

“NATURKIND ORGANIC FREE-RANGE EGGS” BY THE TENGELMANN GROUP

Documentation.

Study undertaken within the PCF Pilot Project Germany

Content

1	Preface	1
2	Executive Summary	4
3	Company Profile.....	5
4	Organization of the Case Study	6
5	Objective 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 and Cut-Off Criteria.....	8
5.4	Data Sources and Quality of Data.....	11
5.4.1	Consumption Data	11
5.4.2	Emission Factors	13
5.5	Allocation Procedure.....	13
6	Inventory and Calculation.....	14
6.1	Extraction of Raw Materials and Pre-Products.....	14
6.2	Production.....	15
6.3	Distribution	16
6.4	Trip to the shops.....	17
6.5	Product Utilization	17
6.6	Recycling/Disposal.....	18
7	Presentation of Results	19
7.1	Overview.....	19
7.2	Pullet Rearing.....	21
7.3	Egg Laying Farm.....	22
7.4	Product Distribution	24
7.5	Trip to the shops.....	25
7.6	Product Utilization	25
7.7	Disposal/Recycling.....	28
8	Assessment of the Results.....	29

8.1	Sensitivity Analysis	29
8.2	Dealing with other Environmental Impact Categories	31
9	Interpretation and Perspectives.....	32
9.1	Challenges of the Case Study	32
9.2	Identification and Assessment of Reduction Options of the PCF.....	32
9.3	Product-Specific Options for Action to Reduce the PCF.....	32
9.4	Future Handling of the Product Carbon Footprint	33
10	Recommendations	34
10.1	Development of International Methods for Product Carbon Footprinting ...	34
10.2	Proposals for Product-Specific Definitions and Rules (EPD, PCR)	34
10.3	Customer and Consumer Information on Product Carbon Footprint	35
11	References.....	36

1 Preface

The case study entitled “Naturkind organic free-range eggs” that follows was elaborated within the scope of the Product Carbon Footprint (PCF) Pilot Project Germany by the Tengelmann Group in association with its own energy company Tengelmann Energie GmbH and Kaiser’s Tengelmann AG, supported and accompanied by Ecofys Germany GmbH. For the PCF pilot project, the Tengelmann Group joined nine other companies to pursue the following project objectives, together with the project initiators – WWF Germany, Öko-Institut (Institute for Applied Ecology), the Potsdam Institute for Climate Impact Research (PIK) and THEMA1:

1. *Gain experience:* On the basis of concrete case studies, the project initiators and participating companies intend to gain experience in the practical application of current methods for determining carbon footprints, and to examine the efficiency of these methods (ISO¹ standards for life cycle assessment, BSI² PAS 2050).
2. *Derive recommendations:* Based on the findings of the case studies, recommendations will be derived for the further development and harmonization of a transparent, scientifically founded methodology for determining the carbon footprint of products. The pilot project explicitly refrains from developing its own methodology.
3. *Communicate results:* Consumers should be informed of the Product Carbon Footprint in a scientifically sound and comprehensible manner. To this end, the pilot project stakeholders are holding discussions on reliable communication on a segmental, company and product level to foster low environmental impact 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 environmental impact label since the current methodological conventions are insufficiently consistent and still under debate, meaning that the significance of such potential courses of action would therefore be low.
4. *Standardize at international level:* 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 substances for which a Global Warming Potential coefficient has been 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 the raw materials and pre-products to 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 PCF Pilot Project Germany, ISO 14040/44 constituted an essential basis for the work carried out on methodologies and thereby for the case studies themselves.

Although many of the basic methodological conditions of ISO 14040/44 can be applied in the case of the PCF methodology, several have to be adapted. Some terms of reference of the ISO 14040/44 are loosely formulated, making it necessary to examine the possibility 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 analyzed in varying detail. From the perspective of the PCF Pilot Project Germany, 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 harmonization 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,

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.

specific methodological issues, discussed in joint working groups, also emerged from the case studies.

The broad spectrum of products selected for the case studies made for a comprehensive discussion. The involvement of companies from very different sectors in the PCF Pilot Project Germany was challenging but also fruitful, constituting an essential prerequisite for the development or optimization of a methodology which could be used as broadly as possible.

The case study “Naturkind organic free-range eggs” by the Tengelmann Group 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 PCF Pilot Project Germany are summarized 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 Germany, 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 would be pleased 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 harmonization of product carbon footprinting. 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.

Mülheim an der Ruhr, 26 January 2009

2 Executive Summary

As a pioneer in environmental protection and nature conservation, the Tengelmann Group is currently combining several projects into the concerted Tengelmann Climate Initiative in order to reduce CO₂ emissions and protect the climate.

By participating in the PCF Pilot Project Germany, the Tengelmann Group would like to have the opportunity to measure the CO₂ emissions of products in future to discover and exploit the potential for improvement. Participation in the PCF Pilot Project Germany is in consistent continuation of the climate preservation program launched by Tengelmann in summer 2007 with the compilation and external validation of the greenhouse gas inventory.

Within the project, the carbon footprint of a box of six Naturkind organic free-range eggs was determined. The carbon footprint is 1.178 g CO_{2e} in the basic scenario.

The analysis shows that approx. 62% of the CO_{2e} emission is caused by the pullet rearing farms and the egg laying farms. The next biggest driver is the utilization phase, a significant factor accounting for approx. 21% of the CO_{2e} emission. Furthermore, 10% of the emission originated from the stores. Transportation between the individual process modules is responsible for only 1.5%.

3 Company Profile

The Tengelmann Group, established in 1867 in Mülheim an der Ruhr, is an internationally oriented company, family-run by the fifth generation, with a variety of business areas in Germany and the rest of Europe. The group currently comprises the Kaiser's and Tengelmann supermarkets, the building supplies and do-it-yourself stores OBI, the textile- und nonfood-discount chain KiK, the Plus Online Shop and Plus Eastern Europe. A variety of production plants and service enterprises complete the portfolio of the Tengelmann Group. Furthermore Tengelmann is deeply involved in the North-American supermarket chain A & P. The group has around 83,000 employees in Europe.

The Tengelmann Group can look back on over 40 years of tradition in environmental protection and nature conservation. This pioneering task is in consistent continuation in the Tengelmann Climate Initiative. The company's commitment comprises several projects to protect the climate and to reduce CO₂ emissions. Among these projects are the annual greenhouse gas inventory and the Product Carbon Footprint Pilot Project Germany, as well as the inauguration of the first Tengelmann Climate Store in December 2008.

4 Organization of the Case Study

The carbon footprint study entitled “Naturkind organic free-range eggs” is a project initiated by the Tengermann Group. It was conducted in collaboration with its own energy company Tengermann Energie GmbH and the business segment Kaiser’s Tengermann AG. Ecofys Germany GmbH helped Tengermann Energie GmbH determine the carbon footprint.

The product under examination is a box of six organic free-range eggs of Kaiser’s Tengermann AG’s private brand Naturkind, available from all Kaiser’s and Tengermann stores.

5 Objective and Scope

5.1 Objectives of the Case Study

In the future, the Tengelmann Group would like to gain clarity regarding the CO₂ emissions of products to enable potential for improvement to be detected and exploited from the identified environmental impact and CO₂ emissions.

The contributions of the individual process steps to the carbon footprint should be visible, in order to enable specific measures for improvement to be deduced and progress to be made in the reduction of product-related CO₂ emissions. The objective is for the carbon footprint to give manufacturers information on how they can influence the energy efficiency of their production processes.

The data obtained from determining the Product Carbon Footprint aims to promote regional, more sustainable production.

The Tengelmann Group currently views its own purchasing departments and suppliers as target groups.

Comparative statements or active marketing using the carbon footprint are not the focus of this study. Nevertheless, consumers should not be fully disregarded because the environmental impact of products should also be rendered understandable to consumers in future.

5.2 Product Selection and Definition of the Functional Unit

In the present study by the Tengelmann Group, the functional unit was taken to be a box of six organic free-range eggs of the Naturkind brand, sizes M/ML (box weight approx. 408 g).

These eggs are one of about 300 products in the Naturkind private brand, established by the company in 1986. All of the products in this private brand meet the requirements of the EC-Eco-Directive, and bear the label of the officially recognized German organic seal.

Hen's eggs are an important source of protein in human nutrition and therefore constitute a staple food. They are used in private households, in the food processing industry and in canteen kitchens and bakeries.

The life cycle and production of a hen's egg are easily and clearly comprehensible. The affiliation to the organic private brand Naturkind promotes collaboration with the upstream chain, and also emphasizes the ecological idea behind this project. Hen's eggs are therefore an appropriate product for creating and developing a method to determine a Product Carbon Footprint within the Pilot Project Germany.



Fig. 1: A box of six Naturkind organic free-range eggs

5.3 System Boundaries and Cut-Off Criteria

The life cycle under consideration starts with the rearing of the laying hens and ends with the consumption of the eggs in the form of soft-boiled eggs. The individual steps of the life cycle are shown in Figure 2:

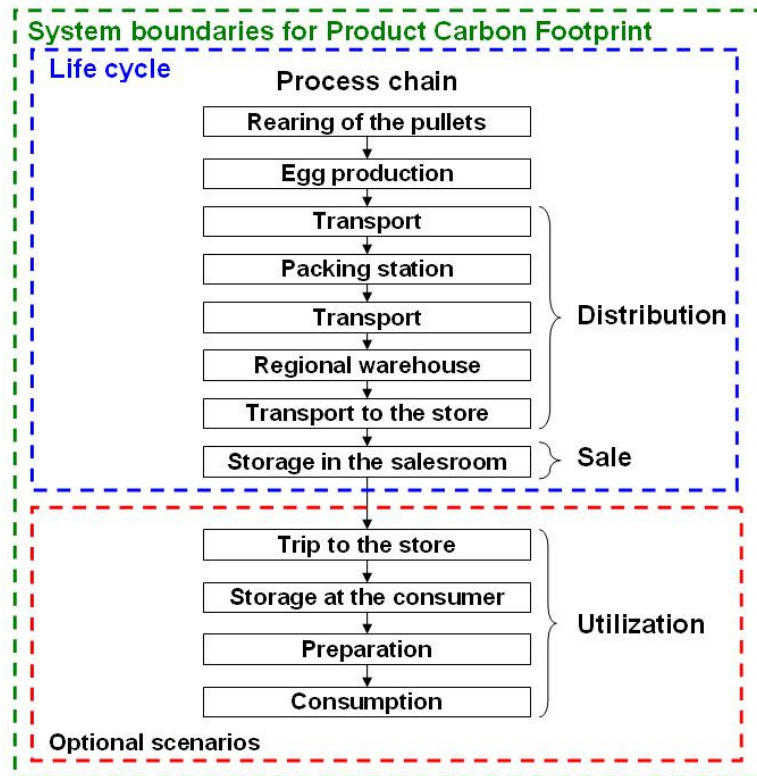


Fig. 2: System boundaries of the life cycle

The stages of transportation from the egg production to the stores of Kaiser's and Tengelmann as well as the intermediate storage in the regional warehouse are summarized as distribution.

The utilization phase covers the storage of the eggs in the fridge, preparation of the soft-boiled eggs and their consumption, among other things.

Rearing of the pullets

This process phase starts with the delivery of day-old chicks from an external breeding farm. The delivery of the chicks was taken to be the starting point because the birth of the chicks cannot be clearly defined. The chicks are reared to an age of approx. 20-22 weeks, after which they are delivered to the egg laying farm.

Due to the expected contribution to the PCF, the rearing of pullets was described as a separate process.

Egg production

The process step "egg production" covers the raising of the hens, starting with the delivery of the pullets. The normal laying period of a hen is slightly over one year. After this period, the laying rate starts to decline, and the egg shells becoming increasingly thin and brittle, for

instance. These hens, which are replaced by new brood hens, are slaughtered and industrially processed.

For this reason, all input and output data (feed, energy consumption, poultry manure) are related to one year.

Distribution (transportation, intermediate storage and sale)

The "distribution" process step starts with the transportation of the eggs from the laying farm to the central packing station, where the eggs are classified according to the following criteria (see Figure 3):

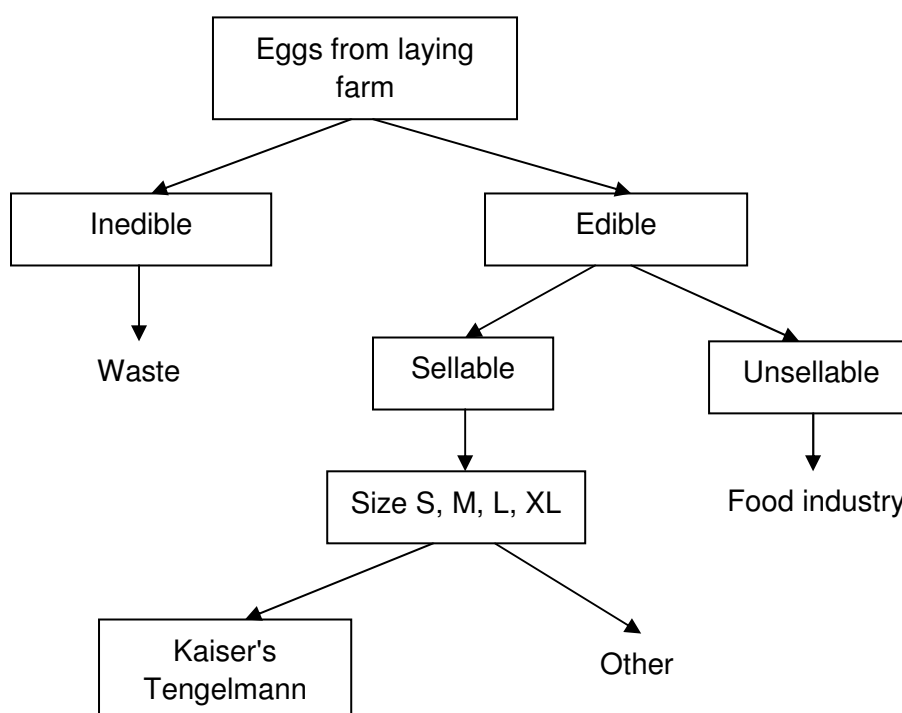


Figure 3: Egg classification

Only eggs classified as size M/ML are delivered to Kaiser's Tengelmann for sale. After classification and packaging into 6-egg or 10-egg boxes, the eggs are transported to one of four regional distribution centers of Kaiser's Tengelmann. The process step ends with the storage and sale of the eggs.

Electricity, fuel and water, generated waste or cooling agents used to chill the eggs at the packing station, regional distribution centers and stores and the fuel consumption for transportation are included as input or output data to calculate this step of the life cycle.

Trip to the shops

The standardized assumption for the trip to the shops includes a 5 km drive to and from a Kaiser's Tengelmann store. The total weight of the shopping basket is assumed to be 20 kg, which means that a box of six organic free-range eggs weighing 408 g (including packaging) accounts for only 2.0% of the total purchase.

As alternative scenarios, shopping by bike or on foot were also investigated, since many Kaiser's and Tengelmann stores are located down town and in residential areas, making them easily accessible by bike or on foot.

Product utilization

The "product utilization" process step includes the storage of the eggs in the fridge (assumed to be energy efficiency class A) for 12 days as well as the preparation of the soft-boiled eggs in an egg boiler. The electricity consumed to clean the spoon and egg cup in a dishwasher was also taken into account. The egg shells were deemed to have been disposed as organic waste.

Boiling the eggs in a pan of water was investigated as an alternative scenario.

Recycling and disposal of the egg box

In the course of the life cycle of Naturkind organic free-range eggs, waste streams accrue in every single process phase. The poultry dung arising in the rearing farm and laying farm and the disposal of the sales packaging (egg box) are identified as relevant waste streams. Further waste streams (e.g. eggs broken in the course of transportation and sale) and the disposal/ processing of effluent are not considered in the calculations, due to their insignificant relevance.

As Figure 2 shows, the life cycle of the Naturkind organic free-range eggs ends with their consumption as soft-boiled eggs. The disposal of human intermediate catabolic products via the sewage system is not included in this study, and is therefore not part of the CFP.

5.4 Data Sources and Quality of Data

5.4.1 Consumption Data

All input and output data, e.g. the consumption of electricity, heating oil, district heating, diesel and feeding stuff, as well as the number of eggs produced, the turnover achieved, the quantities of waste and effluent for the "rearing pullets", "egg laying farm" and "packing

station” process steps, including all transportation between the process steps, were compiled from questionnaires. Obscurities and omissions in the responses to the questions were clarified by phone with the respective respondents. The year taken for the data collection in all process steps was the year 2007 – subject to data availability. Since the packing station receives deliveries from several egg laying farms, one farm was chosen to represent them in the determination of the PCF.

All egg laying and rearing farms are based in Germany, and their methods of operation (only organic egg production) are comparable. None of the egg laying farms has its own electricity production from biomass, nor are they supplied with green electricity from the public grid. Thanks to the detailed information, the activity data of the process steps rearing pullets → transportation → egg production → transportation → packing station → transportation → regional warehouse” can be deemed complete, reproducible and sufficiently accurate. Data gaps leading to the requirement of estimates do not exist. In this respect, all consumption data can be classified as 100% primary data.

All consumption data for the regional warehouses, the stores and the distribution of the eggs to stores (own truck fleet and commissioned logistics companies), as well as the quantities of organic eggs sold and transported were provided by the Tengermann Group. The Tengermann Group had already determined its inventory for the 2006/2007 business year in compliance with the standards of the GHG Protocol, and had had it checked and verified by an external service provider. Among other things, this inventory contains the energy consumption of all Kaiser’s and Tengermann sites (regional warehouses, stores, administration) and the consumption of diesel for the transportation of goods from the regional warehouses to the stores with their own truck fleet and by the commissioned logistics companies. Equivalent CO₂ emissions (CO_{2e}), which result from the operation of air-conditioning in the stores, are also included in the emissions inventory. CO_{2e} emissions resulting from emissions of cooling agents from cold storage plants have not been taken into account for the PCF because eggs are not chilled when transported or stored.

All regional warehouses and Kaiser’s and Tengermann stores are located in Germany. The regional warehouse in Munich, and its associated stores, was selected to determine the PCF. Since the energy consumption of one single store cannot be regarded as representative and the diesel consumption for transportation cannot be assigned to one single branch, all stores were combined into a “virtual” store. In other words, the consumption data from all of the stores were added together and applied to the total numbers of organic eggs sold.

Thanks to the detailed information, the activity data of the process steps regional warehouse → transportation → store (= point of sale, PoS) can be deemed complete, reproducible and sufficiently accurate. Data gaps leading to the requirement of estimates do not exist. In this respect, all consumption data can be classified as 100% primary data.

5.4.2 Emission Factors

The emission factors were mainly taken from secondary data sources (Ecoinvent Data Base [2], IPCC Report 2007 [3]). A factor provided by the Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTLB 2006) was used to calculate the proportional methane production from the fermentation of poultry dung on the fields.

For details on individual emissions factors, see Section 6.

5.5 Allocation Procedure

An economic allocation was conducted for all processes on the basis of the turnover achieved from the organic eggs supplied to or sold by Kaiser's and Tengelmann. This approach comprises all input data (e.g. energy consumption, feeding stuff, fuel quantities, other operating resources) and all output data (e.g. waste for disposal or recycling, poultry dung, effluent).

By-products that accumulate are:

- Egg laying farm: aged hens (food industry)
- Packing station: liquid egg (food industry)
- Eggs that are not sold to Kaiser's and Tengelmann (mainly sizes S and XL)

Emissions arising from waste disposal deemed to be relevant were considered in the PCF:

- Poultry dung (application on fields and methanation)
- Egg box (50% disposal by incineration, 50% recycling)

For all transportations, the reported diesel consumption was apportioned to the economic value of the organic eggs compared to the total value of the freight. Since, due to the extensive assortment of goods in the stores, no information is available on the weight and volume of the total freight, it is not possible to perform a mass- or volume-related allocation.

Mass-related allocation was studied in a sensitivity analysis for the transportation (of the eggs) from the egg laying farm to the packing station as well as to the regional warehouse.

6 Inventory and Calculation

6.1 Extraction of Raw Materials and Pre-Products

The first phase of the life cycle of the Naturkind organic free-range eggs is the rearing of the pullets. The major processes contributing to the carbon footprint are feedstuff production, followed by waste disposal and energy consumption.

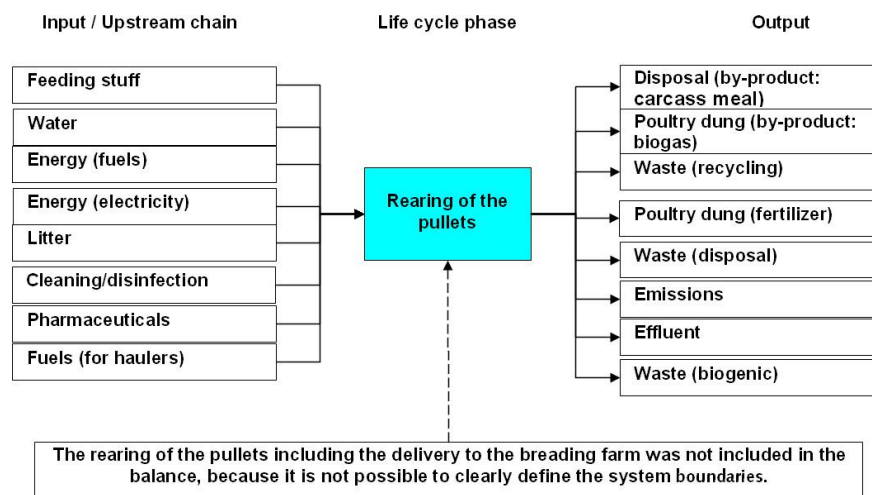


Fig. 4: Elementary inputs and outputs at the rearing farm

The system boundary used excludes the rearing of the day-old chicks delivered to the laying farm. The transportation of feedstuff to the egg laying farm and of the removal of waste from the farm are included in the calculations.

Activity data on feedstuff consumption, energy use (e.g. heating oil, electricity), water consumption, waste, litter and transportation were compiled from questionnaires. The composition of the feedstuff was provided by the feedstock manufacturer in a telephone interview.

Since no data on emissions from waste is available, these values had to be estimated from the secondary literature. Emissions factors for waste disposal on the field, and waste emissions from the egg laying farm (e.g. methane generation from anaerobic decomposition), were estimated from values contained in the KTBL 2006 [4]. Emission factors for water, transportation and energy consumption were taken from Ecoinvent 2.0 [2] and IPCC data [3].

The economic allocation was chosen on the basis of the percentage of turnover generated by Kaiser's and Tengemann and the functional unit. Allocation based on the mass of eggs sold did not yield a significant change in value compared to the economic allocation.

6.2 Production

The production phase of the life cycle of the organic free-range egg is the egg laying farm. The major processes contributing to the carbon footprint here are feedstuff production, waste treatment and energy consumption.

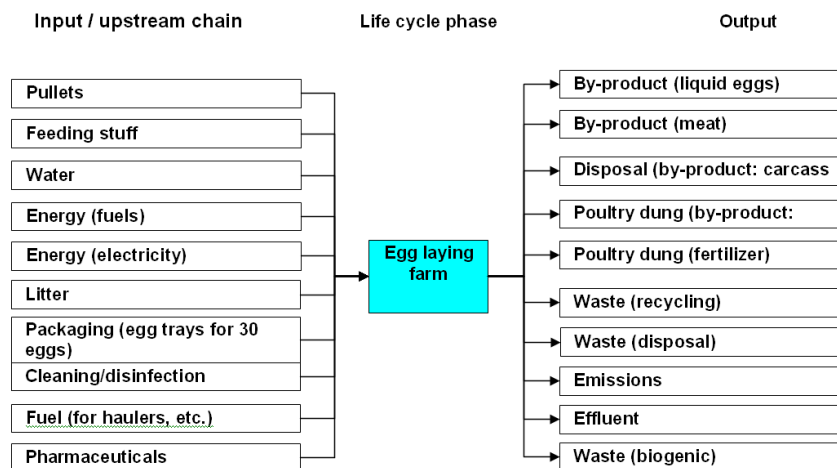


Fig. 5: Elementary inputs and outputs from the egg laying farm

The system boundary used starts with the delivery of the laying hens and ends with the preparation of the laid eggs for pick-up to the distribution facilities. Waste disposal, litter, energy consumption at the egg laying farm and water consumption are also included as process flows.

Activity data on feedstuff consumption, energy use (e.g. heating oil, electricity), water consumption, waste, litter and transportation were compiled from questionnaires. The composition of the feedstuff was provided by the feedstock manufacturer in a telephone interview.

Since no data on emissions from waste is available, these values had to be estimated from the secondary literature. Emissions factors for waste disposal on the field, and waste emissions from the egg laying farm (e.g. methane generation from anaerobic decomposition), were estimated from values contained in the KTBL 2006 [4]. Emission

factors for water, transportation and energy consumption were taken from Ecoinvent 2.0 [2] and IPCC data [3].

The economic allocation was chosen on the basis of the percentage of turnover generated by Kaiser's and Tengelmann and the functional unit. No other type of allocation was deemed applicable. Both by-products – size S eggs and hens for slaughter – were allocated according to their economic value.

6.3 Distribution

The main processes contributing to the carbon footprint are feedstuff production, waste and energy consumption.

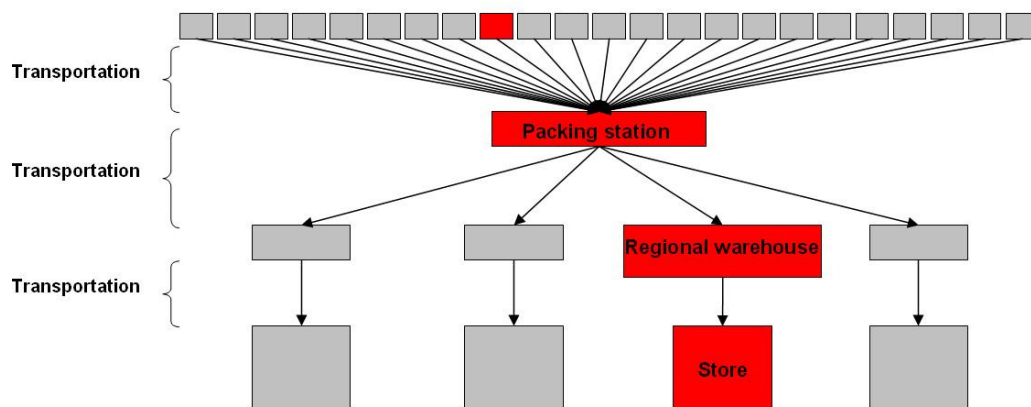


Fig. 6: Distribution steps considered in the life cycle

The system boundary used starts with the pick-up of the eggs at the egg laying farm, followed by the sorting and packaging of the eggs in the packing station. The eggs are then distributed to regional warehouses, from where they are sent to the stores. The energy, and water consumption, the production of the egg box and the transportation are included as input and output flows.

Activity data on feedstuff consumption and energy use (e.g. heating oil, electricity), water consumption, packaging material and haulage distances were compiled from questionnaires.

Emission factors for water, packaging, energy consumption and transportation were taken from Ecoinvent 2.0 [2] and IPCC data [3].

The economic allocation was chosen on the basis of the percentage of turnover generated by Kaiser’s and Tengelmann and the functional unit. Furthermore, a mass-based approach was applied as an alternative to parts of the distribution chain (only the packing station). Allocation based on mass resulted in a 20% lower carbon footprint in this production step.

6.4 Trip to the shops

The standard assumptions for the trip to the shops include a 5 km drive each way and a shopping basket with a total weight of 20 kg. The automobile is assumed to be a mixture, based on German automobile sales. Due to mass allocation, the proportion of the emissions caused by the trip to the shops to purchase organic eggs was only 2.04%. For the purpose of consistent modeling, the trip to the shops was modeled in SimaPro with Ecoinvent data. With TREMOD data⁴, emissions increased by approx. 4 g CO_{2e}.

6.5 Product Utilization

The product utilization of the Naturkind organic free-range eggs involves the storage of the eggs in the fridge, the preparation of the eggs (in this case, soft-boiled eggs) and the cleaning of crockery and cutlery.

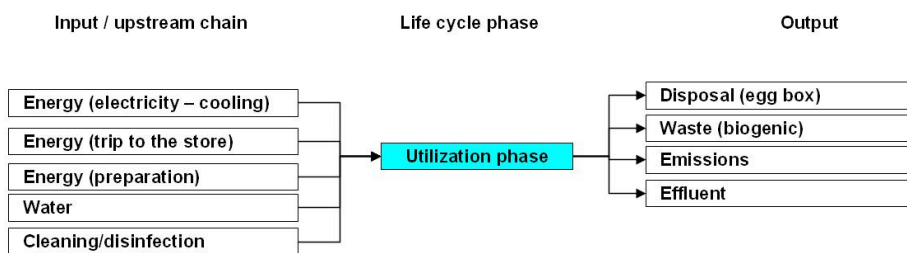


Fig. 7: Elementary inputs and outputs of the utilization phase

⁴ Assumptions: average automobile, within urban areas, including upstream chains – emission factors:
 247.319 g CO₂/km, 0.057 g CH₄/km, 0.009 g N₂O/km

Three scenarios representing individual types of consumer behavior were investigated (variations are highlighted):

- Basic scenario: trip to the shops by car, storage in the fridge, preparation in an egg boiler, cleaning in the dishwasher
- Alternative scenario 1: *trip to the shops by bike or on foot*, storage in the fridge, preparation in an egg boiler, cleaning in the dishwasher
- Alternative scenario 2: trip to the shops by bike or on foot, storage in the fridge, *preparation in an open pan*, cleaning in the dishwasher

The conditions for storage in the fridge and cleaning in the dishwasher were kept constant in all three scenarios.

The consumption data for the devices used were obtained from product ratings based on EcoTopTen data and Ecoinvent 2.0.

6.6 Recycling/Disposal

Waste streams accrue in the individual process phases in the course of a life cycle of Naturkind organic free-range eggs. According to their extent, they were studied in detail or came under the cut-off criterion.

Significant amounts of poultry dung accumulate on the rearing farm and the egg laying farm. The poultry dung is disposed of by applying the dung onto the surrounding fields. During the rotting process and the exposure time in the poultry home, significant quantities of methane are produced, which were estimated using data from the KTLB 2006 [4]. The quantities of effluent produced by the farms were so low per functional unit that they could be neglected.

Only small quantities of waste occur from the packaging, transportation and sale of the organic free-range eggs. Informative and precise data on the number of eggs damaged or broken during and between the transportation from the packing station to the sale in the stores, and therefore disposed as waste, are not available. According to internal estimations by Kaiser's and Tengemann, the proportion of damaged eggs related to the number of eggs sold is very small, resulting in the neglect of the disposal of broken eggs.

The utilization phase of organic free-range eggs is dominated by two primary waste streams: the disposal of the human intermediate catabolic product via the sewerage system and the disposal of the egg box. According to the agreement in the project group, the disposal of the packaging was determined as follows: 50% of the boxes were recycled and the remaining 50% were disposed of in a garbage incineration plant.

The disposal of human intermediate catabolic products via the sewerage system was neglected due to the low proportion of eggs consumed in the human diet.

7 Presentation of Results

7.1 Overview

Contemplation of the PCF reveals that this carbon footprint is dominated by the egg laying farm process step, which causes 693 g CO_{2e} (59%) of the total PCF. With regard to relevance, this process step is followed by the utilization phase, which causes 248 g CO_{2e} (21%) and the sale, which led to 112 g CO_{2e} (10%). The distribution, rearing farm and disposal process steps caused 74 g CO_{2e} (6%), 32 g (3%) and 20 g, respectively.

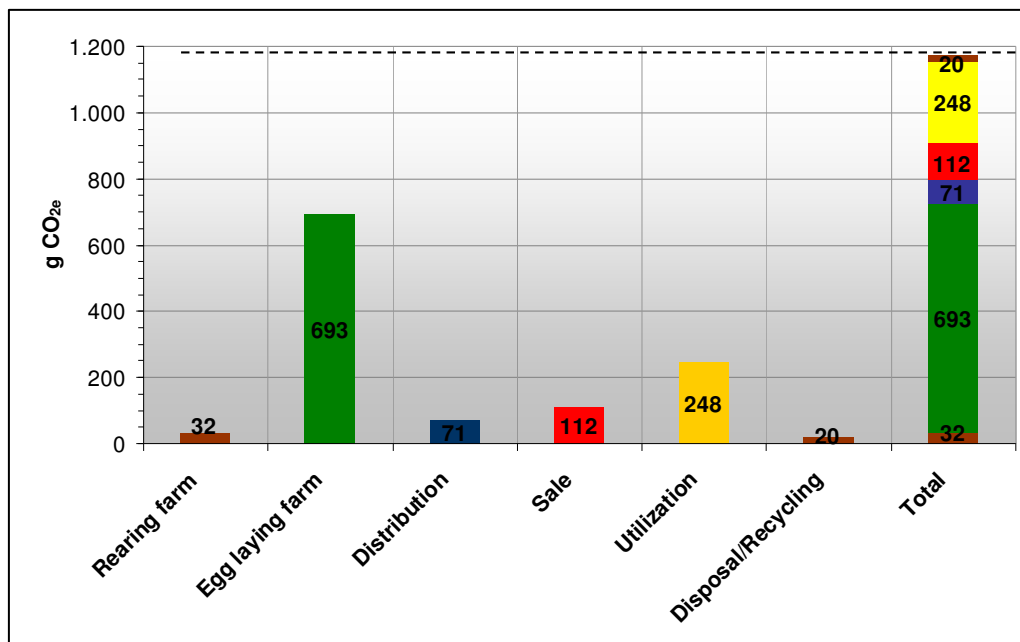


Fig. 8: Overview of the carbon footprint acc. to product phase

With regard to the single processes, it can be seen that the use of lignite (i.e. emissions from lignite power plants in the German electricity mix) is the largest single process (12%).

Further significant processes refer to the application of poultry dung onto the fields (approx. 11%) and the ingredients of the feeding stuff, e.g. wheat (9%) (see Figure 9).

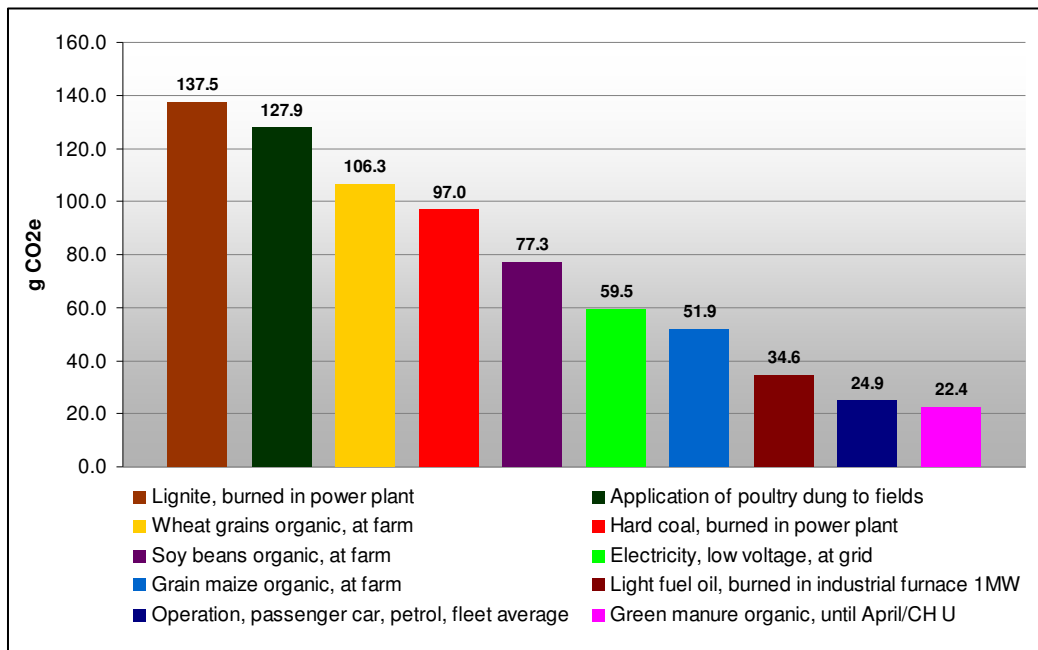


Fig. 9: Percentage contributions of the relevant process steps of the PCF

Contemplation of the different greenhouse gases reveals that carbon dioxide is the main contributor to the PCF, resulting in 628 g CO_{2e} (53%), followed by dinitrogen monoxide (N₂O), which caused 394 g CO_{2e} (33.4 %) and methane (CH₄), which led to 155 g CO_{2e} (10.9%).

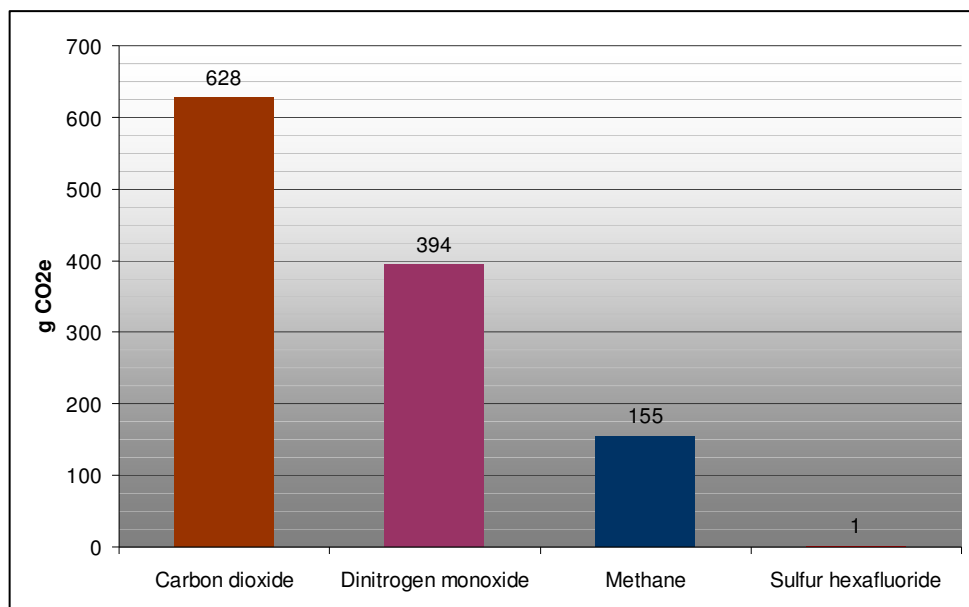


Fig. 10: Distribution of the PCF across the individual green house gases

7.2 Pullet Rearing

The main source of emissions for the “pullet rearing” process step is the disposal of the poultry dung, which caused 8.3 g CO_{2e} (26.5%). This factor is followed by wheat production for the feeding stuff, which led to 6.6 g CO_{2e} (20.9%) and the emissions caused by the production of electricity in the German electricity mix, which led to 3.4 g CO_{2e} (10.7%).

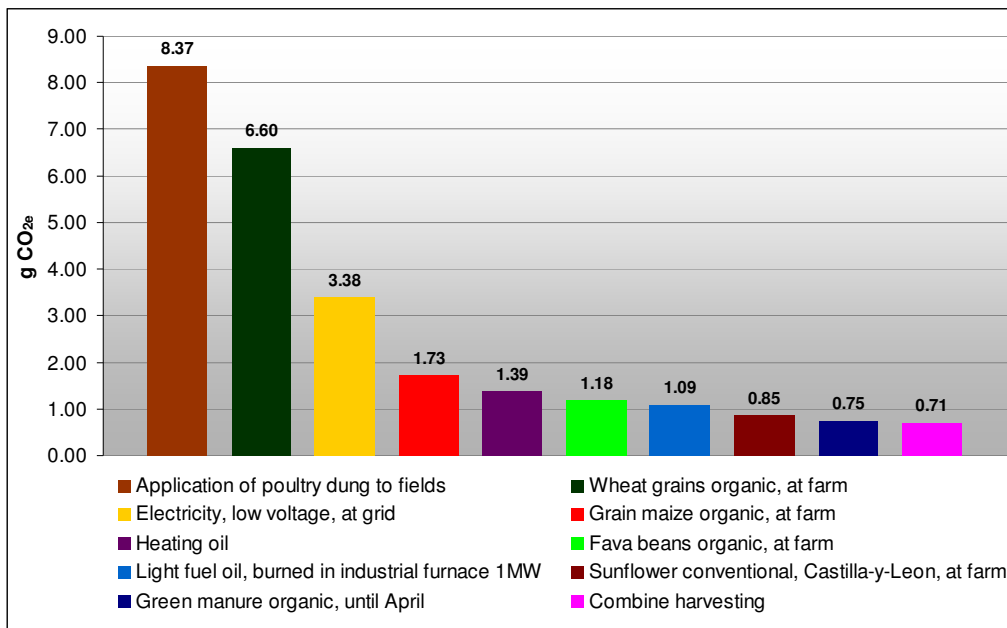


Fig. 11: Contributions of the relevant process steps in pullet rearing

Contemplation of the different greenhouse gases reveals that dinitrogen monoxide is the main contributor to the PCF with 12.8 g CO_{2e} (40.6 %), followed by carbon dioxide, which caused 10 g CO_{2e} (31.8%), and methane, which led to 8.7 g CO_{2e} (27.5%).

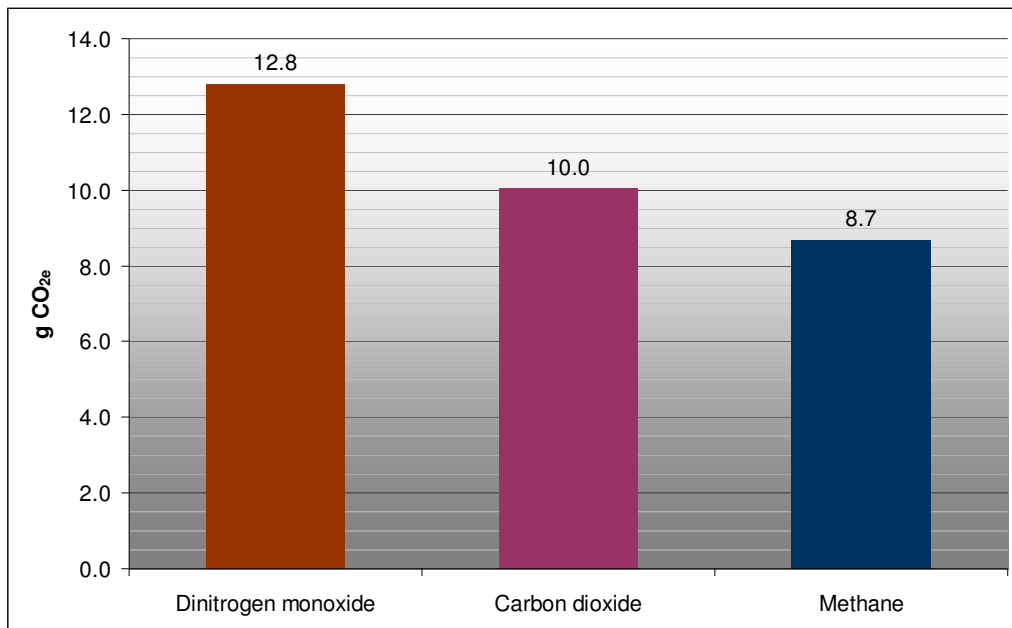


Fig. 12: Distribution of the Product Carbon Footprint of pullet rearing according to green house gases

7.3 Egg Laying Farm

The main source of emissions for the “egg laying farm” process step is the disposal of the poultry dung, accounting for 120 g CO_{2e} (17.2%). This factor is followed by wheat production for the feeding stuff, which led to 100 g CO_{2e} (14.4%) and emissions for the production of electricity in the German electricity mix, which caused 77 g CO_{2e} (11.2%).

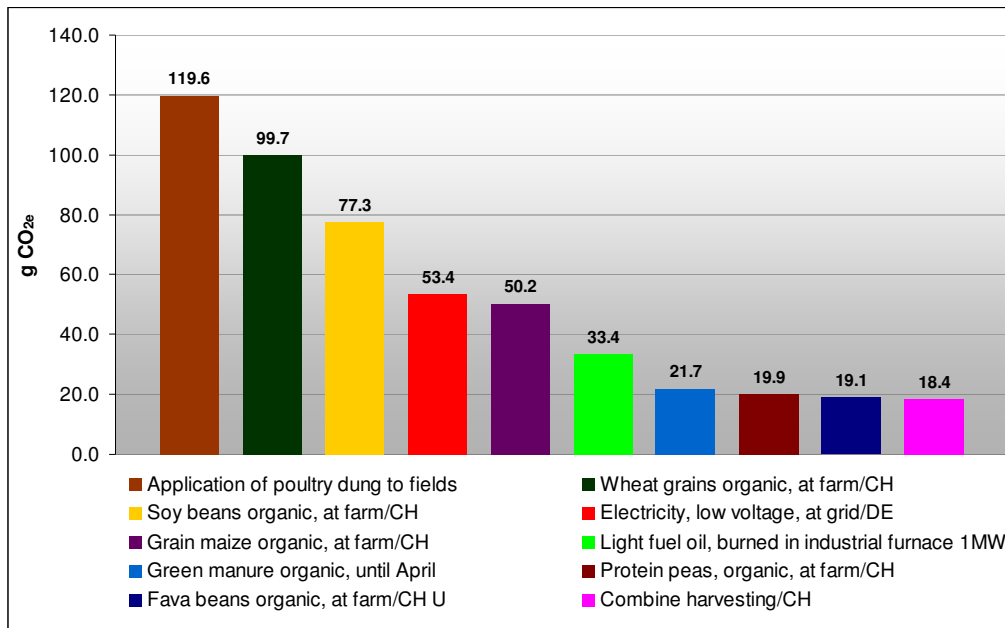


Fig. 13: Contributions of the relevant process steps of the egg laying farm

Contemplation of the different greenhouse gases reveals that dinitrogen monoxide is the main contributor to the PCF with 376 g CO_{2e} (54.2%), followed by carbon dioxide, which led to 188 g CO_{2e} (27.1%), and methane, which caused 120 g CO_{2e} (17.2%).

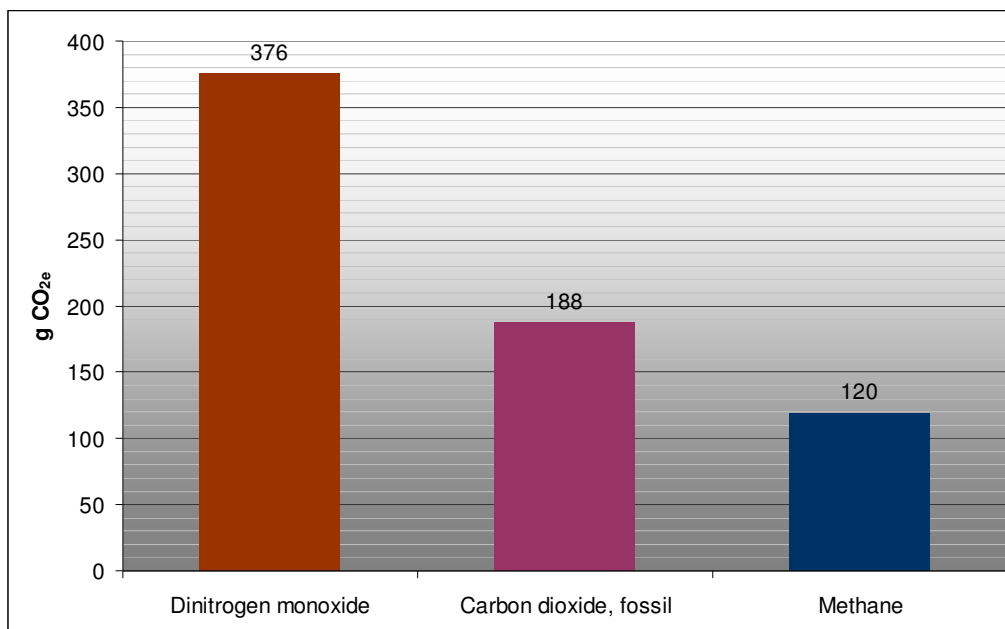


Fig. 14: Distribution of the PCF of the egg laying farm according to green house gases

7.4 Product Distribution

The main source of emissions for the “distribution” process step is the production of the egg box, which accounted for 16 g CO_{2e} (22%). This factor is followed by diesel consumption in combustion engines, which caused 14.1 g CO_{2e} (13%) and the emissions from lignite plants, which led to 3.9 g CO_{2e} (5.3%).

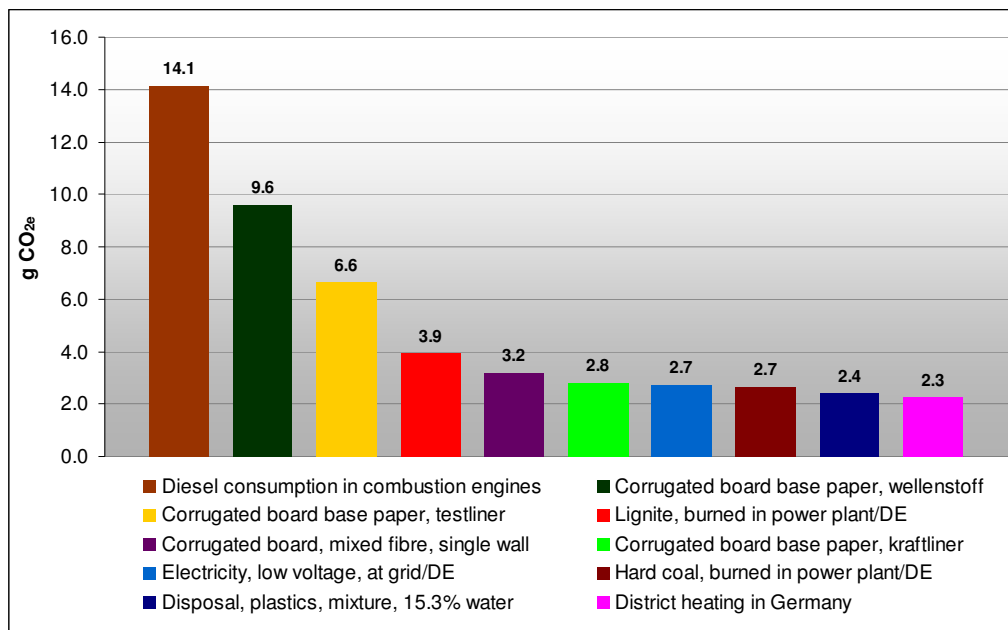


Fig. 15: Contributions of the relevant process steps of product distribution

Contemplation of the different greenhouse gases reveals that carbon dioxide is the main contributor to the PCF, accounting for 69.4 g CO_{2e} (94%), followed by methane and dinitrogen monoxide, which caused 2.8 g CO_{2e} (4%) and 1.3 g CO_{2e} (2%), respectively.

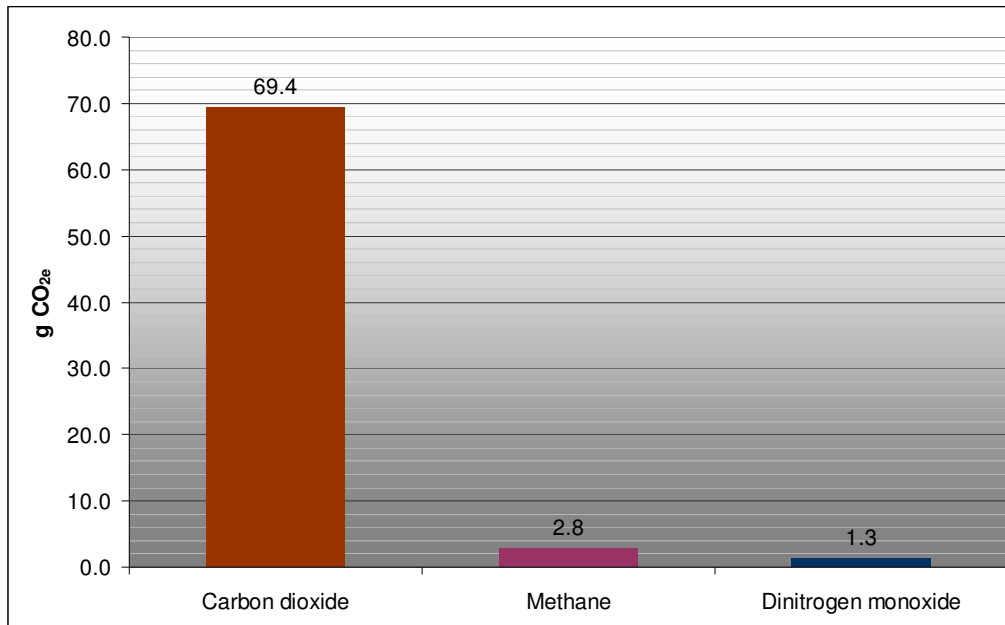


Fig. 16: Distribution of the PCF according to green house gases

7.5 Trip to the shops

It was decided in the project groups to use standardized assumptions to model the trip to the shops. A distance of 5 km and a shopping basket weighing 20 kg were assumed. The vehicle is an automobile mix based on German car sales. Due to mass allocation, a proportional allocation of only 2.04% of the trip to the shops was assumed for the eggs. This figure yields a carbon footprint of 47.3 g CO_{2e} for the trip to the shops. The carbon footprint increases by approx. 4 g CO_{2e} per trip to the shops when TREMOD data [5] are used.

The main source of emissions for the “trip to the shops” process step is the operation of petrol-driven automobiles, accounting for 25 g CO_{2e} (53%), followed by the operation of diesel-fuelled automobiles, which led to 14 g CO_{2e} (30%). The remaining 8.3 g CO_{2e} (16%) of the emissions originate from the upstream chain of the production of petrol and diesel.

Contemplation of the different greenhouse gases reveals that carbon dioxide is the main contributor to the PCF, accounting for 45.6 g CO_{2e} (96.4%), followed by methane and dinitrogen monoxide, which caused 1 g CO_{2e} (2.3 %) and 0.6 g CO_{2e} (1.4 %), respectively.

7.6 Product Utilization

The main source of emissions for the “product utilization” process step is the use of lignite in German power plants, accounting for 88 g CO_{2e} (36%), followed by the use of hard coal and

the operation of an automobile, resulting in 62 g CO_{2e} (25%) and 39 g CO_{2e} (16%), respectively.

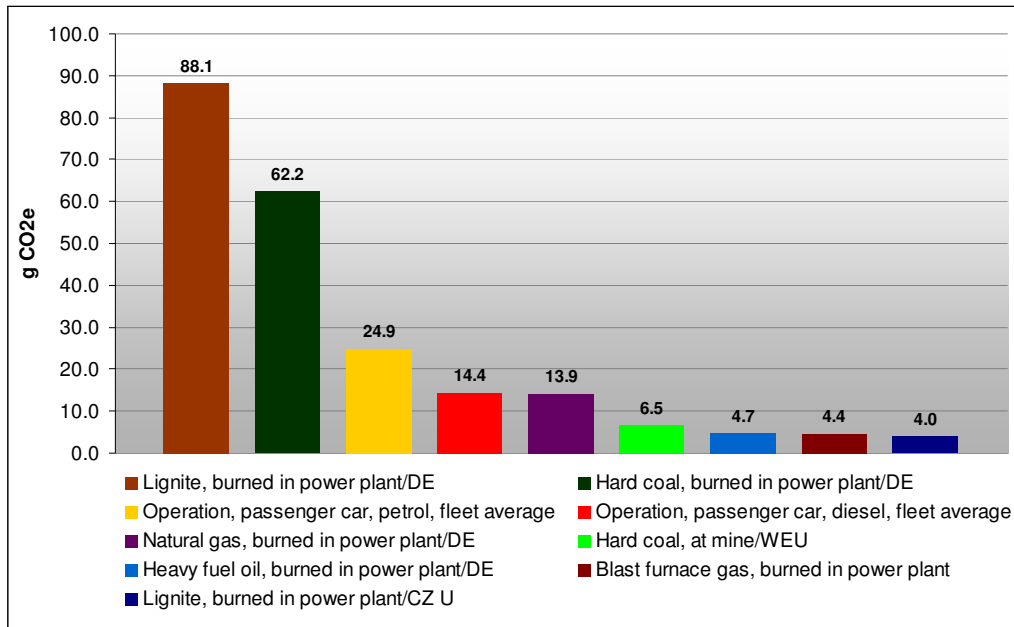


Fig. 17: Contributions of the relevant process steps of the utilization phase (basic scenario)

Contemplation of the different greenhouse gases reveals that carbon dioxide is the main contributor to the PCF, accounting for 233 g CO_{2e} (94.2%), followed methane and dinitrogen monoxide, which led to 10.9 g CO_{2e} (4.4%) and 2.7 g CO_{2e} (1.1%), respectively.

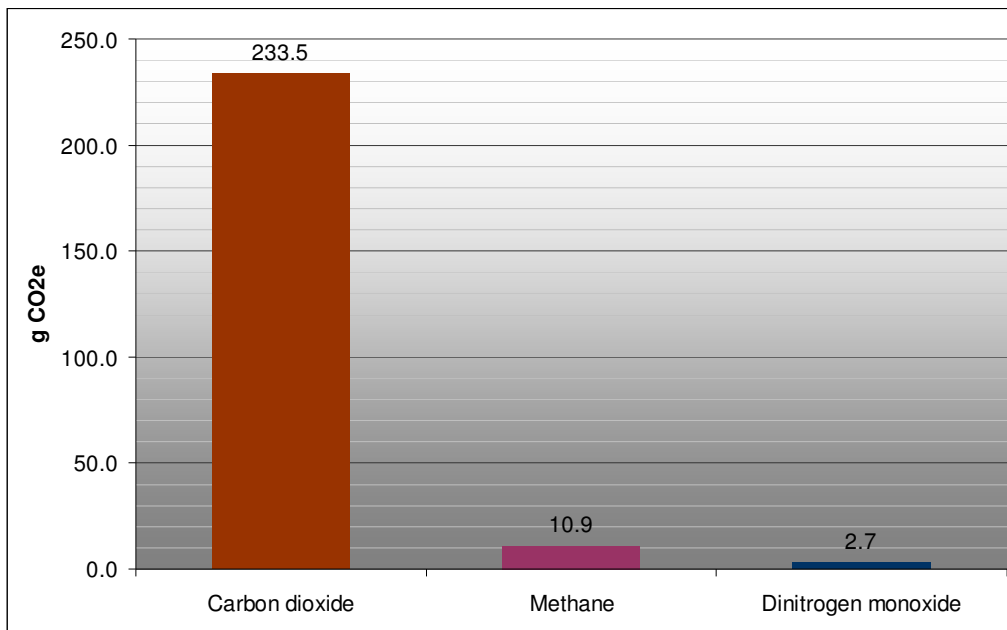


Fig. 18: Distribution of the PCF of the utilization phase (basic scenario) according to green house gases

Comparing the three scenarios, it can be seen that the preparation of the eggs has the greatest influence on the utilization phase of the Product Carbon Footprint. While the use of a bicycle instead of an automobile for the trip to the shops only reduces the PCF by 47.3 g CO_{2e}, preparing the eggs in an open pan instead of in an egg boiler increases the PCF of the utilization phase from 248 g CO_{2e} to 377 g CO_{2e}.

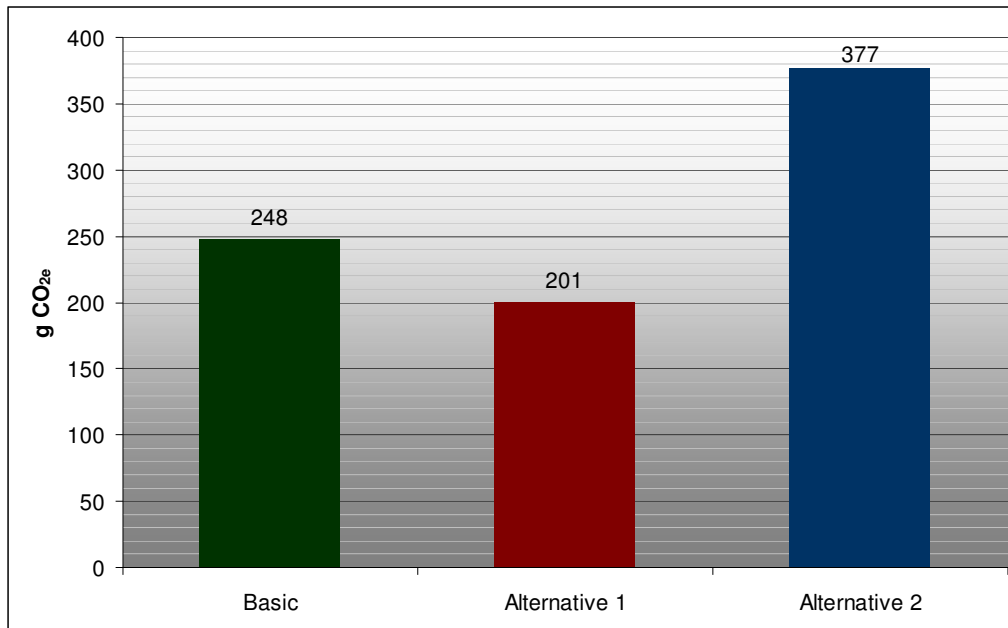


Fig. 19 Comparison of the PCFs of the three utilization scenarios

7.7 Disposal/Recycling

The project group decided to determine the following disposal scenario regarding the disposal of the egg box: 50% of the egg box is recycled and the remaining 50% is thermally utilized in a garbage incineration plant. This results in total emissions of 19.8 g CO_{2e}.

The methane emissions resulting from the disposal of poultry dung total 0.0175 kg CH₄ per kg poultry dung. Taking a global warming potential of 25 (IPCC [4]) into account, these emissions total 437.5 g CO_{2e} per kg poultry dung or 128 g CO_{2e} per functional unit.

8 Assessment of the Results

8.1 Sensitivity Analysis

A sensitivity analysis was performed using emission factors based on GEMIS 4.4.2 as well as on estimates. Emission factors for five key processes were used. Table 1 shows the upper and lower thresholds for these emission factors.

	Low	Used (PCF)	High
Feedstuff	0.156 kg CO _{2e} / kg (Gemis 4.4.2)	0.539 kg CO _{2e} / kg (Ecoinvent)	0.695 kg CO _{2e} / kg (IST +29%)
Chicken manure waste	0.089 kg CO _{2e} / kg (KTBL 06-Minimum)	0.438 kg CO _{2e} / kg (KTBL 06-mittel)	0.714 kg CO _{2e} / kg (KTBL 06-Maximum)
Electricity mix	0.602 kg CO _{2e} / kWh (Gemis 4.4.2)	0.719 kg CO _{2e} / kWh (Ecoinvent)	0.836 kg CO _{2e} / kWh (IST +16%)
District heat	0.288 kg CO _{2e} / kWh (Gemis 4.4.2)	0.453 kg CO _{2e} / kWh (TUG Inventar 2007)	0.618 kg CO _{2e} / kWh (IST +36%)
Natural gas	0.252 kg CO _{2e} / kWh (Gemis 4.4.2)	0.276 kg CO _{2e} / kWh (Ecoinvent)	0.300 kg CO _{2e} / kWh (IST +9%)

Table 1: Upper and lower thresholds of the sensitivity analysis

The sensitivity analysis shows that the choice of emission factor can have a great influence on the emitted quantities of CO_{2e}, in particular concerning the feeding stuff, while the effects concerning the heating media – district heat and natural gas, are relatively low, even though the difference between the highest and the lowest emission factor is 0.33 kg CO_{2e} per kWh in the case of district heat.

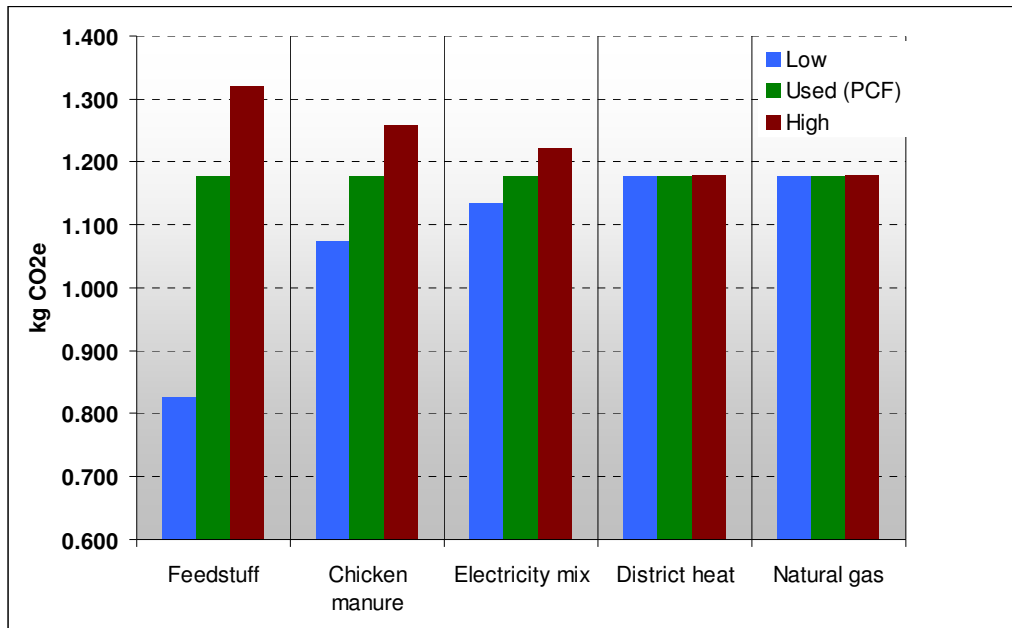


Fig. 20: Effects on individual process steps

The significant impact of the emission factor can also be seen in the process modules. Significantly high deviations can be seen in the “egg laying farm” process step. Here the value of emitted CO_{2e} varies by 0.665 kg CO_{2e} per kWh. These strong variations can, of course, also be seen in the final result, which varies between 0.660 kg CO_{2e} per kWh and 1.463 kg CO_{2e} per kWh, depending on the emissions factors assumed.

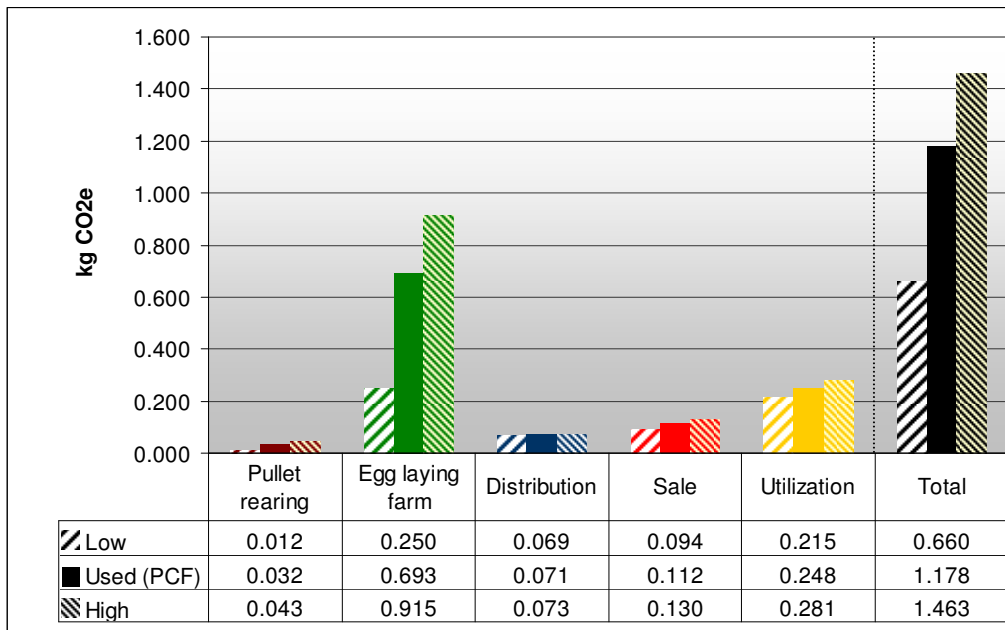


Fig. 21: Effects on the life cycle phases

8.2 Dealing with other Environmental Impact Categories

No other environmental impact categories were investigated in detail. Due to an overall lower environmental impact of organic agriculture compared to conventional production, the project partners agreed to concentrate their efforts on determining the carbon footprint. Due to the use of the Ecoinvent database, other impact categories can be considered whenever required.

9 Interpretation and Perspectives

9.1 Challenges of the Case Study

Due to the previous highly efficient and smooth collaboration between the Tengelmann Group, the business segment Kaiser's Tengelmann AG, Tengelmann Energie GmbH and Ecofys Germany GmbH, the case study cannot be described as a challenge.

Moreover, the proven contact with the upstream chains and suppliers via Kaiser's Tengelmann AG benefited the study and was the source of very good data.

From the methodological perspective, the boundaries of the life cycle were a challenge. For a completely biological product, it is always the question when calculating the carbon footprint where the life cycle of a product begins. In the case of eggs, for instance, the question was whether the life cycle started with the breeding of the laying hen or with the egg laying farm. Based on the defined cut-off criteria, it was decided to start the life cycle with the rearing of the laying hens.

A second challenge entailed the assessment of the life cycle. Since the utilization phase of the product was also calculated, a representative scenario for this phase had to be developed. Due to the multitude of possibilities of using, storing and preparing eggs, as well as the different options available to the consumer to go shopping, it was decided to consider the utilization phase in three scenarios, each of which represents different consumer behavior.

9.2 Identification and Assessment of Reduction Options of the PCF

A preliminary analysis of the process chain has shown that the biggest reduction potentials can be found in the utilization phase, as well as in the pullet rearing and egg laying farms.

For example, installing a biogas plant at the egg laying farm could save up to 160g CO_{2e}, corresponding to around 14% of the carbon footprint in the basic scenario.

In the utilization phase, a further reduction of approx. 48 g CO_{2e} (depending on the distance and the automobile used) could be achieved by going shopping by bike or on foot. Moreover, preparing the eggs in an egg boiler saves up to 130 g CO_{2e}, according to this study.

Further reductions of approx. 110 g of carbon emissions can be achieved by using electricity from renewables in the regional warehouses and stores.

9.3 Product-Specific Options for Action to Reduce the PCF

It was explained in Section 9.2 that the use of electricity from renewables can lead to a reduction of CO_{2e} emissions in the life cycle of the product.

Since 1 August 2008, the entire Kaiser's Tengelmann AG has been supplied with green electricity from hydroelectric power, i.e. also the stores and warehouses considered in the present study, as well as the headquarters in Viersen are powered by electricity from renewables.

This circumstance has not been taken into account in this study since there is not yet any internationally recognized methodology available to deal with green electricity.

9.4 Future Handling of the Product Carbon Footprint

The Tengelmann Group has a long tradition of commitment to environmental protection and nature conservation. Following this tradition, the Tengelmann Group also takes the balancing of product-related CO_{2e} emissions into account, and will accompany the developments of a new methodology.

As things currently stand concerning the methodological development of the PCF, the Tengelmann Group considers it an important task to actively participate in the processes and to be a driving force, using its own experiences practical work with carbon footprinting to reinforce and actively accompany the developments.

In the future, further experiences in balancing a carbon footprint will be made based on recent developments. Contacts and communication with customers with regard to the carbon footprint shall be enhanced, without losing sight of the fact that the Product Carbon Footprint is only at its beginning of development, and that customers first have to be introduced to the subject carefully.

10 Recommendations

10.1 Development of International Methods for Product Carbon Footprinting

Three issues are highly relevant to achieve the broader acceptance of the Product Carbon Footprint: simplicity – transparency – credibility. The international method development should pay great attention to these keywords. An irreproducible carbon footprint, which not only conceals or glosses over the approach and the drivers of CO₂ emissions, does not lead to the desired results.

In the course of credible transparency, we would advise the separated examination and depiction of the Product Carbon Footprint in life cycle phases. This division simplifies the analysis and assessment of the single contributions to the carbon footprint of the product and increases traceability. Concrete measures to improve the CO₂ balance can be determined, implemented and monitored specifically. Especially with regard to an additional examination of the utilization phase of the product, we do not consider the aggregated portrayal to be expedient.

A further important impulse the Tengelmann Group would like to give to the international development of the method is the advice to improve the work with secondary databases. It would be desirable to standardize or internationalize the databases used for carbon footprints to eliminate “gaming” or glossing over balances by choosing the “right” database. Alternatively, a binding quality standard and reliable proof of origin of secondary data should be created to avoid the above-mentioned problems and to increase the credibility of carbon footprints.

Furthermore, in the international development of the method, attention should be paid to other important uncertainties in balancing. Such uncertainties include the use of green electricity and certificates, rules for balancing CO₂-free or CO₂-neutral energy and/or material flows.

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

With reference to product-related recommendations, it just remains to say that biological products definitely require greater harmonization.

Let us mention here the definition of the start of a life cycle of a biological product. Product category rules should stipulate whether the life of an egg starts with the rearing of the hen or with the laying of the egg.

Furthermore, the stakeholders should work towards the comparability of breeding stock and wild populations. Forage and rearing, for instance, should be balanced for breeding stock, but it is virtually impossible to generate this information for wild populations, and would lead to greater imprecision or their neglect.

Moreover, it is advisable to stipulate binding rules and basic conditions in product category rules when considering the utilization phase since biological products in particular usually have a multitude of different uses.

10.3 Customer and Consumer Information on Product Carbon Footprint

Since experiences and comparisons on the subject of the carbon footprint are still lacking, the Tengelmann Group will initially furnish customers with general information to introduce them to the subject. Since the PCF Pilot Project Germany is embedded in the Tengelmann Climate Initiative I, customers will receive extensive information on this subject. Only when a broad knowledge base can be assumed, quantitative PCF communication will make sense. Nevertheless, the results of this study will also be presented to customers, both at the point of sale and on the internet.

11 References

- [1] **Greenhouse Gas Protocol**
"A Corporate Accounting and Reporting Standard", World Business Council of Sustainable Development (WBCSD) and World Resources Institute (WRI), Edition 2.0, 2005
(<http://www.ghgprotocol.org/>)

- [2] **Ecoinvent Database**
ecoinvent Centre (2007), ecoinvent data v2.0 final reports Ecoinvent 2000 No. 1-25, Swiss centre for Life Cycle Inventories, Dübendorf, 2007

- [3] **IPCC Report 2007**
Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp
<http://www.ipcc.ch/ipccreports/ar4-wg1.htm>

- [4] **KTBL 2006**
Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V., Nationaler Bewertungsrahmen Tierhaltungsverfahren, Darmstadt

- [5] **TREMOT - Transport Emission Model**
Version 4.17, Institut für Energie- und Umweltforschung Heidelberg GmbH