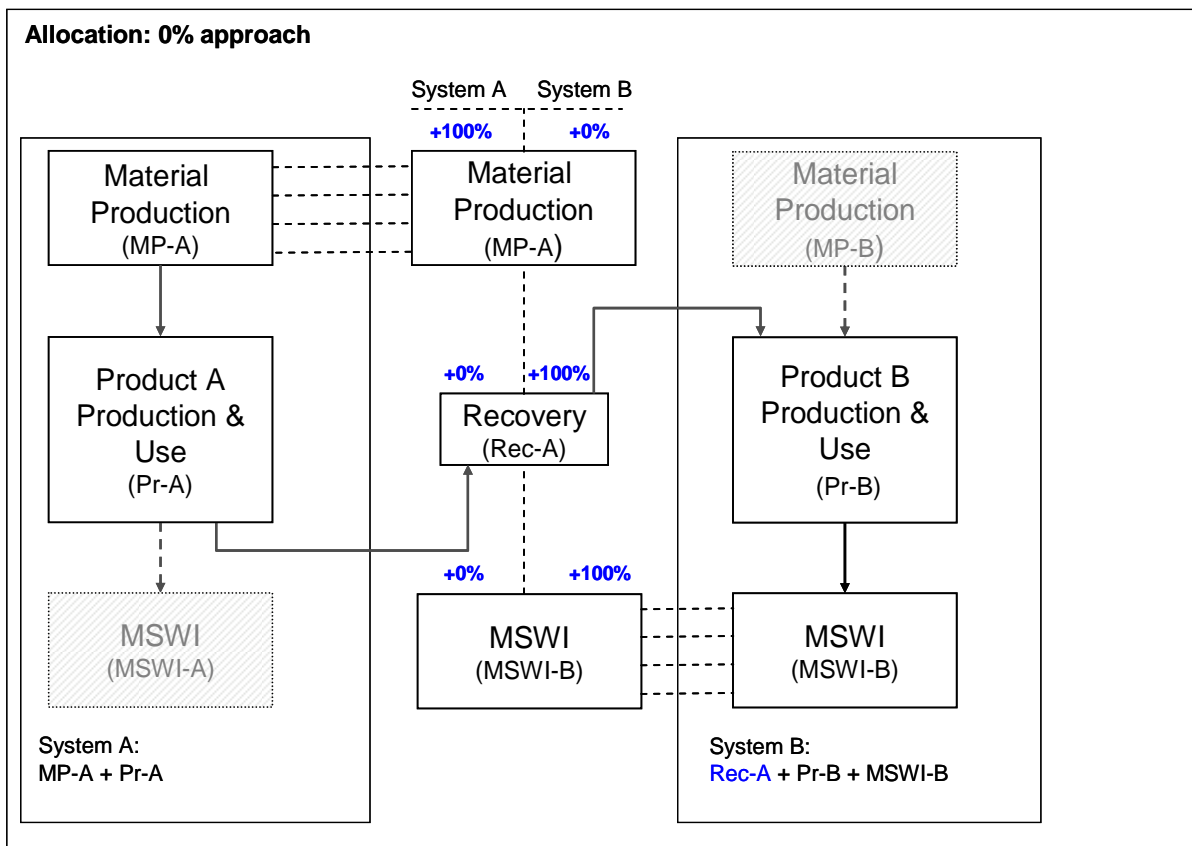


Figure 5-3: Principles of 0% allocation (schematic flow chart)

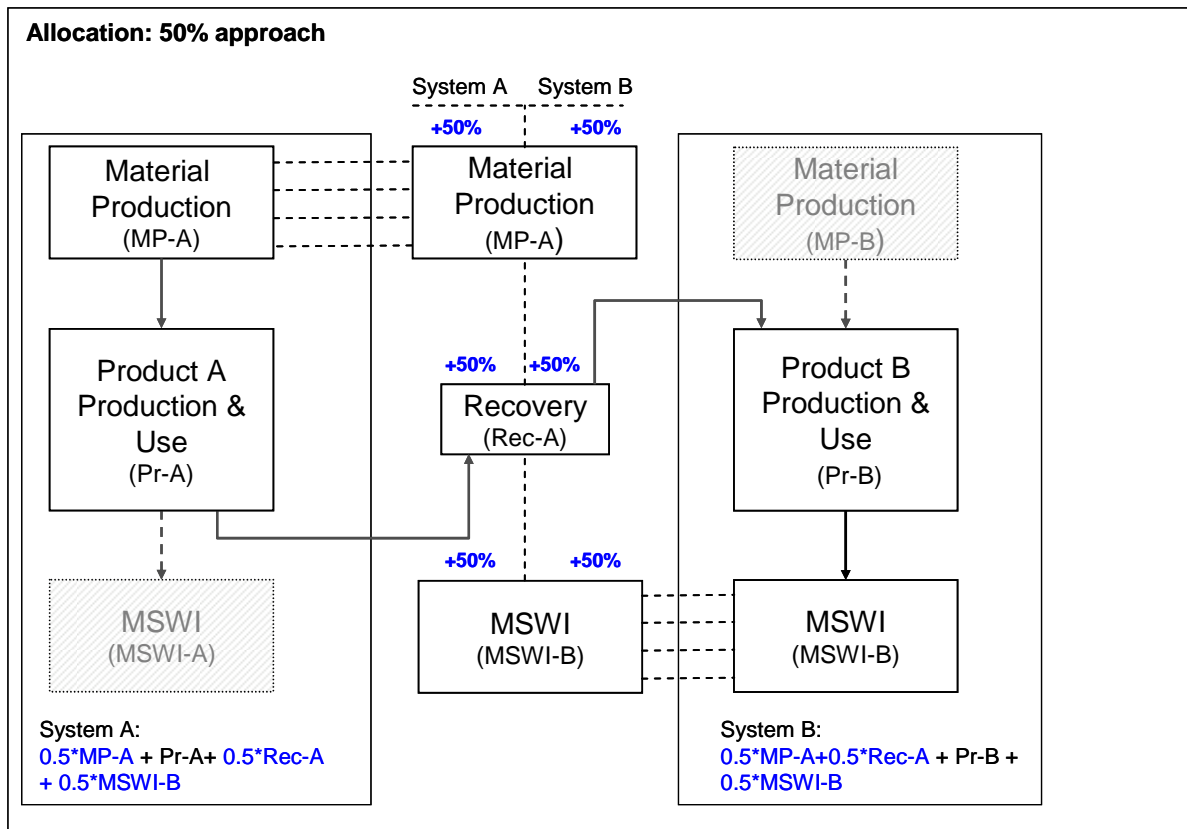


Figure 5-4: Principles of 50% allocation (schematic flow chart)

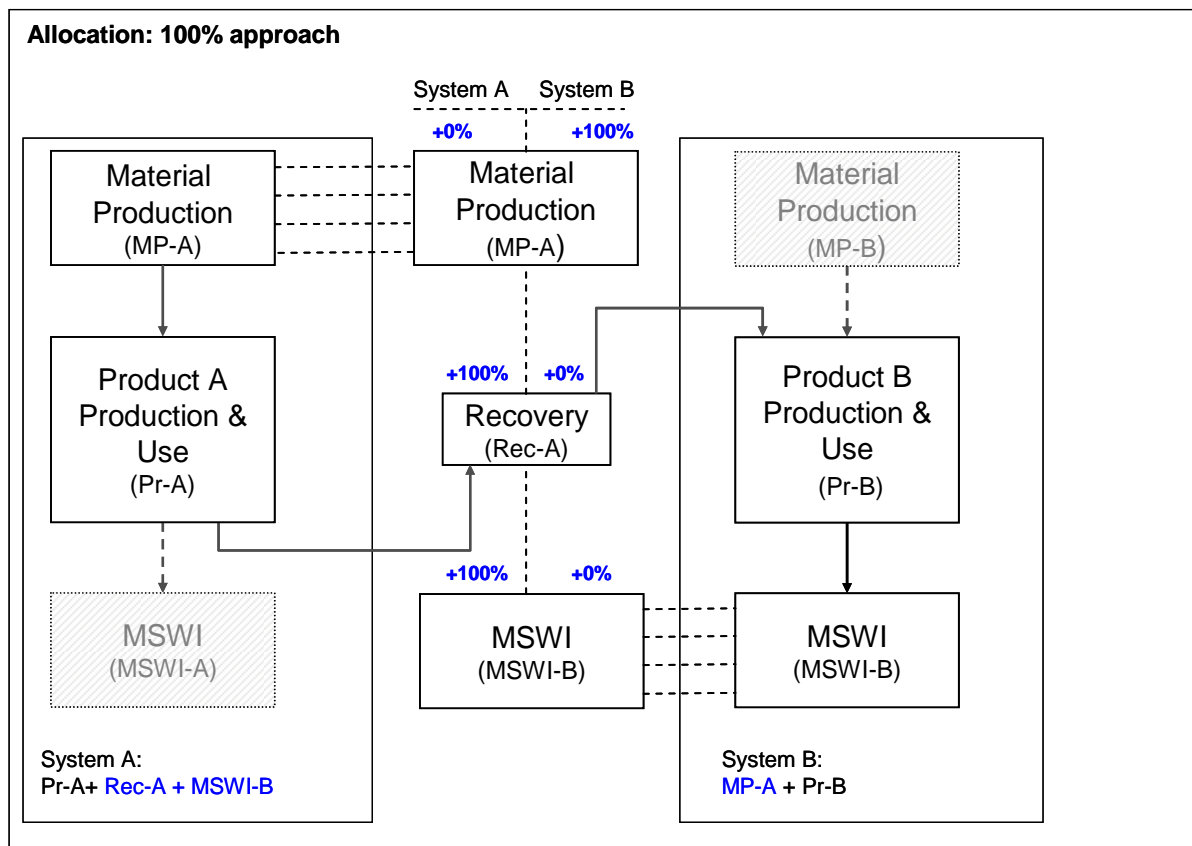


Figure 5-5: Principles of 100% allocation (schematic flow chart)

5.6 Treatment of particular emission sources

In the LCA community two main approaches are taken to model and calculate CO₂ based global warming potential (GWP) related to biogenic carbon at the inventory and impact assessment level. The two approaches in discussion are

- the “carbon-uptake” approach: the non-fossil CO₂ uptake is included in the model with negative GWP values in the growth phase and positive GWP values as it is emitted at end of life; and
- the “carbon-neutral” approach: The uptake of non-fossil CO₂ is disregarded in the GWP and its emission as non-fossil CO₂ has a zero contribution to the GWP.

In the present study approach b) – the carbon neutral approach - has been applied.

6 Inventory and Calculation

Process data on TBA Slim production and converting were either collected at Tetra Pak and producers of raw materials or taken from literature and IFEU's database respectively. Background processes on energy generation, transportation as well as waste treatment and recycling which are continuously updated internally by IFEU-Institute have been used in the most recent format. An overview on datasets used can be found in the annex to this study.

Data validation for industry data used in this study was carried out by cross-check with literature data, manufacturer's/ machine manufacturer's data, and other data available in the IFEU internal database.

For the implementation of the system model the computer tool Umberto[®] (version 5.5) was used. Umberto[®] is standard software for mass flow modelling and LCA. It has been developed by the institute for environmental informatics (ifu) in Hamburg, Germany in collaboration with IFEU, Heidelberg.

The system model and the related module processes were implemented into mass-flow scenarios. Calculation of input/output balances was scaled to the defined functional flow. Input/output balances are composed of elementary and non-elementary flows. Elementary flows are materials or energy entering the system being studied, which have been drawn from the environment without previous human transformation or materials and energy respectively leaving the system, which are discarded into the environment without subsequent human transformation. The materials listed in the input/output balances are compiled into environmental profiles.

6.1 Extraction of Raw Materials

Low density polyethylene

Low density polyethylene (LDPE) is manufactured in a high pressure process and contains a high number of long side chains. The present carbon footprint study uses the ecoprofile published on the website of Plastics Europe (data last calculated March 2005) [Plastics Europe 2005a].

The data set covers the production of LDPE granulates from the extraction of the raw materials from the natural environment, including processes associated with this. The data refer to the 1999 time period and were acquired from a total of 27 polymerisation plants producing 4,480,000 tonnes of LDPE annually. The total production in Europe in 1999 was ca. 4,790,000 tonnes. The data set hence represented 93.5% of LDPE production in Western Europe. Transport distance of LDPE from the production site to the converting site in Limburg is 1025 km. Transport is by articulated lorry.

High density polyethylene

High density polyethylene (HDPE) is produced by a variety of low pressure methods and has fewer side-chains than LDPE. The present carbon footprint study uses the data published on the website of Plastics Europe (data last calculated March 2005) [Plastics Europe 2005b].

The data set covers the production of HDPE granulates right from the extraction of the raw materials from the natural environment, including processes associated with this. The data refer to the 1999 time period and were acquired from a total of 24 polymerisation plants producing 3,870,000 tonnes of HDPE annually. The total production in Europe in 1999 was ca. 4,310,000 tonnes. The data set hence represented 89.7% of HDPE production in Western Europe. Transport distance of LDPE from the production site to the converting site in Limburg is 1025 km. Transport is by articulated lorry.

Aluminium bars and foils

The data set for primary aluminium covers the manufacture of aluminium ingots starting from bauxite extraction, via aluminium oxide manufacture and on to the manufacture of the final aluminium bars. This includes the manufacture of the anodes and the electrolysis. The data set is based on information acquired by the European Aluminium Association (EAA) covering the year 2005. Respectively, this represented 90% to 92% of the single production steps alumina production, past and anode production, as well as electrolysis and casthouse of the primary aluminium production in Europe [EAA 2008].

The data set for aluminium foil (5-200 µm) are based on data acquired by the EAA together with EAFA covering the year 2005 for the manufacture of semi-finished products made of aluminium. For aluminium foils, this represents 51% of the total production in Europe (EU27 + EFTA countries). According to EAA [EAA 2008], the foil production is modelled with 20% of the production done through strip casting technology and 80% through classical production route. The LCI dataset is according to EAA applicable for foils with a thickness range of 5-200 µm.

For the present carbon footprint study, aggregated LCI datasets for primary aluminium and aluminium foil are used as published in the EAA report [EAA 2008].

Transport distance of aluminium foil from the production site to the converting site in Limburg is 180 km. Transport is by articulated lorry.

Production of liquid packaging board (LPB)

The data set for the production of liquid packaging board is modelled based on data gathered from several Nordic LPB producers and covers the following process steps in the manufacture of liquid packaging board:

- Pulping
- Bleaching
- Board making

The dataset was coupled with data sets for the process chemicals used from IFEU's database, including a forestry model to calculate inventories for this sub-system. The specific energy sources (i.e. Finnish and Swedish electricity mix) were also taken into account. Data gathered refer to the years 2002-2004. Transport distance of LPB from the production site to the converting site in Limburg is 1890 km. Transport is by sea ship, train and articulated lorry.

Printing Ink

For the manufacture of the printing ink used for the TBA Slim no current data could be obtained by the practitioners of this study. A proxy data set for water based printing inks is taken from the study: "Ökologischer Vergleich graphischer Papiere" [IFEU 1998] is used. Transport distance though has been verified by Tetra Pak and amounts to 35 km. Transport is by articulated lorry.

6.2 Converting

Manufacture of carton laminate for TBA Slim

The carton laminate consist of a LPB layer, a polymer layer as well as an aluminium foil layer. The core converting steps are:

- extrusion of LDPE
- lamination of liquid packaging board
- printing, cutting and packing of coated board

Data regarding the manufacture of carton laminates at the production site in Limburg has been provided by Tetra Pak. Process data provided by Tetra Pak was then coupled with required prechains, such as process heat and grid electricity. Tetra Pak uses "green electricity" for their converting processes at the Limburg site. This is accounted for in sensitivity analyses A1 and A2 (see section 8.1) Transport distance from the production site in Limburg to the filling sites averages to 111 km. Transport is by articulated lorry.

6.3 Secondary and tertiary packaging

Corrugated board and cardboard trays

For the manufacture of corrugated cardboard and corrugated cardboard packaging the data sets published by FEFCO in 2006 [FEFCO 2006] were used. More specifically, the data sets for the manufacture of "Kraftliners" (predominantly based on primary fibres), "Testliners" and "Wellenstoff" (both based on waste paper) as well as for corrugated cardboard packaging were used. The data sets represent weighted average values from European locations recorded in the FEFCO data (see also table 6-1). They refer to the year 2005.

Table 6-1: FEFCO data sets used for corrugated cardboard

Cardboard material	Publication date	Reference year	Representative-ness	Production Countries covered
Kraftliner	2006	2005	>80%	AT, FI, FR, PL, SK, SE
Testliner	2006	2005	51%	AT, BE, CZ, FR, DE, IT, NL, ES, GB
Wellenstoff	2006	2005		
Corrugated cardboard and trays	2006	2005	24% (162 plants)	AT, BE, CZ, DK, EE, FI, FR, DE; GR, HU, LV, IT, LT, NL, NO, PL, RU, ES, SE, CH, GB

In order to ensure stability, a fraction of fresh fibres is often used for the corrugated cardboard trays. According to [FEFCO 2006] this fraction on average is 18% in Europe. Due to a lack of more specific information, this split was also used for the present study. Transport distance of corrugated cardboard trays from the production site to the filling site is assumed to be 400 km. Transport is by articulated lorry.

LDPE stretch foil

For the modelling of the production of LDPE stretch foil the same data set was used as for the production of low density polyethylene used for the manufacture of carton laminate.

Wood and pallets

For the manufacture of wooden pallets a data set based on UBA data from the internal IFEU database was used.

Transport distances for wood are assumed to be 70 km to the manufacturer of pallets and 295 km for the pallets themselves. Both transports are by articulated lorry.

6.4 Filling

Filling data for TBA Slim was provided by the German filling industry in 2008 and is based on effective capacities of respective filling lines. The data has been cross-checked with machine data from machine producers and the internal IFEU database.

The filling data include all filling process steps which are not related to the treatment of the milk as such (package handling, filling, check weighing, packaging and palletizing of filled packs for retail, etc.).

6.5 Distribution

The transport distance from filler to retailer is assumed to be 360 km. This distance has been determined for the distribution of milk in another yet unpublished study for a German dairy company (2008). It results from one filling site only, but is considered to be of average value. It is implemented in the model as a two-stage delivery to retailers, where the first step indicates the transport to a central warehouse, and the second represents the delivery from a central warehouse to the supermarket (point-of-sale).

Overall structure of the distribution model is shown in figure 6-1 and distances and assumed lorry types are summarized in table 6-1. It is aimed at to include typical lorry specifications in this study.

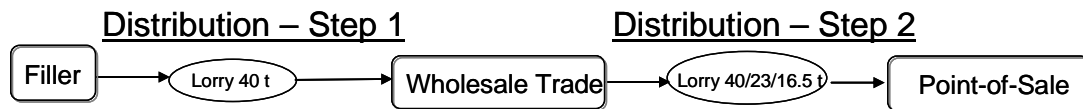


Figure 6-1: Simplified distribution model for delivery to the point-of-sale.

In the life cycle model, emissions related to distribution have been allocated between milk and packaging based on respective masses and on the degree of utilisation of the lorry. The lorry model for the 40 t articulated trucks is based on 23 tonnes maximum load and a maximum number of 34 pallets per lorry.

Table 6-2: Overview on distribution distances and lorry types for retail

Parameter	Transport distance (km)	Vehicle type (percentage)			
		Articulated lorry	lorry+ trailer	lorry	lorry
		40 t	40 t	23 t	16.5 t
Distribution – Step 1	270	50 %	50 %	0 %	0 %
Distribution – Step 2	90	34 %	0 %	33 %	33 %
Total distance	360	-	-	-	-

6.6 Shopping Tour

For the purpose of this study it is assumed that the consumer's shopping tour is done by the means of an average passenger car. The transport distance from the point-of-sale to the consumer's home is assumed to be 5 km. Furthermore an assumption is made of a basket of goods with a mass of 20 kg. This basket contains one TBA Slim carton. Emissions are allocated to it by mass (of the packaging material only).

6.7 Product Use

UHT milk packaged in aseptic beverage cartons has not to be stored in a fridge as long as the package is unopened. Cooled storage is recommended after the TBA Slim has been opened for the first time. The milk should be used by 3-5 days after first opening. For the purpose of this study it is assumed that the TBA Slim is stored in an average sized fridge with average electricity consumption rates for 5 days. Electricity consumption data for fridges is taken from the EcoTopTen study by Öko-Institut e.V. of the year 2004 [ÖKO-INSTITUT 2004]. Allocation of emissions from the operation of the fridge to the TBA Slim is done by volume.

6.8 Recycling and Disposal

Standard beverage cartons like the TBA Slim are positively sorted into a beverage carton fraction, which subsequently is sent to a paper recycling facility for fibre recovery. Related process data are taken from the IFEU internal database.

The secondary fibre material is used e.g. as a raw material for cardboard. The rejects (plastics and aluminium compounds) are assumed to undergo a thermal treatment in cement kilns where the energy content of the reject substitutes the use of fossil fuels, whereas the aluminium content is substituting bauxite in cement production.

6.9 Background data

Electricity generation

Modelling of electricity generation is particularly relevant for the production of raw materials as well as for the converting and filling process. Electricity generation was considered using the Nordic mix of energy suppliers in the year 2004 for the production of liquid packaging board and the German mix of energy suppliers in the year 2006 for the converting and filling process. The German grid mix is also considered for all end-of-life related processes (such as recycling operations). The emission factor for this grid mix is 598 kg CO₂ equivalents per MWh.

The mix of energy suppliers to the Nordic electricity networks was determined by using data from the Statistical Office of the European Communities. [EUROSTAT 2004]. The weekly reports of the German Economy Research Institute (DIW) were used to derive the electricity mix for Germany. Table 6-3 shows the mix of energy sources for the German electricity grid.

Table 6-3: Mix of energy resources in electricity production of Germany

Energy resource	Germany 2006 Share [%]
Hard coal	20.9%
Lignite	23.4%
Mineral oil	1.1%
Natural gas	13.5%
Nuclear energy	26.6%
Hydroelectric (without pump or regenerative)	3.6%
Wind power	5.1%
Other	5.8%
Source: Germany: [DIW 2007]: DIW-Wochenberichte, Nr. 8/2007	

The modelling of power plants was carried out based on emission measurement data available from the IFEU internal database, which were supplemented by data taken from literature such as [GEMIS 2001], [Ecoinvent 2003], [Ecoinvent 2007].

Lorry transport processes

The dataset used is based on standard emission data that were collated, validated, extrapolated and evaluated for the German, Austrian and Swiss Environment Agencies (UBA Berlin, UBA Vienna and the Bundesamt für Umwelt (BAFU, Bern) in the “Handbook of emission factors” [INFRAS 2004]. The “Handbook” is a database application and gives as a result the transport distance related fuel consumption and the emissions differentiated into lorry size classes and road categories. Data are based on average fleet compositions within several lorry size classes. The emission factors used in this study refer to the year 2005.

Based on the above-mentioned parameters – lorry size class and road category - the fuel consumption and emissions as a function of the transport load and distance were determined.

7 Presentation of Results (best guess)

7.1 Overview

The results of this Carbon Footprint study are presented in this section in graphical format as bar charts which are broken down to individual life cycle steps, so-called sectors, which are:

- the production and shipping of liquid packaging board (“liquid packaging board”)
- the production of plastics (LDPE, HDPE) used for the carton sleeve as well as for its closure (“plastics”)
- the manufacture of aluminium foil for the carton sleeve (“aluminium foil”)
- the manufacture of printing ink for the carton sleeve (“ink”)
- the production of the carton sleeve (“beverage carton (converting)”)
- the production of the carton closure (“closure (converting)”)
- the production of secondary and tertiary packaging materials for distribution: corrugated cardboard, LDPE shrink film, pallets (“secondary & tertiary packaging”)
- the filling process (“filling”)
- the retail of the filled packaging from the filler to the point-of-sale (“distribution”)
- the transport of the filled packaging from the point-of-sale to the home of the consumer (“shopping tour”)
- the cooling of the opened packaging in the product use phase (“use phase”)
- the recycling and disposal of used packaging materials (“recycling & disposal”)

Secondary products (recycled materials or recovered energy) are obtained through recovery processes of used packaging materials. Typically, recycled fibres from the carton, may replace primary fibres. It is assumed that those secondary materials are used by a subsequent system. In order to consider this effect, the Carbon Footprint of the packaging system under investigation is reduced by means of credits based on the environmental loads of the substituted material. The so-called 50% allocation method has been used for the crediting procedure (see section 5.5) This is only of relevance for material credits.

The credits are shown in form of separate bars in the LCA result graphs (figures 7-1 to 7-9). They have been broken down into:

- Credit for mechanical recycling (fibre recycling of beverage carton packages) (“credits materials”)
- Credit for energy recovery (replacing e.g. grid electricity) (“credits energy”)

Each graph shows 3 bars for the packaging system under investigation, namely the following (as seen from left to right):

- sectoral results of the packaging system itself (stacked bar) “system results”
- credits given for secondary products leaving the system (negative stacked bar) “credits”
- net results (grey bar) as a result of the subtraction of credits from overall Carbon Footprint “net results”

All Carbon Footprint results refer to the primary, secondary and tertiary packaging material flows required for the delivery of 1 litre of UHT milk to the consumer including the use phase and end-of-life of the packaging materials.

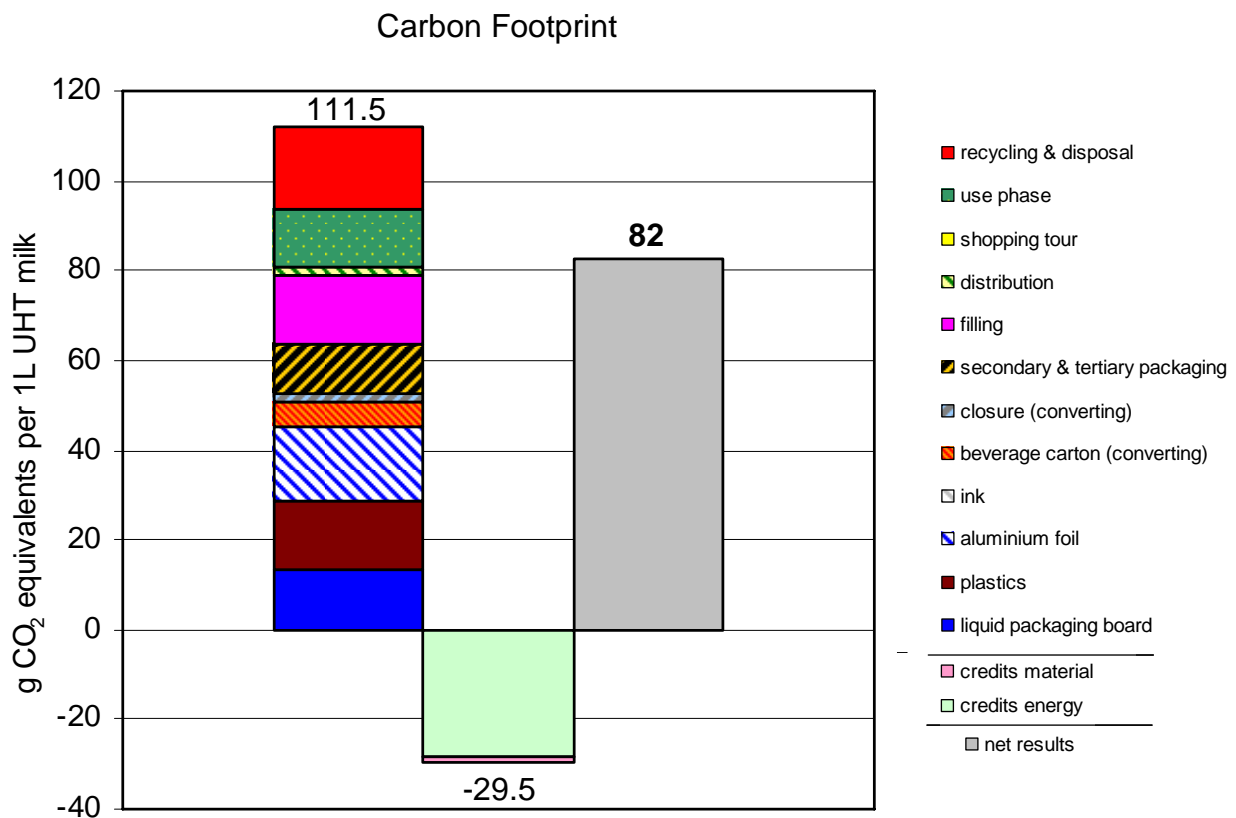


Figure 7-1: Carbon footprint of TBA Slim with light cap

Figure 7-1 shows the overall Carbon Footprint result of the TBA Slim beverage carton with LightCap. It amounts to 82 g of CO₂ equivalents per 1 litre of UHT milk packaged. The biggest shares are contributed by the production of raw materials, the filling process and the disposal and recycling processes as well as the energy recovery attributed as credit.

Main drivers are the emissions from energy consumption especially for the production of raw materials, the filling process and the use and end-of-life phases respectively.

7.2 Extraction of Raw Materials

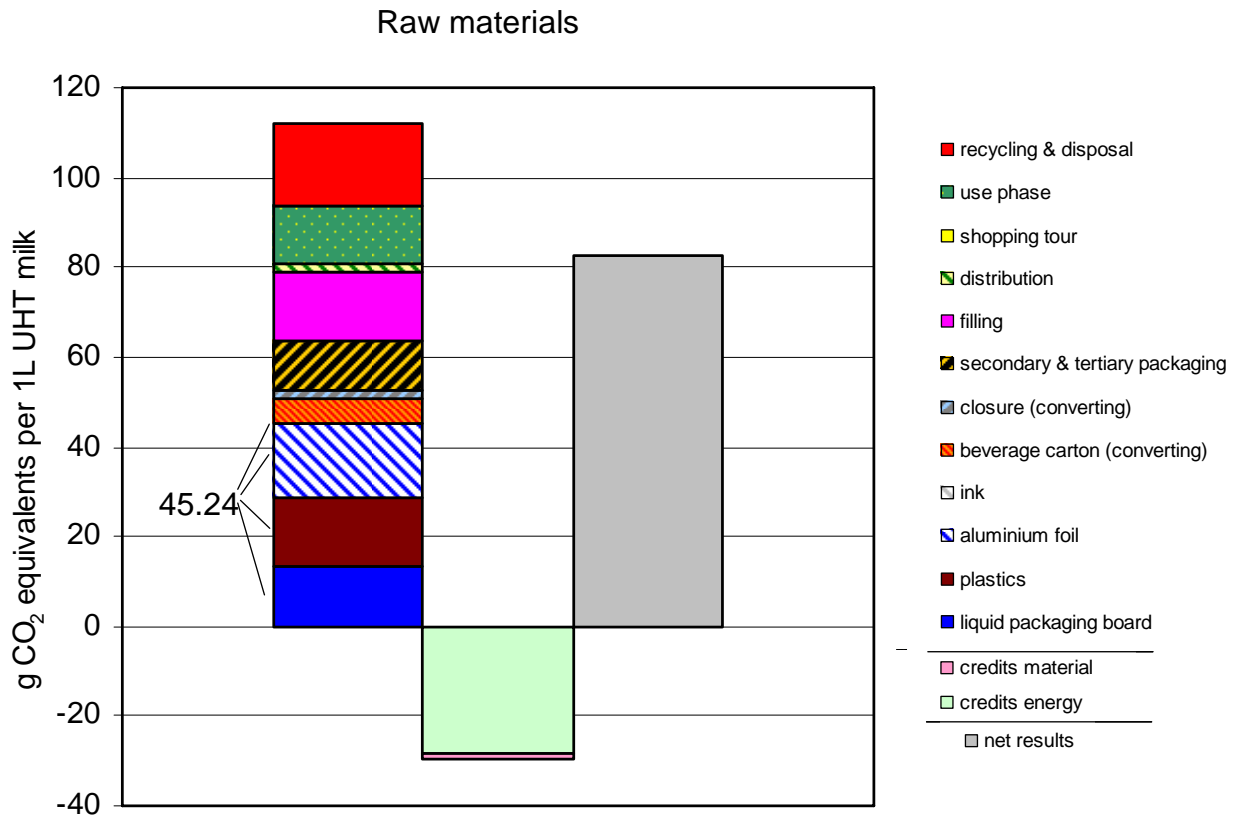


Figure 7-2: Carbon footprint of TBA Slim with light cap – life cycle step: raw materials

The extraction and production of raw materials for the TBA Slim carton amount to emissions of 45.24 g CO₂ equivalents per 1 litre of UHT milk packaged. This result is made up of the emissions resulting from the provision of liquid packaging board, plastics for carton and closure, aluminium foil and printing ink. The biggest share (16.59 g) derives from the production of aluminium foil, while the production of printing ink is almost insignificant (0.06 g).

Main driver of this life cycle step is the high electricity consumption for the production of raw materials, especially for the production of aluminium foil.

An uncertainty of these data results from the use of heavily parameterised data sets for the production of plastics and aluminium.

7.3 Production

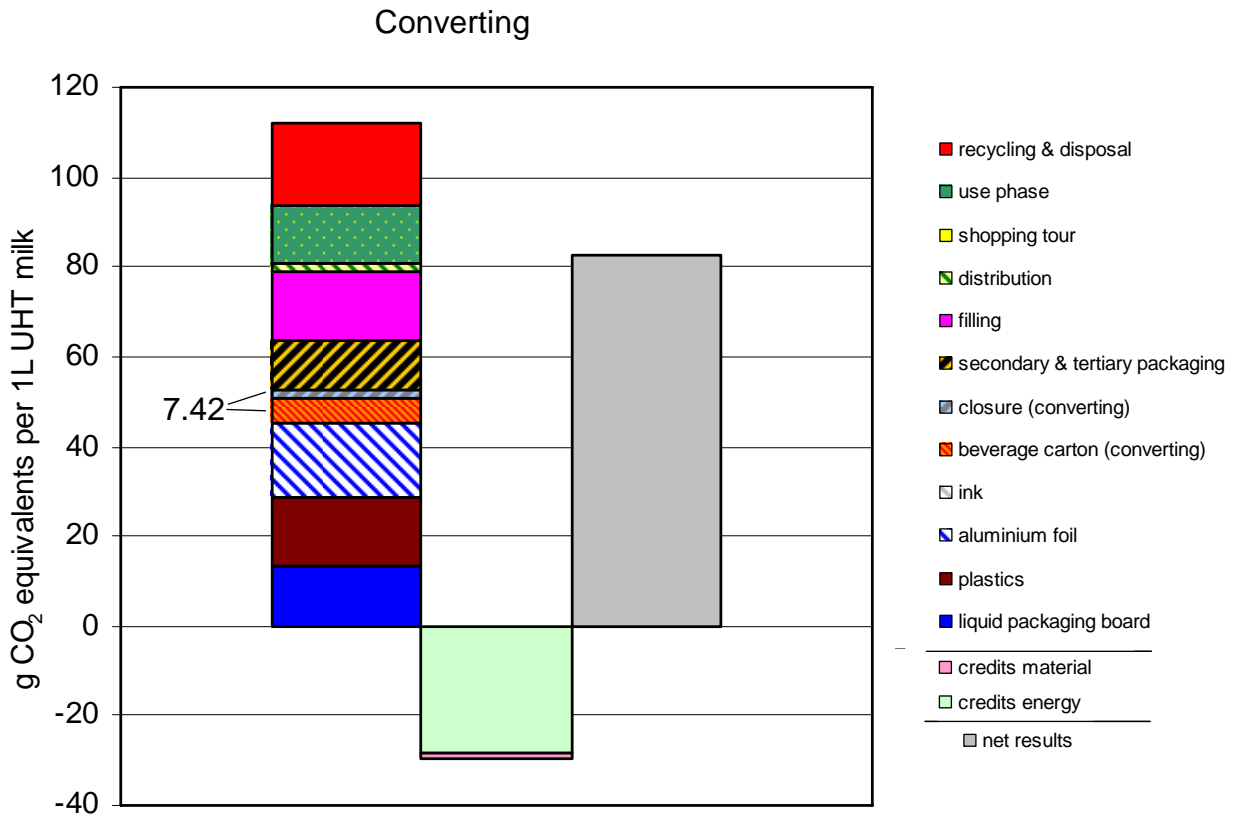


Figure 7-3: Carbon footprint of TBA Slim with light cap – life cycle step: converting

The production of the TBA Slim carton including its closure amounts to emissions of 7.42 g CO₂ equivalents per 1 litre of UHT milk packaged. This result is made up of the converting processes for the actual carton sleeve and the plastic closure. The share of the converting process of the sleeve (5.25 g) is approximately 2.5 times higher than the one for the closure (2.17 g).

Main driver of this life cycle step is the electricity consumption for the converting of beverage carton sleeves.

An uncertainty of these data results from the assessment of Tetra Pak’s use of “green electricity” for their converting processes. See sensitivity analysis I, section 8.1.

7.4 Secondary & Tertiary Packaging

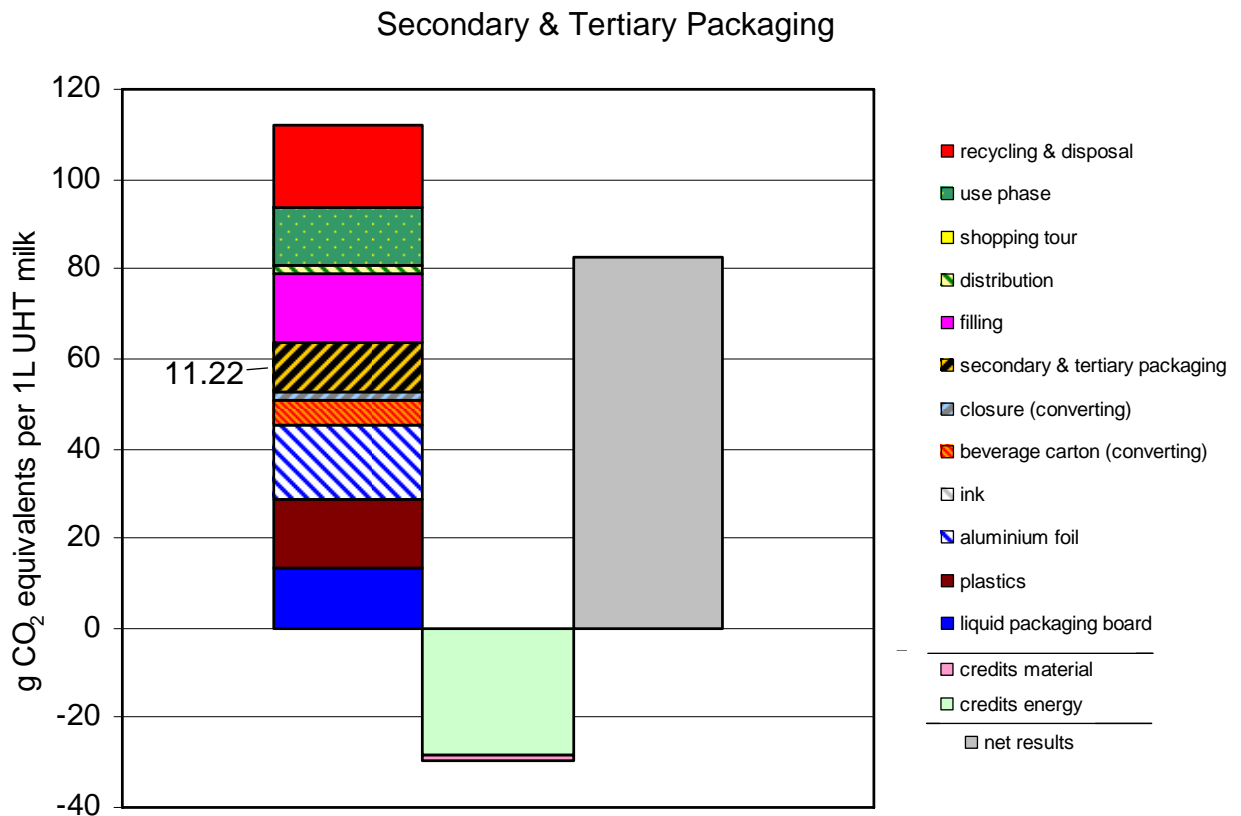


Figure 7-4: Carbon footprint of TBA Slim with light cap – life cycle step: secondary and tertiary packaging

The production of the secondary and tertiary packaging of the TBA Slim carton amounts to emissions of 11.22 g CO₂ equivalents per 1 litre of UHT milk packaged. Examples for secondary and tertiary packaging are paperboard trays, shrink foil made from PE and wood pallets. This result is made up of the production processes of the used packaging products as well as the extraction of their raw materials.

Main driver of this life cycle step is the electricity consumption for the production of LDPE foil.

7.5 Filling

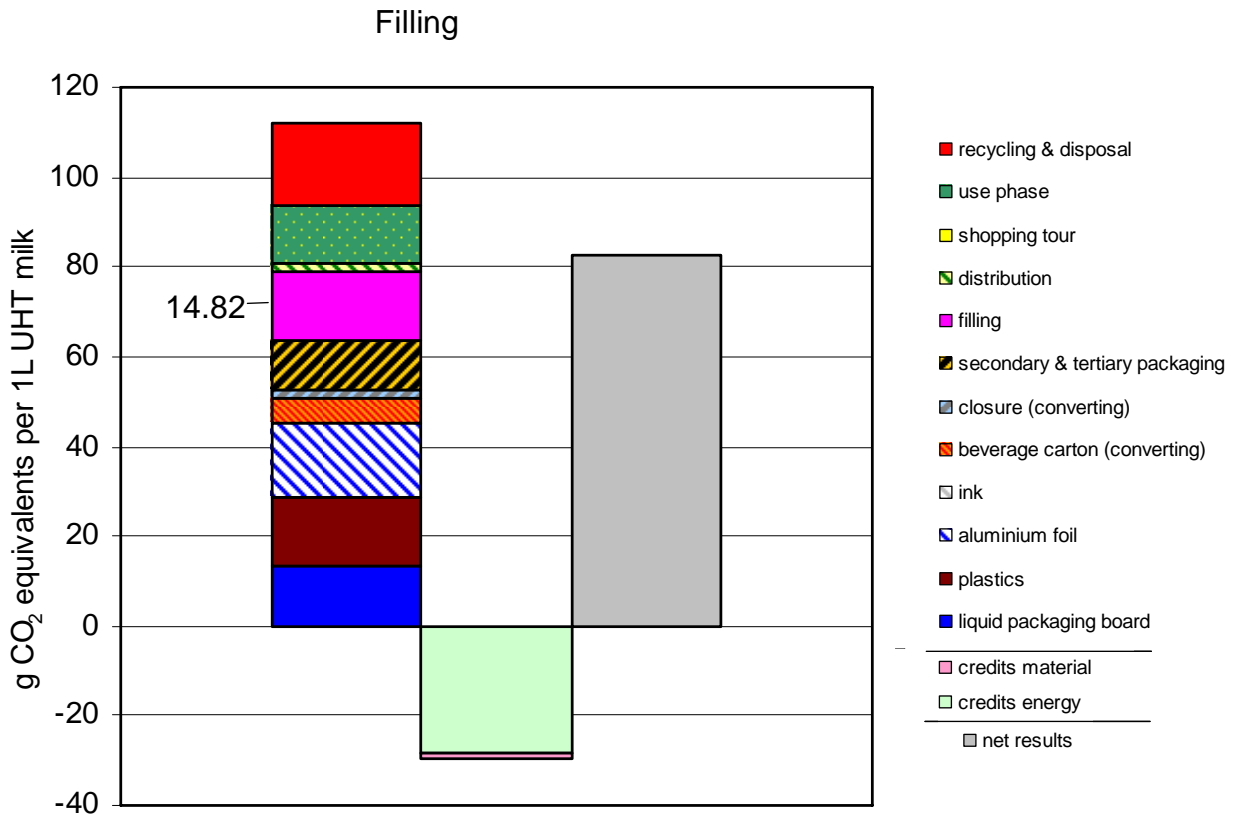


Figure 7-5: Carbon footprint of TBA Slim with light cap – life cycle step: filling

The filling process of UHT milk into the TBA Slim carton amounts to emissions of 14.82 g CO₂ equivalents per 1 litre of UHT milk packaged.

Main driver of this life cycle step is the electricity consumption of the filling line.

7.6 Distribution

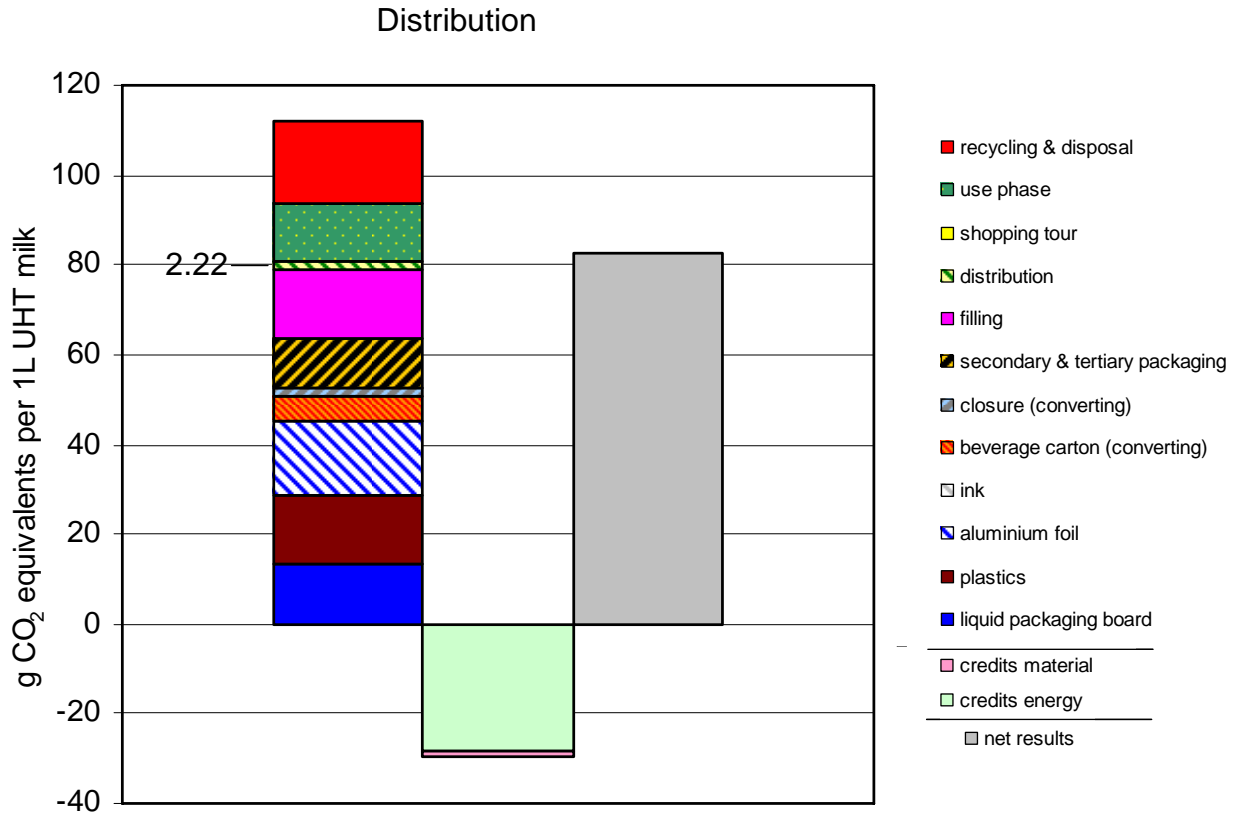


Figure 7-6: Carbon footprint of TBA Slim with light cap – life cycle step: distribution

The distribution of the TBA Slim carton from the filling plant to the point-of-sale amounts to emissions of 2.22 g CO₂ equivalents per 1 litre of UHT milk packaged.

Main driver of this life cycle step is the diesel consumption of transporting lorries.

7.7 Shopping Tour

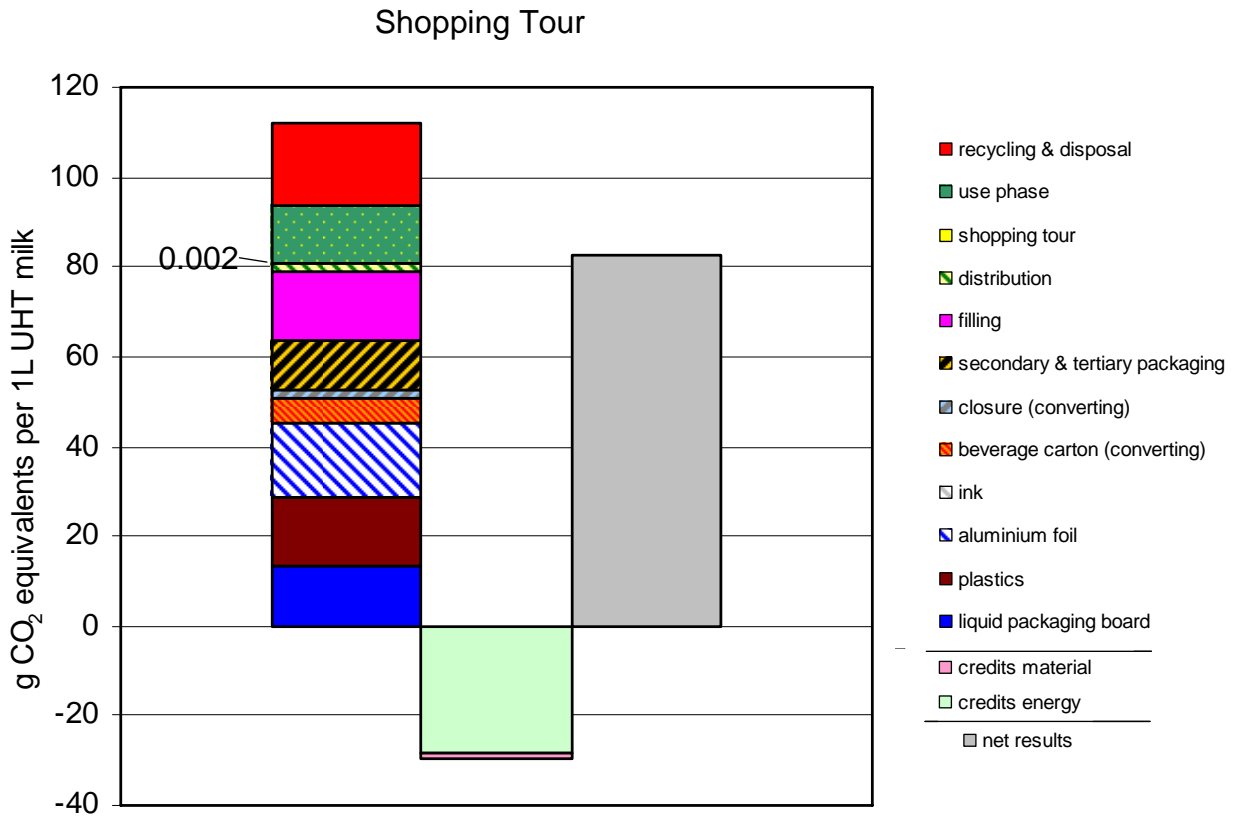


Figure 7-7: Carbon footprint of TBA Slim with light cap – life cycle step: shopping tour

The transport of the TBA Slim carton from the point-of-sale to the customer’s home amounts to emissions of 0.002 g CO₂ equivalents per 1 litre of UHT milk packaged.

Main driver of this life cycle step is the fuel consumption of passenger cars used for the shopping tour.

An uncertainty of these data results from the difficulties to specify a typical shopping trip of a consumer and the allocation of other goods transported.

7.8 Product Use

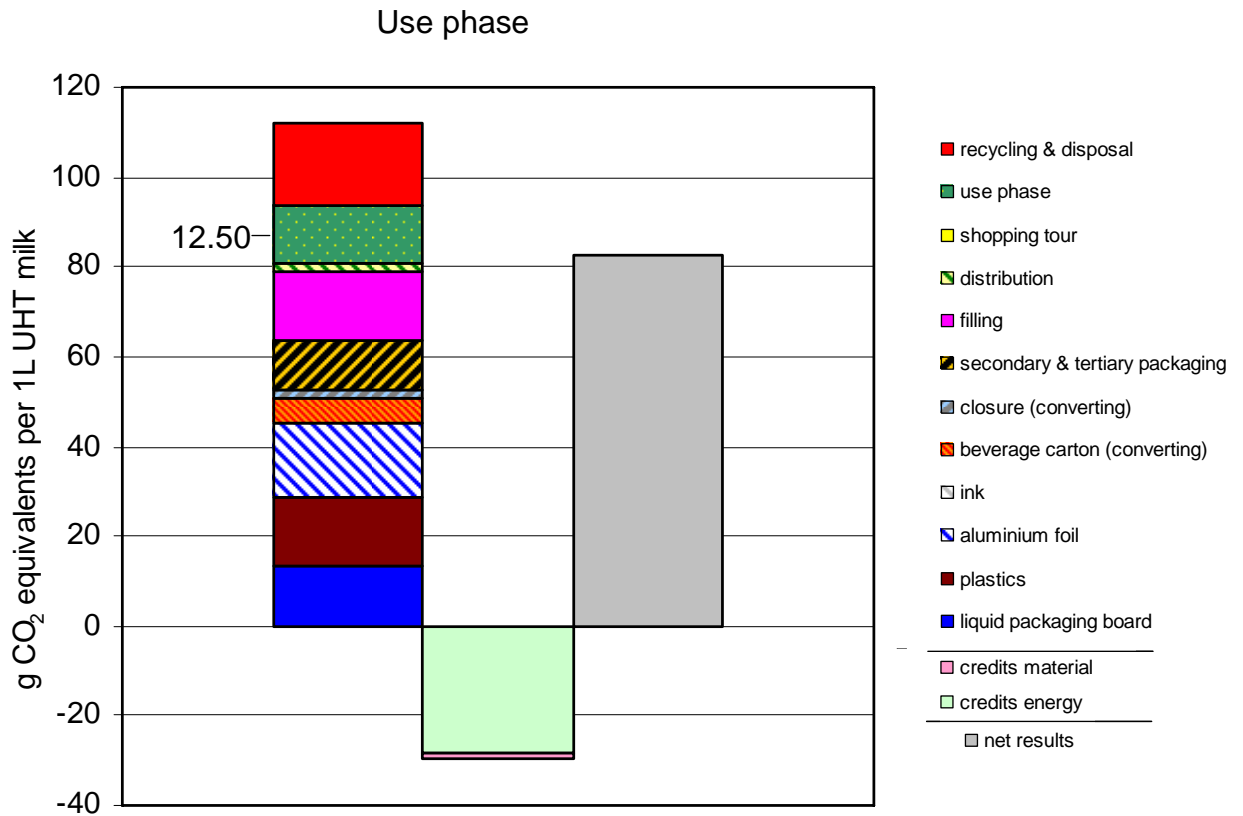


Figure 7-8: Carbon footprint of TBA Slim with light cap – life cycle step: use phase

The product use phase of the TBA Slim carton amounts to emissions of 12.50 g CO₂ equivalents per 1 litre of UHT milk packaged.

Main driver of this life cycle step is the electricity consumption of a fridge used for cooling the contained milk once the packaging has been opened.

An uncertainty of these data results from the difficulties to specify a typical consumer behaviour towards the packaged UHT milk.

7.9 Disposal/Recycling

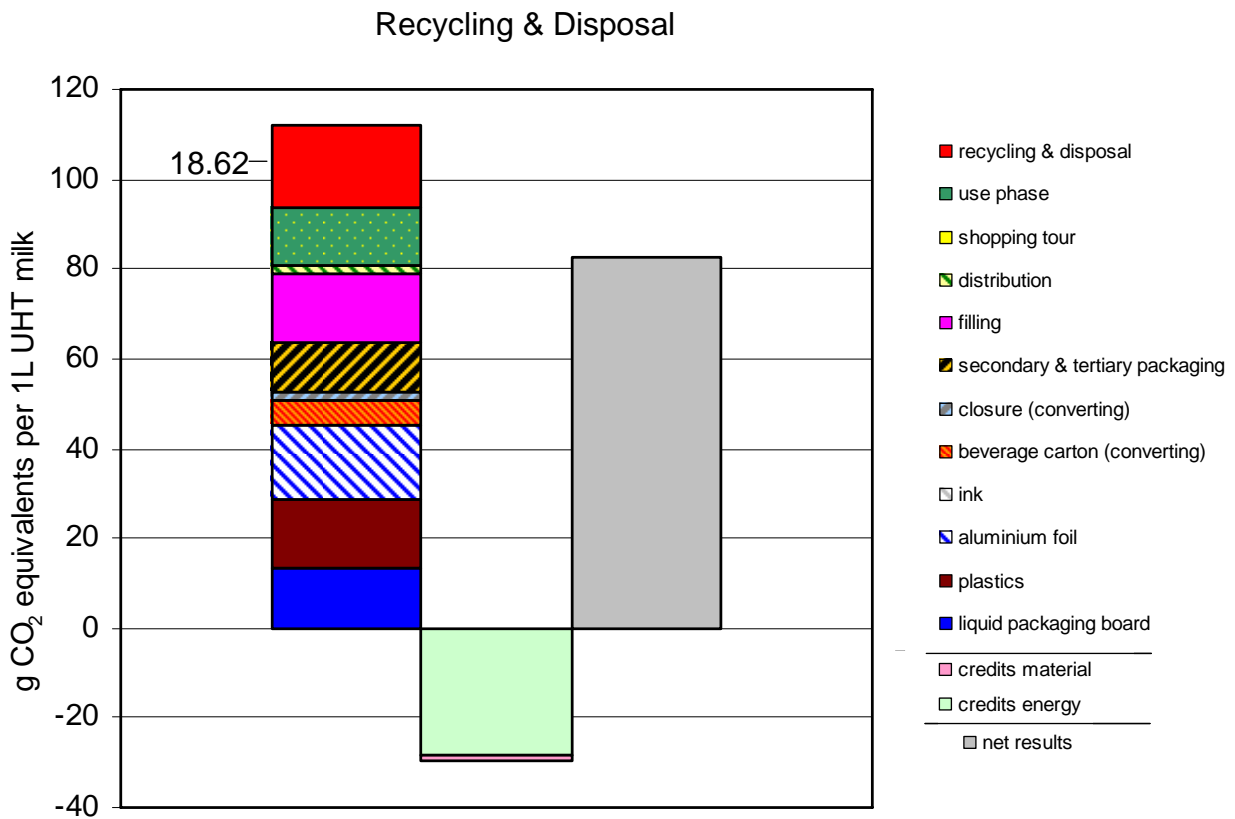


Figure 7-9: Carbon footprint of TBA Slim with light cap – life cycle step: recycling and disposal

The disposal and recycling processes of the TBA Slim carton amounts to emissions of 18.62 g CO₂ equivalents per 1 litre of UHT milk packaged. For the recovery of energy and to a smaller scale of recycled material the equivalent of emissions of 29.5 CO₂ are credited to the system.

Main driver of this life cycle step is the electric and thermal energy recovery from incineration plants.

8 Assessment of the Results

8.1 Sensitivity Analysis

In addition to the base scenario (best guess) three sensitivity scenarios are modelled.

Sensitivity analyses A1 and A2 account for the fact that Tetra Pak uses green electricity for all their German sites for the converting of beverage cartons. Tetra Pak holds renewable energy certificates from German energy provider NaturEnergie. Following a recommendation by Öko-Institut and IFEU emissions from electricity production are only omitted if the renewable electricity is provided by power plants that have been built within the past 6 years. According to NaturEnergie this is true for 33% of their renewable energy.

For sensitivity analysis A1 therefore 33% of the emissions from electricity used for the production of TBA Slim at the converting site of Limburg are not accounted for.

For sensitivity A2 a best case scenario is modelled. All the renewable electric energy is supposed to be produced by power plants not older than 6 years. This implies that no emissions from the production of electricity are calculated for the life cycle step of beverage carton converting.

Sensitivity analysis B takes into account that the consumer behaviour is hard to guess and the assumption of storage of the TBA Slim carton in a fridge for 5 days can be considered conservative. Sensitivity analysis II shows how much the overall carbon footprint results may be influenced by the consumer in the product use phase. For this purpose it is assumed for sensitivity analysis II that the consumer does not store the beverage carton in a fridge before final consumption of the contained milk.

Sensitivity analyses

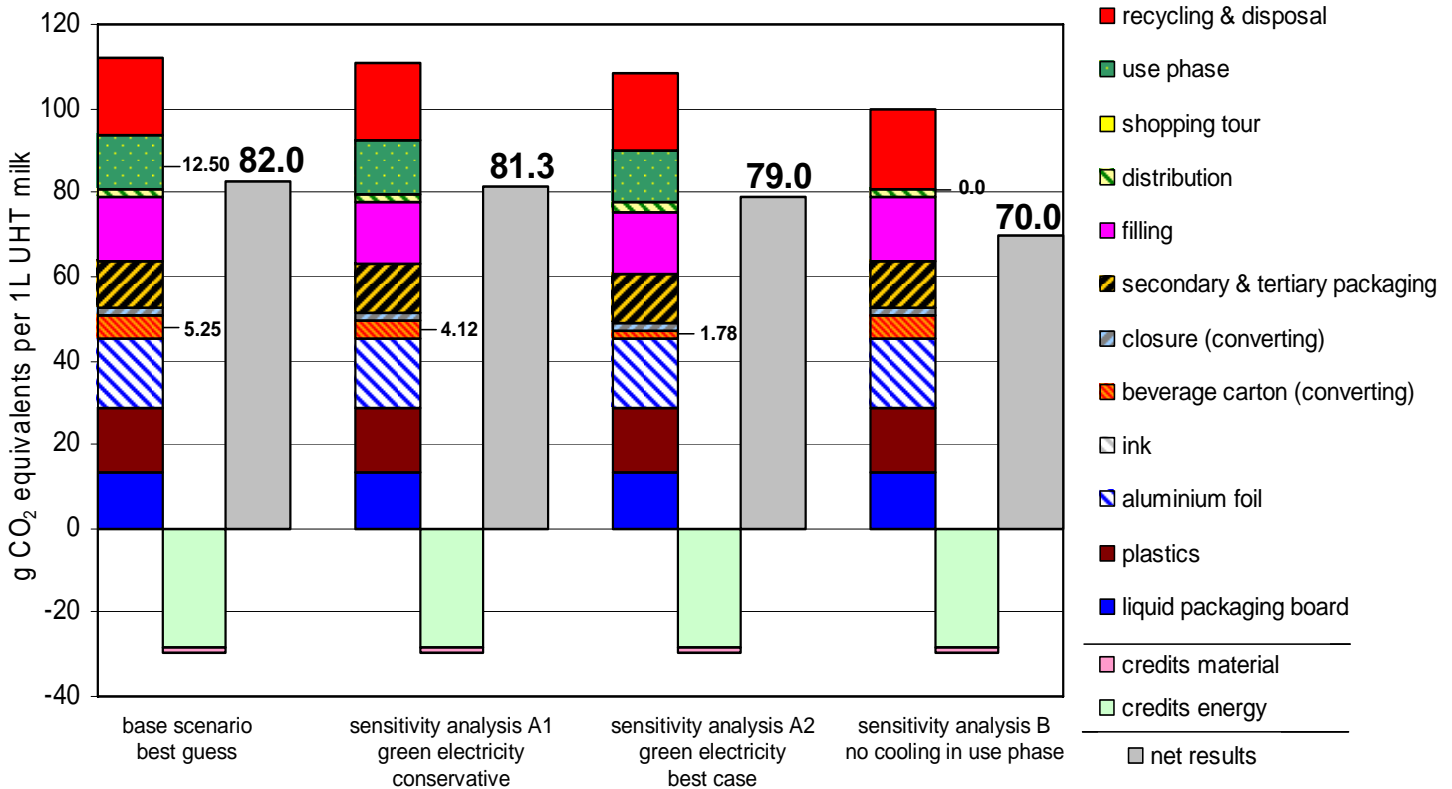


Figure 8-1: Carbon footprints of TBA Slim with LightCap – sensitivity analyses

Sensitivity analysis A1

Figure 8-1 shows an overall carbon footprint for sensitivity analysis A1 that is less than 1% lower than the one of the base scenario. Although the footprint of the life cycle step of beverage carton converting drops from 5.25 to 4.12 g CO₂ equivalents per 1 litre UHT milk the significance for the overall result is very low, as the converting process accounts for a relatively small share in the full life cycle of TBA Slim anyway (6.4%).

Sensitivity analysis A2

Figure 8-1 shows an overall carbon footprint for sensitivity analysis A2 that is about 3.7% lower than the one of the base scenario. The footprint of the life cycle step of beverage carton converting drops from 5.25 to 1.78 g CO₂ equivalents per 1 litre UHT milk. In spite of this significant difference impact on the overall result is still low, as the converting process accounts for a relatively small share in the full life cycle of TBA Slim anyway (6.4%).

Sensitivity analysis B

Figure 8-1 shows an overall carbon footprint for sensitivity analysis II that is approximately 15% lower than the one of the base scenario. The GHG emissions from the use phase fall away completely if the milk and its packaging are not cooled in a fridge.

8.2 Handling of other Environmental Impact Categories

Apart from the Carbon Footprint of a product several other environmental impact categories may be examined. A valuation method by IFEU which is developed on basis of the publications by IPCC, CML and Klöpffer [IPCC 1995], [CML et al. 2002], [Klöpffer 1995] is used in this case study. This section shows results of the TBA Slim for impact categories usually examined in full LCA studies.

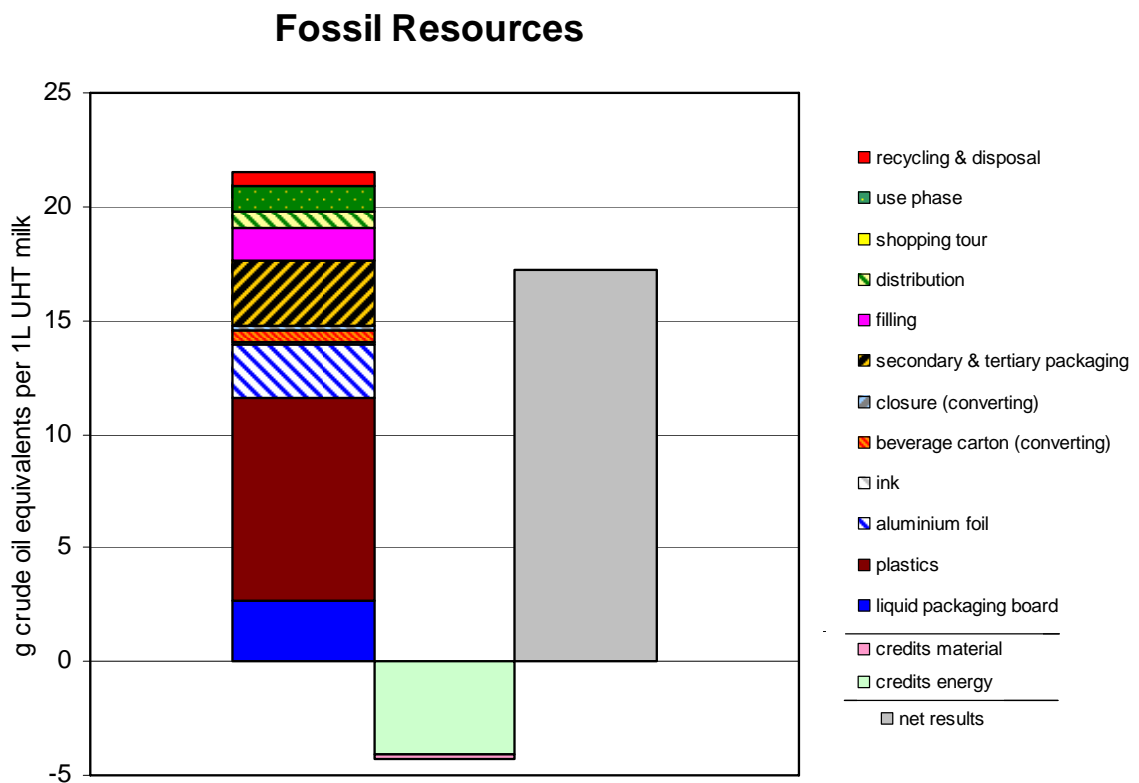


Figure 8-2: Fossil Resources

The consumption of resources is deemed adverse for human society. In all considerations regarding sustainable, environmentally-compatible commerce, the conservation of resources

plays a key role. The term resources is often limited in use to finite mineral or fossil resources but is at other times interpreted very widely to include for example genetic diversity, agricultural land, etc.

Fossil Resource Consumption for TBA Slim is measured in g crude oil equivalents per 1 litre UHT milk.

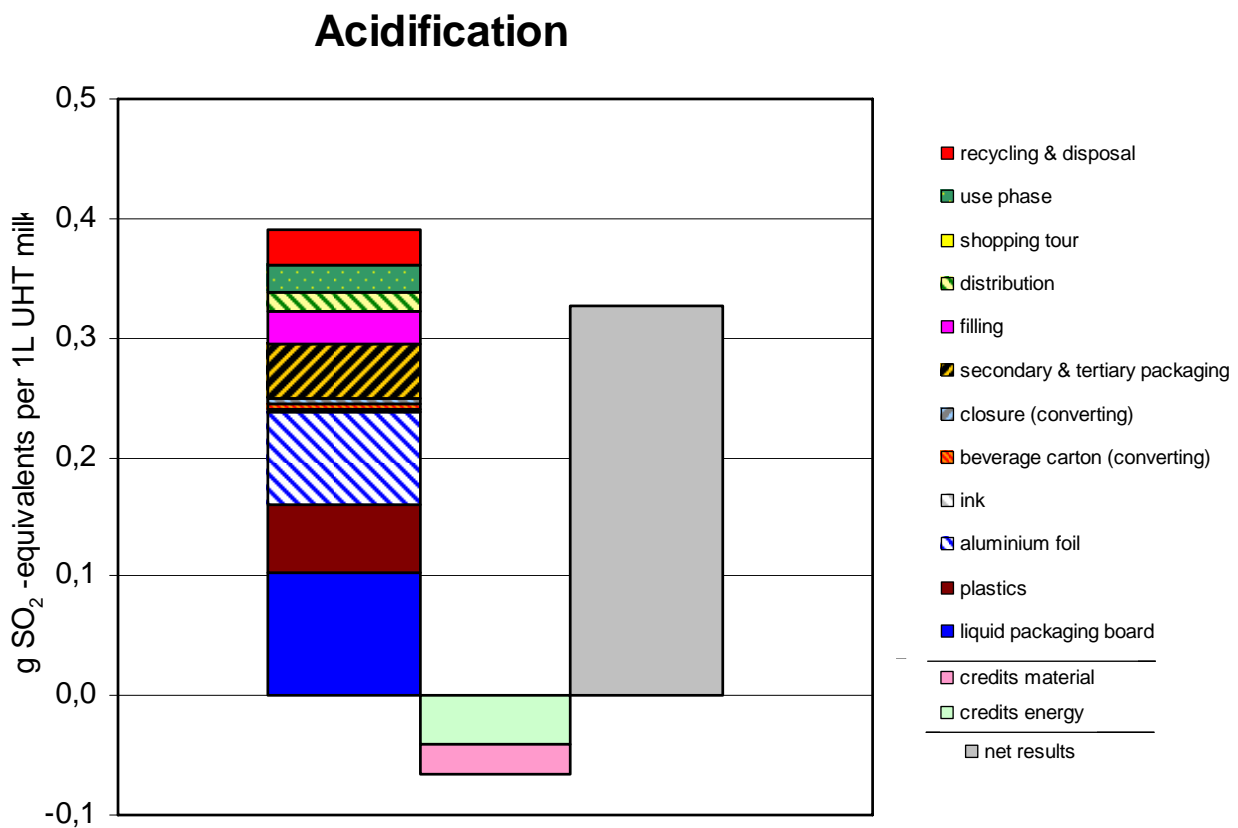


Figure 8-3: Acidification

Acidification can occur in both terrestrial and aquatic systems. The emission of acid-forming substances is responsible for this.

Acidification for TBA Slim is measured in g SO₂- equivalents per 1 litre UHT milk.

Aquatic Eutrophication

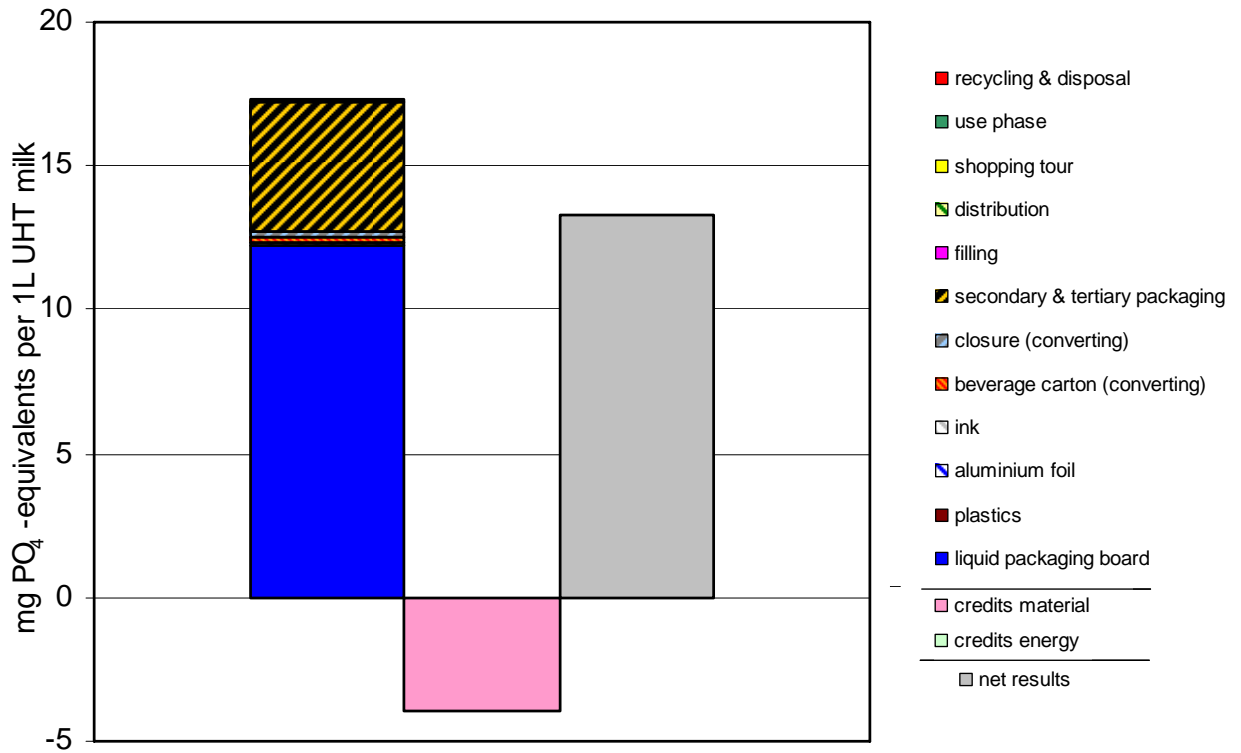


Figure 8-4: Aquatic Eutrophication

Eutrophication means the excessive supply of nutrients, and can apply to both surface waters and soils. As these two different media are affected in very different ways, a distinction is made between water-eutrophication and soil-eutrophication. It is assumed here for simplification that all nutrients emitted via water cause enrichment of the water.

Aquatic Eutrophication for TBA Slim is measured in mg PO₄-equivalents per 1 litre UHT milk.

Terrestrial Eutrophication

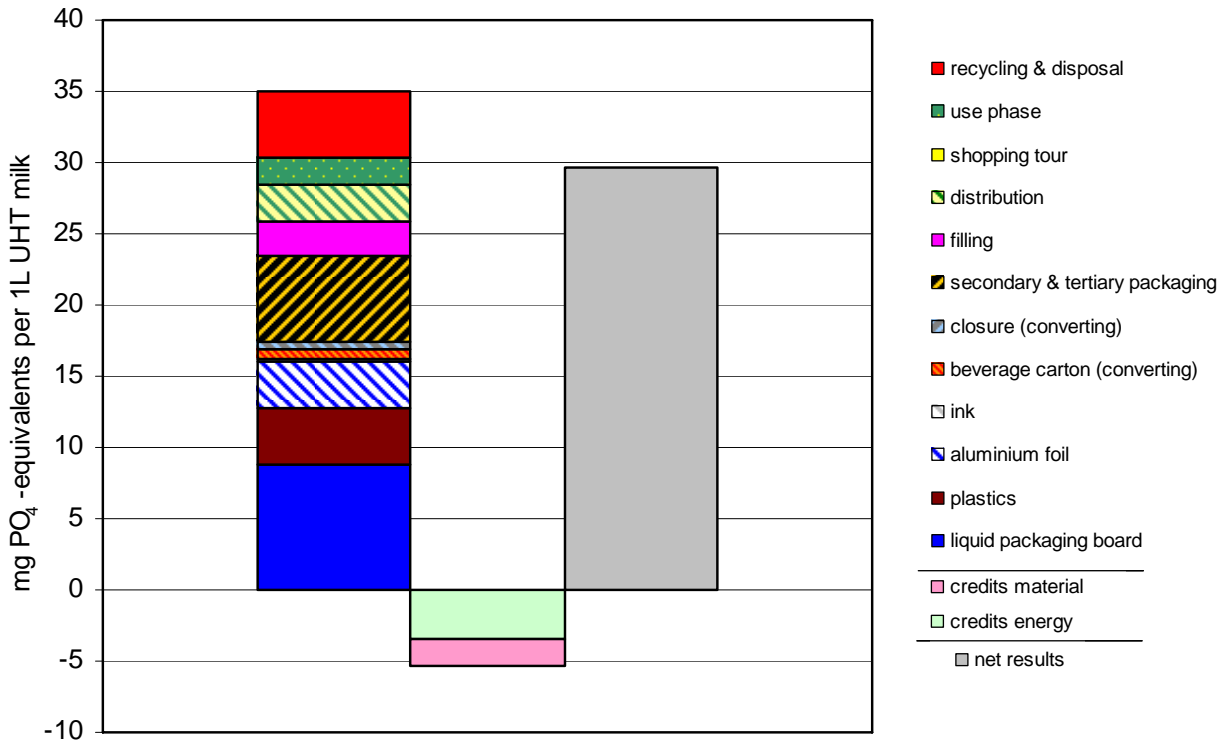


Figure 8-5: Terrestrial Eutrophication

Eutrophication means the excessive supply of nutrients, and can apply to both surface waters and soils. As these two different media are affected in very different ways, a distinction is made between water-eutrophication and soil-eutrophication. It is assumed here for simplification that all nutrients emitted via the air cause enrichment of the soil. As the nutrient input into surface waters via air emissions is small compared to the nutrient input via wastewater, this assumption does not give rise to noteworthy error.

Aquatic Eutrophication for TBA Slim is measured in mg PO₄-equivalents per 1 litre UHT milk.

Human Toxicity: PM 10

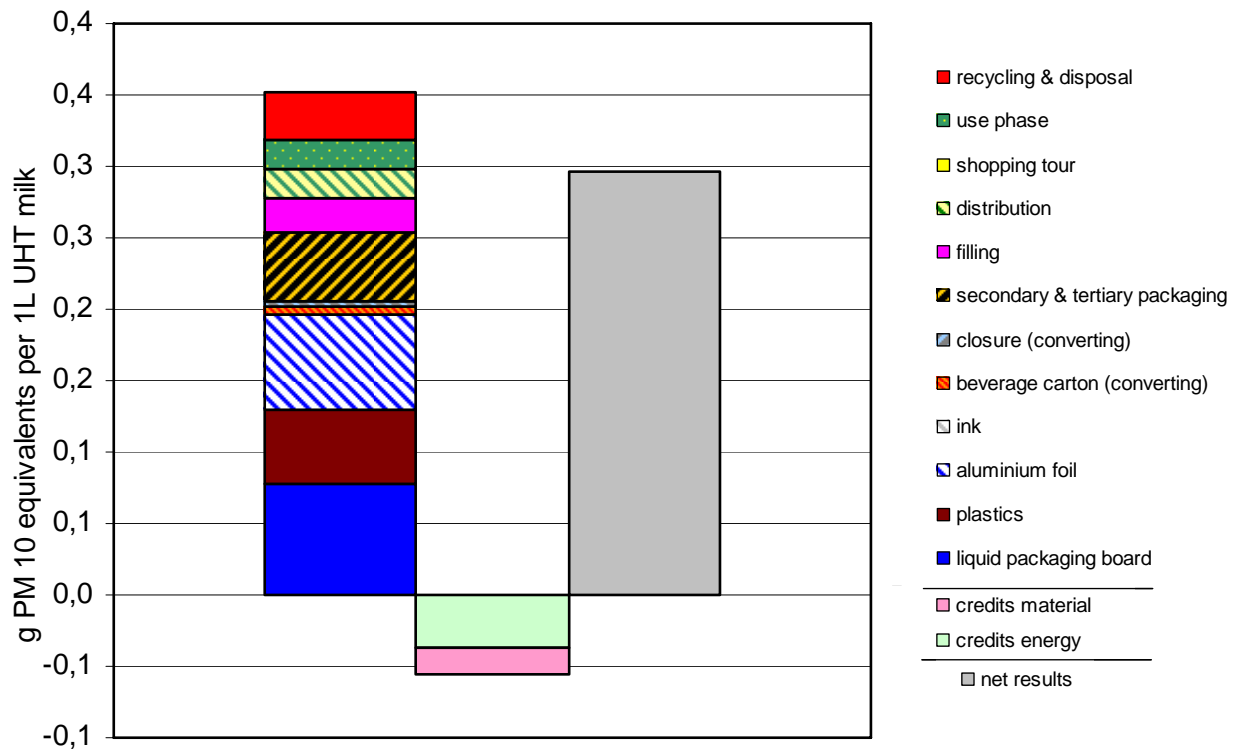


Figure 8-6: Human Toxicity: PM 10

Concerning the impact category “human toxicity”, a generally accepted approach covering the whole range of toxicological concerns is not available. In this assessment, two indicators have been chosen to represent human toxic effects: carcinogenic pollutants and fine particulates (primary particulates as well as precursors).

Fine particulates (PM10) are subsuming primary particulates and precursors of secondary particulates. They are characterized according to an approach by the European Environment Agency (EEA).

Epidemiological studies have shown a correlation between the exposure to particulate matter and the mortality from respiratory diseases as well as a weakening of the immune system. Relevant are small particles with a diameter of less than 10 and especially less than 2.5 µm (in short referred to as PM10 and PM2.5). These particles can not be absorbed by protection mechanisms and thus deeply penetrate into the lung and cause damage.

Human Toxicity: PM 10 for TBA Slim is measured in g PM 10 equivalents per 1 litre UHT milk.

Human Toxicity: Carcinogenic Risk

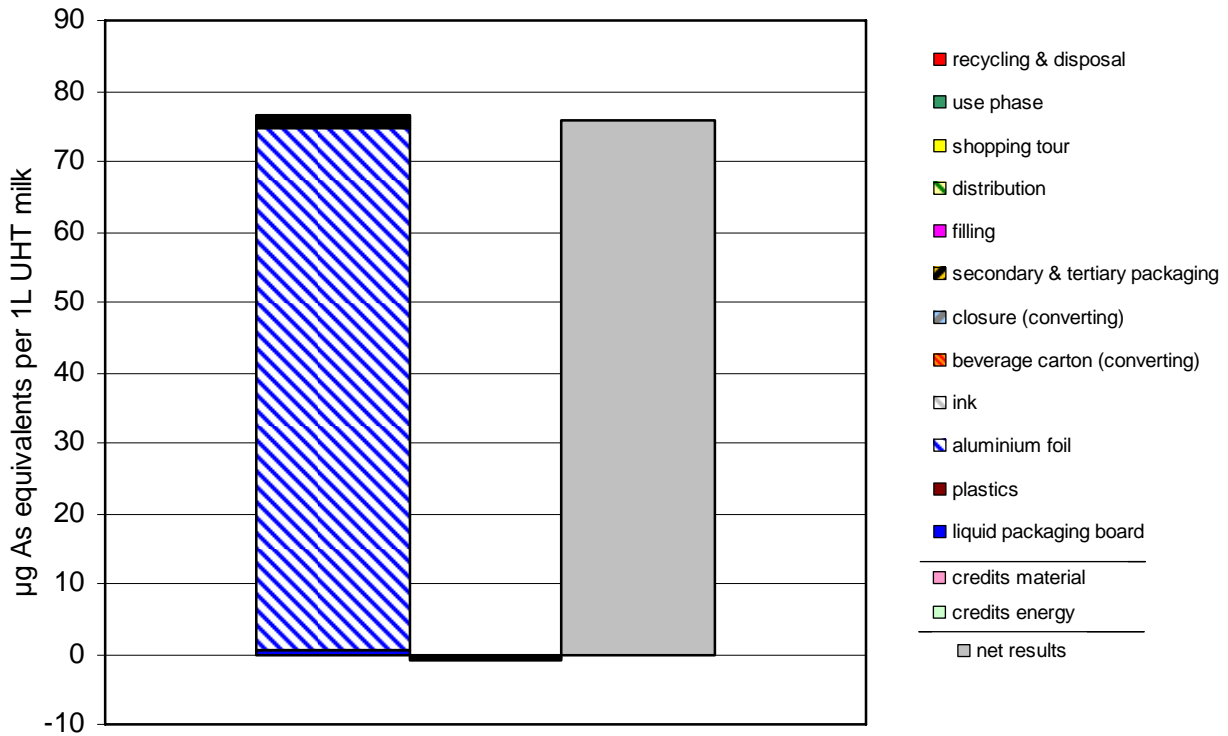


Figure 8-7: Human Toxicity: Carcinogenic Risk

Generally toxicological evaluations are conducted on a site specific local scale within a risk analysis or an environmental impact assessment (EIA). Within a clearly defined spatial unit an exposition analysis can be applied which allows an evaluation of potential toxicological impacts on human. In contrast, LCA is a system specific method without local reference of emission inventory data, thus the generally accepted tools for toxicological evaluations can not be applied.

Human Toxicity: Carcinogenic Risk for TBA Slim is measured in µg As-equivalents per 1 litre UHT milk.

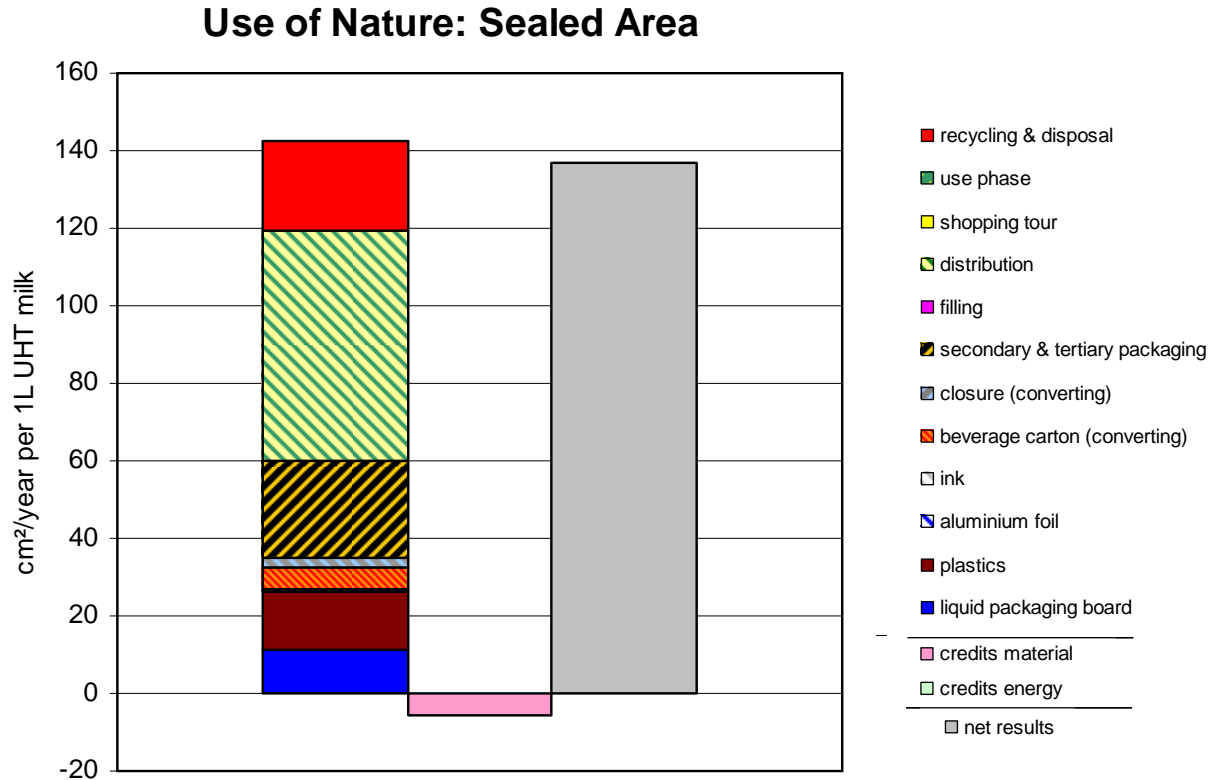


Figure 8-8: Use of Nature: Sealed Area

Land can be considered a finite resource when evaluating environmental impact. It is however not helpful to consider land as merely an available area. Land has to be defined by the environmental state of this land.

When the environmental status of an area of land is being considered, this takes into account all land-related environmental impact such as the reduction in biodiversity, soil erosion, adverse effects on the landscape, etc. It seems appropriate to include all such natural interrelationships in the term "use of nature" - in contrast to the term "land".

Use of Nature: Sealed Area for TBA Slim is measured in cm²/year per 1 litre UHT milk.

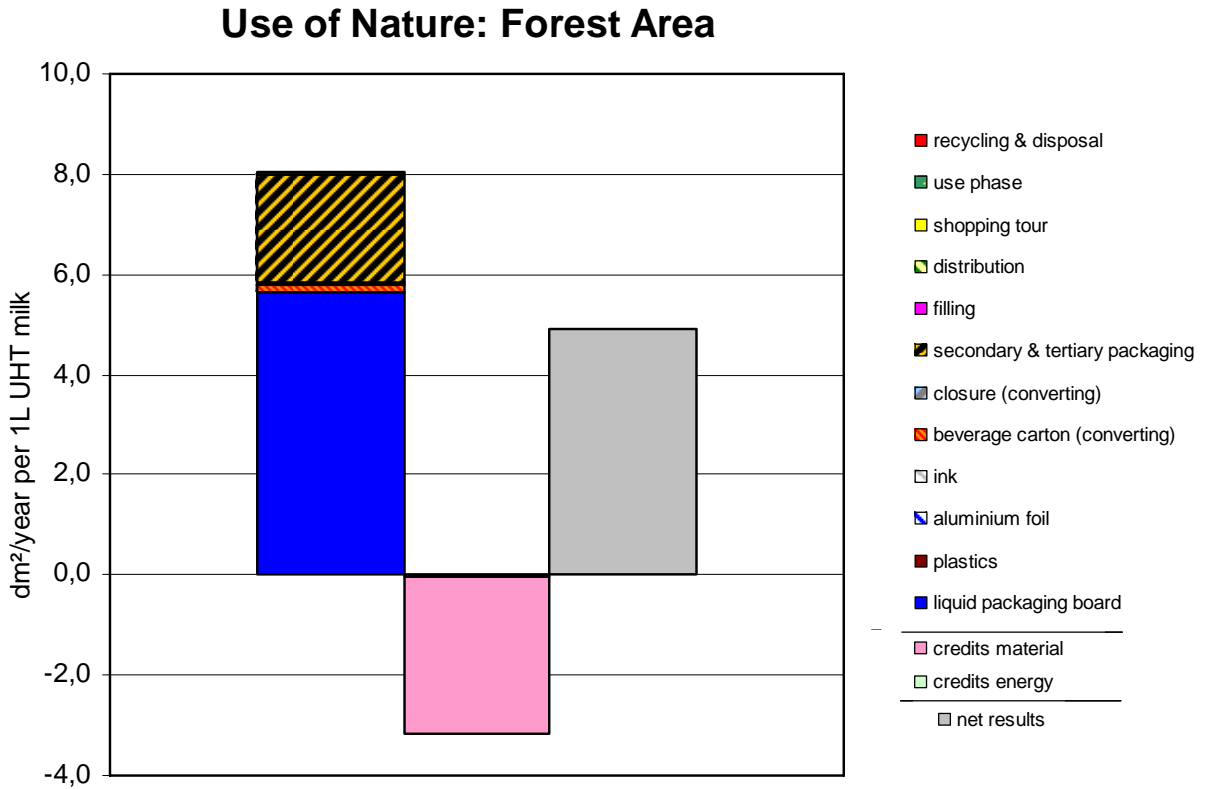


Figure 8-9: Use of Nature: Forest Area

Use of Nature: Forest Area for TBA Slim is measured in $dm^2/year$ per 1 litre UHT milk.

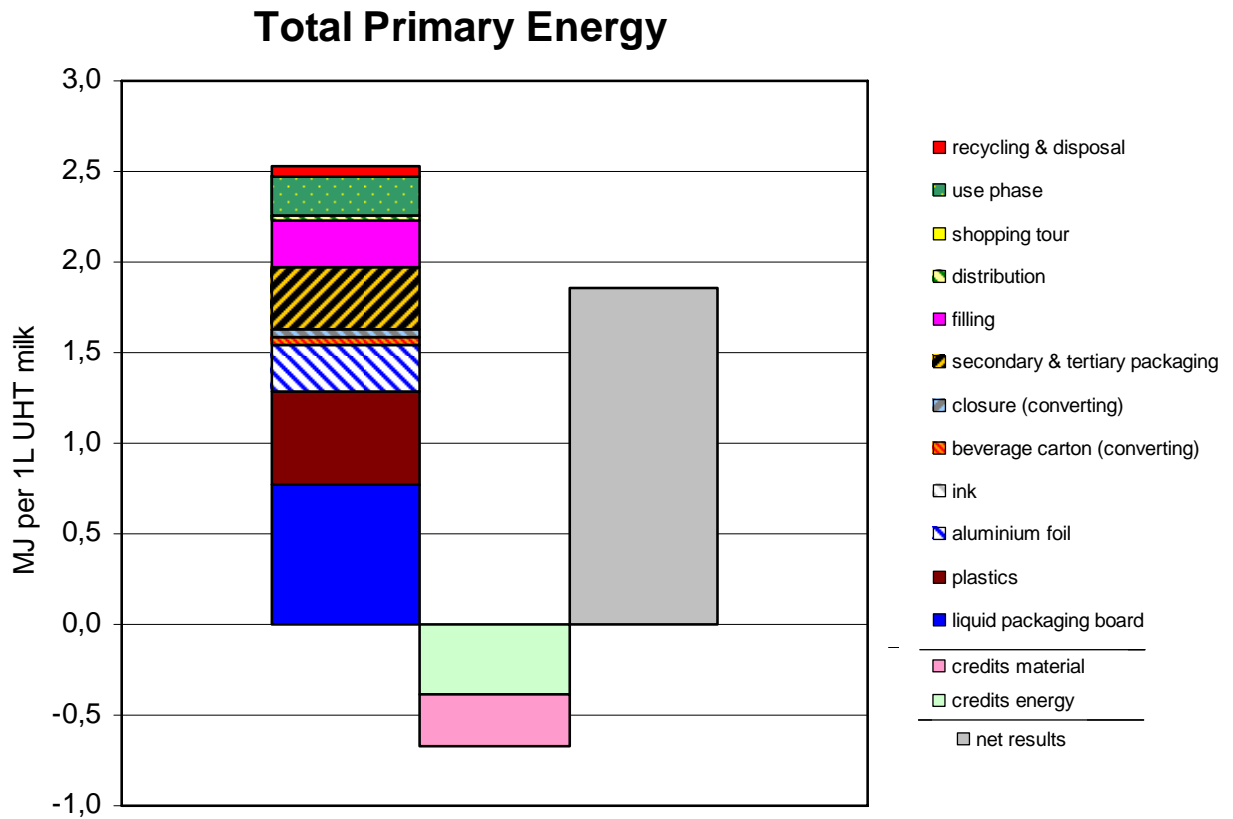


Figure 8-10: Total Primary Energy

Total Primary Energy consumption does not mark an environmental impact. It is an inventory level information category that is measured in MJ per 1 litre UHT milk.

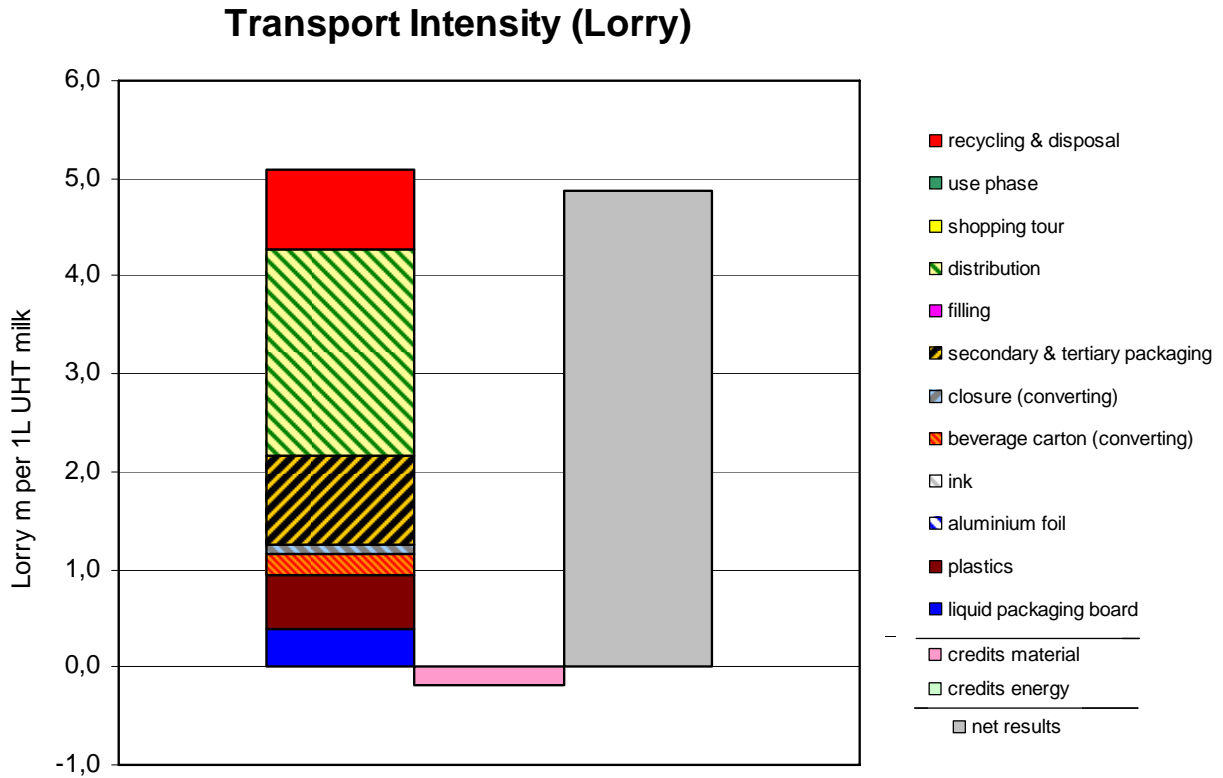


Figure 8-11: Transport Intensity (Lorry)

The Transport Intensity (Lorry) does not mark an environmental impact.

It is an inventory level information category that is measured in m driven by lorry per 1 litre UHT milk.

9 Interpretation and Perspectives

9.1 Challenges of the Case Study

Because of many years of experience with product Life Cycle Assessments (LCA) and the importance that LCAs mean for the status of packaging in Germany, Tetra Pak Germany-Switzerland participates in the PCF Pilot Project Germany to mainly work on the methodology for PCF measurement. Therefore, the realisation of the case study as such did not mean a challenge for Tetra Pak as the tool and ISO 14040 ff. is familiar to Tetra Pak responsables.

Despite of this, there was a challenge in data gathering in the area of “capital goods” and storage at retail. It was not possible to get sufficient data on these issues to include them into this study. Therefore, these criteria have to be investigated further on.

9.2 Identification and Assessment for Further Reduction Options of the PCF

Already today, Tetra Pak contributes to a high extent to the reduction of CO₂ emissions with its ambitious, worldwide climate activities both in production and in relation to the individual Tetra Pak beverage carton. Optimizations along the Supply Chain as well as in the product development are already in place. The two German Converting Factories where the packaging material is produced have been dealing with ambitious reduction targets through energy efficiency and 100% supply of so-called “Green Power” for years. However, one key uncertainty is how to deal with and how to include the purchase and use of “Green Power” in the production process.

Product related improvements are in the development of alternative materials for the 20-25% of components consisting of non-renewable materials.

Another area to be considered is the proper collection of post-consumer beverage cartons for recycling. Compared to the incineration with energy recovery, the recycling of post-consumer beverage cartons provides significant ecological advantages. Over years, the recycling of used beverage cartons has been at a constantly high recycling rate of 65% in Germany. Improvements are seen for the recycling of the Polyethylene and Aluminium components for the packaging.

9.3 Measures under Consideration to Further Reduce the PCF

See 9.2

9.4 Product Carbon Footprinting at Tetra Pak GmbH & Co. KG in the Future

In 2005, Tetra Pak set a goal to reduce CO₂ emissions by 10% in five years. The goal will be achieved through continued improvement in energy efficiency and the use of green power

from renewable energy sources. With its climate programme Tetra Pak qualified for the WWF Climate Savers initiative.

In January 2006, Tetra Pak and WWF signed a three year agreement to globally cooperate in forestry and climate change programmes. But why is Tetra Pak involved?

Increasing emissions of greenhouse gases is threatening to change the climate on earth. About 90% of world primary energy comes from non-renewable energy sources, mainly coal and oil, which release carbon dioxide (CO₂) when burned. Energy production and transportation are two main sources of greenhouse gas emissions. Rising levels of carbon dioxide in the atmosphere, which enhances earth's natural greenhouse effect, is widely believed to change our climate in a way that will have serious consequences for society and natural habitats. Climate change effects include rising sea level and melting of polar ice and glaciers, caused by increasing temperatures, changed rainfall patterns leading to more severe droughts, as well as more frequent and extreme storms and flooding. Most industrialised countries have committed to reduce their greenhouse gas emissions under the Kyoto Protocol of the UN Framework Convention on Climate Change.

Energy use at Tetra Pak sites is the company's closest link to greenhouse gas emissions. Emissions are reported as tonnes of CO₂ equivalents and include direct emissions from burning fuels at our sites, indirect emissions from the generation of electricity and district heating that we use, and to a limited extent, the emission of cooling agents. Our reporting covers scope 1 and 2 of the Greenhouse Gas Protocol.

Through ensuring that 3/4 of Tetra Pak's material feedstock is coming from living systems the company ensures they work with nature - helping to keep the climate stable naturally. Tetra Pak works with suppliers and environmental groups such as WWF and its forest programmes (Global Forest and Trade Network, and Forest Stewardship Council) and the High Conservation Value Resource Network, to keep forests alive and healthy for the plants and animals that live there.

Climate change, forestry and recycling are three key areas for Tetra Pak. Driven by the company's global climate goal Tetra Pak reduced CO₂ emissions by 3% in 2007, in total 7% since 2005. Paperboard is the main material in Tetra Pak packages, and in 2007, 25% of all wood fibre came from forests certified to the Forest Stewardship Council standard for sustainable forest management. In 2007 the number of packages collected and recycled increased by 1.1 billion. In total, 22 billion Tetra Pak packages were recycled in 49 Market Companies worldwide.

Tetra Pak's aim is to have one of the best environmental packages on the market. Best means having the lowest environmental impact of comparable packages in the market. Public studies reflect the findings of Tetra Pak's internal work: that carton based packages compare favourably with many other liquid packaging formats, particularly on global warming. In fact, the German Government classified cartons as "environmentally advantageous", based on comparative scientific studies. But Tetra Pak wants to ensure they keep improving – and these studies have shown them how:

They have demonstrated that the single greatest determinant is the choice of materials. Specifically, the greater the proportion of renewable materials Tetra Pak uses, the lower the impact.

The second most important determinant comes from the package's end-of-life: the more packages are recovered for recycling or energy, the lower the climate impact.

And third, energy efficiency, the type of energy Tetra Pak uses, as well as logistics also play a crucial role. Tetra Pak's choices are clear:

- Increase the share of renewable materials and energy
- Increase the recycling and recovery of Tetra Pak packages
- Increase the efficiency of production and transportation

Whether Tetra Pak communicates their environmental profile on packages, on the web, in advertisements, or in any other way – in order to clearly communicate this internationally agreed standards are needed, as well as transparency, scientifically robust data, and the participation of stakeholders such as environmental NGOs. Also, the environmental performance of a product needs to be verified by an independent research institute. However, agreed common standards do not yet exist. Tetra Pak actively supports the development of transparent and coherent rules and regulations of any kind of environmental profiling for a product. These standards will help communicate the environmental issue in a credible and understandable way.

10 Recommendations

10.1 International Methods for Calculation and Assessment of Product Carbon Footprints

With the ISO 14040 and ISO 14044 guidelines there are already international instruments for the calculation and assessment of Life Cycle Assessments available. As a full LCA will always include a Carbon Footprint calculation, these guidelines can be used for the preparation of Carbon Footprint reports. The methodical recommendations of the ISO 14040 and 14044 give the practitioner a wide scope to adapt to the special requirements of the product examined. For the preparation of Carbon Footprints through more strictly fixed rules as in the British guideline PAS 2050 could be more useful. The PAS 2050 however also leaves crucial questions unanswered, for instance regarding open loop recycling or allocation issues.

10.2 Proposals for Product Specific Definitions and Rules (EPD, PCR)

The question about Product Categories cannot be answered in the scope of this study.

There are however some criteria that are of special importance for the assessment of packaging systems in general. These are a detailed look onto primary, secondary and tertiary packaging and a particularly comprehensive consideration of end-of-life settings.

10.3 Reporting, Communication and Claims of Reductions to Customers and Consumers

Supported by this case study, Tetra Pak will continue to communicate the overall advantages of Tetra Pak beverage cartons focusing on the continuous improvements throughout the entire life-cycle. Like in the past, Tetra Pak will always consider all environmental effects arising from its business, being automatically linked to the reduction of both the company's and the individual product's Carbon Footprint.

References

- [EAA 2008]: Environmental Profile Report for the European Aluminium Industry. Report published by the European Aluminium Association, April 2008.
- [EUROSTAT 2004] - Energie/Jährliche Statistik 2004
- [IFEU 1998] Ökologischer Vergleich graphischer Papiere - Datenband. Im Auftrag des Umweltbundesamts, Berlin; FKZ 10350120. Erstellt vom Institut für Energie- und Umweltforschung Heidelberg (ifeu)
- [ISO 14044]: Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006); German and English version EN ISO 14044:2006
- [ÖKO-INSTITUT 2004] EcoTopTen –Innovationen für einen, nachhaltigen Konsum, Erstellt vom Öko-Institut e.V., Freiburg, 2004
- [Plastics Europe 2005a]: Boustead, I.: Eco-profiles of the European Plastics Industry – Polyethylene Terephthalate (PET) (Amorphous grade), data last calculated March 2005, report prepared for Plastics Europe, Brussels, 2005. (Accessed August 2005 at <http://www.lca.plasticseurope.org/index.htm>)
- [Plastics Europe 2005b]: Boustead, I.: Eco-profiles of the European Plastics Industry – Polyethylene Terephthalate (PET) (Amorphous grade), data last calculated March 2005, report prepared for Plastics Europe, Brussels, 2005. (Accessed August 2005 at <http://www.lca.plasticseurope.org/index.htm>)

11 Annex

11.1 Documentation of the Data

11.1.1 Extraction of Raw Materials

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
LDPE	extraction from natural environment, production of LDPE granulates	1999	Western Europe	LDPE production	L	A	C	Plastics Europe 2005
HDPE	extraction from natural environment, production of HDPE granulates	1999	Western Europe	HDPE production	L	A	C	Plastics Europe 2005

aluminium	bauxite extraction, aluminium oxide manufacture, aluminium manufacture	2005	Western Europe	production of ingots and foil	L	A	C	EAA Environmental Profile Report 2008
Liquid Packaging Board	forestry prechain, pulping, bleaching, board making	2002 - 2004	Finland and Sweden	production of LPB	I	A	C	Nordic LPB Producers
printing ink	pigment production	1998	Germany	Production of printing ink	L	A	C	IFEU 1998

11.1.2 Production

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
carton lamination	extrusion of LDPE lamination of liquid packaging board printing, cutting and packing of coated board	2007	Limburg/Germany	converting of carton	I	A	C	Tetra Pak 2008

11.1.3 Secondary and Tertiary Packaging

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
corrugated cardboard and trays	Production of "Kraftliners", "Testliners" and "Wellenstoff"	2005	Europe	production of cardboard and trays	L	A	C	FEFCO 2006
LDPE	extraction from natural environment, production of LDPE granulates	1999	Western Europe	LDPE production	L	A	C	Plastics Europe 2005
wood and pallets	forestry, sawmill	1993-1997	Europe	pallet production	L	A	C	UBA 1995/1998

11.1.4 Filling

						Data index		
Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	Data source
filling	package handling, filling, check weighing, packaging and palletizing of filled packs	2007	Germany	filling process of TBA Slim	I	A	M	filling industry 2008

11.1.5 Distribution

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
distribution	lorry transport to warehouse and point-of-sale	2007	Germany	distribution	I	A	E	IFEU 2008

11.1.6 Shopping Tour

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
shopping tour	car transport to consumer's home	2007	Germany	shopping tour	I	A	E	IFEU 2008

11.1.7 Product Use

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
cooled storage	Cooling in fridge	2004	Germany	cooling	L	A	C	Öko-Institut 2004

11.1.8 Disposal/Recycling

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
beverage carton recycling	sorting, recycling	2004	Germany	recycling	I	A	C	IFEU 2004

11.1.9 Background data

Data Module (Output)	Processes covered	Time related coverage	Geographical specificity	Technological specificity	Data index			Data source
					Place of reference: in-house (I), literature (L), other (O and specify)	Single value (S); aggregated value (A) and specify the percentage or absolute amount of each part	Measured (M); calculated (C); estimated (E)	
electricity generation, NORDIC	power plants	2004	Scandinavia	electricity mix	I	A	C	IFEU 2004
electricity generation, Germany	power plants	2006	Germany	electricity mix	I	A	C	IFEU 2006
lorry transport	diesel combustion	2004	Germany	lorry transport	I	A	C	IFEU/HBEFA 2005