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Requirements on Consumer Information about Product Carbon Footprint

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Table of contents

List of tables

List of figures

1 Executive Summary

The term 'carbon footprint' has become tremendously popular over the last few years. A variety of different CO2 or climate protection labels partly tailored to certain product groups is meanwhile available at the international level – e.g. Carbon Reduction Label/UK; Carrefour Initiative (France), Stop Climate Change Label/Germany; KRAV Climate Marking Sweden (KRAV Sweden); Climatop-Migros Switzerland, Carbon Label Initiatives or programs in Japan (Japan Environmental Management Association for Industry), Korea (Korea Eco-Products Institute), Thailand (Thailand Greenhouse Gas Management Organization). Interestingly, the main focus lies on foods although individual foods are clearly less relevant to the climate than other product groups, i.e. household appliances or automobiles. Already existing labelling obligations as the Statutory Declaration of Carbon Footprint for Electricity are hardly covered by media and little-noticed by customers.

With climate change high up on the political and corporate agenda, carbon footprint calculations are in strong demand. Nevertheless the focus on CO2-emissions does not only provide possibilities, but also bears some risks that might as well weaken environmental labelling approaches in the future. These risks include for example the negligence of environmental impacts others than CO2, a disregard of product-quality aspects and the distortion of competition caused by insufficiently detailed or asymmetric life cycle data.

The definitions and uses of the term "product carbon footprint" differ internationally. For the herewith presented study the following definition, that was also agreed upon within the scope of the PCF Pilot Project Germany (PCF-Pilote 2009), seems most appropriate:

"*Product carbon footprint describes the sum of greenhouse gas emissions accumulated during the full life cycle of a product (good or service)*[1] *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 term Product Carbon Footprinting encompasses the determination and assessment of one PCF.

At the moment, the standardisation process for the determination of one PCF is still ongoing (ISO 14067 „Carbon Footprint of Products", quantification and communication). Therefore most available resp. currently performed PCFs are done on the basis of PAS 2050:2008 (Public Available Specification „Specification for the assessment of the life cycle greenhouse

[1] In the following the term "product" always includes goods and services even if this is not explicitly written.

gas emissions of goods and services“, a guideline below a British Standard) or resp. in combination with ISO 14040 / 14044 (LCA) and taking into consideration the Greenhouse Gas Protocol Product / Supply Chain Initiative of World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

Against this background the herewith presented study analysed the suitability of the LCA / PCF approach for environmental labelling, prioritisation of consumer information and the relevance of PCF in different product groups.

From these analyses the following general recommendations to standardisation and legislation can be given:

Other environmental effects should not be disregarded

The narrow approach to only focus on greenhouse gas emissions bears the risk to overlook other relevant environmental impacts or even lead to wrong conclusions that increase negative environmental effects in the worse case (e.g. in the case of electricity). Therefore screening analyses of other environmental impacts must be included in a PCF.

The PCF is a fundamental indicator for some products or product groups. Still a comprehensive sustainability assessment of products cannot be carried out on the basis of the PCF alone. Other useful evaluation tools like life cycle assessments, eco-efficiency analyses and sustainability analyses can be used to complete the picture.

The screening of relevant other environmental impact categories besides global warming potential must thus be an obligatory component of a Carbon Footprint study.

ISO 14024 Type I labels like the Blue Angel should be retained as lead labels

The above considerations clearly support retention of eco-labels in accordance with ISO 14024 (Type 1), such as the Blauer Engel eco-label, as lead labels. The advantages of ecolabels over CO2 labels are summarized again below (the arguments apply both to the Blauer Engel and by analogy to other national eco-labels and the European eco-label):

- easily understood and reliable information for consumers: from an overall environmental perspective an eco-labelled product is clearly better than comparable products;
- inclusion of all relevant environmental and health aspects;
- identification of criteria on the basis of LCAs and eco-toxicological assessments;
- subsequent discussion by a panel of experts;

- final decision by an “environmental jury” on which relevant stakeholder groups are represented;
- certified award process and checking of the criteria for products marked with the ecolabel.

Drawing up of Product Category Rules for particularly relevant products is essential

The main challenge of PCF meant for communication is to define the whole framework in a way that all products belonging to one product group can be calculated in a as much as possible defined way to assure the same approach even if the studies are performed by different experts. This requires e.g. the same goals, the same system boundaries, the same calculation rules and similar data quality for different studies. With a general ISO standard this can not be achieved as it only provides generic rules. Therefore it essential for the future that product category rules (PCRs) will be developed that ensure a comparable proceeding within one product group. Such PCRs would have to be defined and adopted at the European level. Given the many different product groups this will take time and needs prioritisation.

Basing on PCF it is not possible at the moment to perform product comparisons of multiple products carried out on behalf of different clients and by different practitioners as well as public comparison with competing products in ways that are acceptable under competition law (e.g. through reporting of CO2e values or use of CO2e labels).

Methodological restrictions when using the LCA / PCF approach

For the PCF approach the same is true as for the general LCA approach: The assessment of the whole life cycle is a strength compared to other techniques. The approach can be used to compare products with similar function but differing production and/or operating technologies. Still the methodology has some restrictions that have to be kept in mind when applying it: Like LCA also PCF is *per definitionem* a purely quantitative tool. As it has to be requested that at least a screening analyses on other environmental impacts then greenhouse gases has to be performed in a PCF study, the same problems occur as with LCA. Current LCA-approaches cannot exhaustively cover site-specific aspects: As greenhouse gases have a global impact and no site-specific one, this weakness does not apply to PCF studies in the narrow sense. As for LCA the variability and reliability of data may represent a problem concerning data quality (e.g. time-related, geographical and technology coverage), data origin, effort of data acquisition and possibly fast changes of supply chains. Spatial and temporal variations are theoretically no obstacle for the applicability of LCA / PCF in product labelling. Nevertheless, the things can get quite complicated a proper definition of the functional unit can be quite critical. Fast changes in supply chains are difficult to be

accounted for in LCA / PCF since they require a functioning information system which is not yet in place. As for the calculation rules, there are still methodological questions to be solved and consensus to be found among different existing approaches (see chapter above). Concerning the differences between different products from the same product group PCF results may show only small deviations similar to that of LCA results. LCA as well as PCF cannot eliminate uncertainty. Due to these uncertainties (e.g. parameter or model uncertainty) PCF results will always have a restricted precision. Therefore the display of a single CO2e figure on a product is misleading.

Current CO2 labels neglect consumer comprehensibility, benchmarks and indication of excellence

In order to be useful to consumers a CO2 label would have to

- ***be comprehensible***, e.g. by a well structured display, aggregation of the information, concentration on the gist. Additionally, have a standardised look thus enabling consumers to quickly comprehend the information, compare different products and include the information on the climate impact in their purchasing decision.
- ***include a rating scheme***, enabling consumers to recognise if the products' Carbon Footprint represents a relatively low greenhouse gas emission for the respective product group or a relatively high emission. It must be possible for consumers to recognise excellent products. Only then an effective reduction of the climate impact due to "the right" purchasing decision can be achieved. Consumers are already well acquainted with the A-G labelling scheme of the EU energy label, so this could be a promising starting point.
- ***be third party certified***. As credibility is of high importance for consumers, it is crucial that a third party review should be requested for the PCF when used in product-related communication.
- ***be backed-up*** by easy to access and transparent documentation of the PCF study the label is basing on. This includes the motivation for calculating a PCF and assumptions and quantifiers used in the calculations. Any publication of the data must be clear, understandable, conclusive and open to scrutiny. It should ne noted to what extent PCF calculations are reliable and/or uncertain and whether other important environmental impacts have been taken into consideration.

Single number CO2 labels make no sense

A static PCF stand-alone label providing a total CO2 footprint on products does not make sense and is not very relevant for consumer decision making. Although consumers are increasingly aware of the relevance of climate impacts resulting from their purchasing

behaviour and usage of products, the display of a total CO2e footprint figure alone would not be of much help to them. It has to be stressed that a figure of this kind suggests a precision and conclusiveness which cannot be achieved using the current state of methodology. At the current state with only few products being labelled this even bears the risk that the sheer display of such a label makes consumers believe that the product might be better then another without label.

Climate change might be addressed by other means than PCF

It is not always necessary to use PCF to address climate change issues. As CO2e emissions are at the moment often highly correlated to the demand of electric and thermal energy and fuel consumption (e.g. in cars) climate change issues more easily can be addressed by energy efficiency parameters. The latter is also cheaper and more reliable as it addresses a key parameter that can be directly measured and restricted e.g. by legislation. In other cases, like food for example, PCF is a good base for the development of general recommendation for consumers taking into account climate change issues (e.g. "*eat regional and seasonal food*", "eat less meat" etc.) but needs not be communicated as PCF.

Overall it can be concluded that in some cases there is no added value to the use of PCF and in other cases PCF should only serve as base for general recommendations.

Recommendations on how to address global warming best in the analysed product groups

The following table summarises the results on how global warming is best addressed for the specific product groups that have been analysed.

Table 1 Overview of the conclusions concerning how global warming is addressed best

Product category	Product group	Best options to address global warming
Energy consuming products	Cars	The existing mandatory label on CO_2 communication for the marketing of new passenger cars should be complemented by a benchmarking system e.g. in the form of a colour or letter code. Petrol consumption tests should be developed that are more in line with real driving and including also electric cars. Adequate measures to improve the outcome of the label in the sense of climate friendly purchase decisions by consumers. In later steps: include non CO_2 greenhouse gases and precombustion of fuel as well as production (in the from of average data for different size classes of cars)
	Household appliances	EU energy label addresses energy efficiency and therefore indirectly also CO2e emissions. An addition of CO2 values on the label is not helpful. Type I labels should include in-depth PCF studies as starting point for the development of criteria. To set CO2e values as a direct limit makes no sense.
Energy saving products	Insulation material	Instead of focussing on the PCF of insulation materials it will be more successful to concentrate on energy certificates for buildings. About 80 percent of climate relevant emissions relate to the usage phase and correlate with the energy standard of the building!
Products with relevance concerning greenhouse gas emissions at production phase	Electricity	The obligatory information of customers concerning of at least CO_2 emissions and radioactive waste resulting from the electricity production is purposeful. Adequate measures to improve the outcome of the obligatory information in the sense that more consumers buy green electricity. Type I labels should include in-depth PCF studies as starting point for the development of criteria (CO2e, nuclear waste). Measures to reduce electricity consumption (e.g. communication measures) are also beneficial.
	Food	Development and communication of “simple” general recommendations taking into account climate change issues (PCF based) concerning food purchase and preparation. In order to do so, further in-depth PCF studies are necessary. Basing on in-depth PCF studies integration of climate change issues in the development of the standards for organic agriculture. The communication of CO2e figures on the product makes no sense and is not helpful to consumers.
	Paper	Type I labels should include in-depth PCF studies as starting point for the development of criteria. To set CO2e values as a direct limit makes sense concerning the production processes.
	Textiles	Inclusion of CO2e issues in the multicriterial approach of type I labels. Promotion of a label awarding textiles made of fibres from organic agriculture. A PCF label makes no sense.

2 Introduction

The term 'carbon footprint' has become tremendously popular over the last few years. A variety of different CO2 or climate protection labels partly tailored to certain product groups is meanwhile available at the international level – e.g. Carbon Reduction Label/UK; Carrefour Initiative (France), Stop Climate Change Label/Germany; KRAV Climate Marking Sweden (KRAV Sweden); Climatop-Migros Switzerland, Carbon Label Initiatives or programs in Japan (Japan Environmental Management Association for Industry), Korea (Korea Eco-Products Institute), Thailand (Thailand Greenhouse Gas Management Organization). Interestingly, the main focus lies on foods although individual foods are clearly less relevant to the climate than other product groups, i.e. household appliances or automobiles. Already existing labelling obligations as the statutory declaration of carbon footprint for electricity are hardly covered by media and little-noticed by customers.

With climate change high up on the political and corporate agenda, carbon footprint calculations are in strong demand. Nevertheless the focus on CO2-emissions does not only provide possibilities, but also bears some risks that might as well weaken environmental labelling approaches in the future. These risks include for example the negligence of environmental impacts others than CO2, a disregard of product-quality aspects and the distortion of competition caused by insufficiently detailed or asymmetric life cycle data.

BSI has published the PAS 2050 as the first approach for a consistent method for assessing the life cycle GHG-emissions of goods and services. It builds on existing methods established through EN ISO 14040 and EN ISO 14044. ISO adopted a new work item entitled "Carbon footprint of products" which consists of 2 parts: part 1 on quantification and part 2 on communication, in November 2008. WRI/WBCSD is standardising accounting frameworks for assessing CO2-emissions of corporate value chains (scope 3) and products.

Against this background, ANEC commissioned the Öko-Institut e.V. to conduct a research study on various issues related to communication of PCF to consumers. The issues involve:

(a) conditions under which CO2-indicators/labels make sense or should be avoided;
(b) conditions under which CO2-indicators/labels are useful consumer information;
(c) options to address sustainability issues ignored by CO2-indicators/labels;
(d) measures to ensure that efficiency is not neglected;
(e) formats to ensure comprehensibility to consumers, including benchmarks and scales;
(f) methods to address different energy mixes and conversion factors and their update;
(g) conventions and methodological choices which need to be defined to ensure comparability and the necessary frameworks for this.

3 Definition of Product Carbon Footprint (PCF)

3.1 Targets, usage and fields of application of PCF

The definitions and uses of the term “product carbon footprint” differ internationally. For the herewith presented study the following definition, that was also agreed upon within the scope of the PCF Pilot Project Germany (PCF-Pilote 2009), seems most appropriate:

“*Product carbon footprint describes the sum of greenhouse gas emissions accumulated during the full life cycle of a product (good or service)*[2] *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 term Product Carbon Footprinting encompasses the determination and assessment of one PCF.

At the moment, the standardisation process for the determination of one PCF is still ongoing (ISO 14067 „Carbon Footprint of Products“, quantification and communication). Therefore most available resp. currently performed PCFs are done on the basis of PAS 2050:2008 (Public Available Specification „Specification for the assessment of the life cycle greenhouse gas emissions of goods and services“, a guideline below a British Standard) or resp. in combination with ISO 14040 / 14044 (LCA) and taking into consideration the Greenhouse Gas Protocol Product / Supply Chain Initiative of World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

As a consequence, the available studies and PCFs are far from being comparable at the moment. And there is still some dynamic concerning methodological aspects to be expected in the future. In the PCF-Pilote Project (PCF-Pilote 2009) several PCFs of different products were calculated in parallel in order to identify work steps that should be done in the same way and others that have to be specific for a specific product group. It seems to be highly necessary to define Product Category Rules for specific product groups (comparable to PCRs as defined in ISO 14025 for EPDs).

In the international debate different targets are discussed concerning the calculation of PCFs: the quantification of CO2e for a CO2e-Label, the optimisation of processes within companies, the comparison of a broad variety of products in a retailer chain. In order to reach these targets, a number of methodological requirements concerning scope as well as data gathering and data processing have to be fulfilled.

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[2] In the following the term “product” always includes goods and services even if this is not explicitly written.

In general, it is claimed that PCF is able to reach the following targets:

- Analyses of the greenhouse gas emissions that occur along the value chain of a good or service.
- Identification of the hot spots of greenhouse gas emissions over the life cycle of a product or service and of realisable reduction potentials.
- Identification of the possible courses of action in order to achieve reduction potentials for different players along the value chain of a good or service: producers, customers, procurers, consumers, politicians etc..
- Evaluation and comparison of different products of the same product group (e.g. different models of cars).

Within the study on hand it will be discussed in the following whether the listed targets can be reached by PCF and which problems occur.

Although climate change is very important to be addressed there is consensus that the analyses and the assessment of greenhouse gas emissions have to be carried out taking into account (all the) other environmental impacts of the specific product group under consideration. This is only possible when broadening the perspective beyond the actual PCF.

The communication of PCF results to consumers is widely discussed (see e.g. ISO). Possible targets may be here

- the assessment of the greenhouse gas emissions of private households,
- the identification of the most important courses of action for consumers,
- the support for purchase decisions and usage of products.

The study of Prakash et al (2008) already pointed out the following advantages and disadvantages of the use of CO2e indicators as single product information[3].

Advantages / Pro‘s

- CO2-indicators meet a high level of public awareness,
- are easily understandable,
- are in line with various new fiscal and legislative procedures in many countries,
- are more precisely representing the environmental impact,
- use a well-established aggregation method,
- and avoid confusion with traditional energy indicators.

[3] Prakash et al (2008) focused on the comparison between CO2e indicators and primary energy indicators. For more detailed see http://www.anec.org/attachments/ANEC-R&T-2008-ENV-005final.pdf

Disadvantages / Drawbacks

- Other environmental impacts of energy generation may get neglected.
- Data availability for energy consumption is better than for CO2 emissions.
- CO2 indicators might lead to a negligence of efficiency.
- Energy indicators have a long tradition and are key characteristics of energy-using products (EuPs).
- CO2 indicators on national average data would cause problems with EuPs.
- Concentration on, and improvement of energy or CO2 issues could shift negative impacts to other environmental areas.
- No consumer guidance for the use phase of energy using products.
- Need for regular updates as a result of changing conversion factors for primary energy.

3.2 PCF/CO2e indicators versus energy indicators

Besides CO2e indicators, energy indicators have been relatively well-known for years and are widely used for communication purposes. Examples are the European energy label for household appliances that displays the electricity demand (end energy) of specific appliances measured under defined conditions. But also the primary energy demand (alternatively the terms CED, cumulative energy demand, or “grey” energy are used) is fairly common at least for some products such as for building products.

The advantage of energy indicators is that they can directly address energy efficiency issues like the electricity demand of an appliance or the thermal energy demand of a building. A CO2e indicator would need to include the specific supply process (e.g. electric grid, heating system) in order to do so. Given an electric grid with a high share of renewable energies, the specific CO2e emissions per kWh will be low compared to one with a high share of fossil fuels. As a consequence the differences between two products with a demand of thermal or electric energy may mainly result from supply processes (e.g. different electric grids) but not (or much less) from their different energy demand. Therefore, energy efficient alternatives can not as easily be identified and promoted. Additionally, no pressure can be built up towards more energy efficiency although energy demand that is avoided is the most environmental and climate friendly one. The focus on CO2e indicators alone also bears the risk to privilege nuclear power. Therefore, this aspect has always to be considered when addressing electricity supply, e.g. in the form of nuclear waste or fuel mix.

On the other hand, the concentration on energy indicators alone will completely leave out the supply system and the two ways the supply system can be optimised: to lower the emissions of a fossil based system or to increase the share of renewable energies (e.g. wood, solar energy, wind).

Prakash et al. (2008)[4] concluded: "*There is a general dilemma when choosing between the two indicator-systems: While energy-indicators are unable to promote renewable energies, they are effective instruments to stimulate energy-efficiency. In contrast, CO_2-indicators can stimulate a shift towards renewable energies, but also bear the risk of neglecting efficiency potentials.*"

As there is no elegant way leading away from this dilemma at this point, the CO2e indicator is not able to substitute the energy indicator and vice versa. It has to be checked in each individual case which one of the two indicators is more suitable or whether both should be used.

Furthermore an eye has to be kept on the supply systems, e.g. when addressing the situation in the EU it is more suitable to use an average European electricity mix instead of the electricity mix of single countries (e.g. France with a low value, Poland with a high value for CO2 emissions).

Methodological questions have to be solved concerning "green" electricity and an agreement has to be found concerning possible incentives for its use.

4 General views on the suitability of the LCA approach for environmental labelling – what are the consequences for the PCF approach?

Prakash (2008) worked out in detail the strengths and weaknesses of the LCA approach in general for environmental labelling purposes. As PCF is to be seen as an indeed focussed but basically the same approach as LCA, the findings of Prakash (2008) will be shown in the following (*see excerpt of the original text in italics*). It will be discussed whether the conclusions are the same for both the PCF and the LCA approach.

[4] For a more detailed discussion on this issue see Prakash et al. 2008

4.1 Advantages of the LCA/PCF for environmental labelling

Integration of all life cycle stages

"LCA is one of the few methodologies that are capable of dealing with all stages of a product life cycle. Although the depth and breadth of the analyses widely depend on the scope and the defined system boundaries, LCA is at least theoretically capable of summarising the environmental impacts of all process steps from cradle to grave. Therefore, LCA-methodology has in this respect a clear advantage over other labelling techniques, which is especially effective for product groups featuring a variety of severe environmental impacts during various life cycle stages." Prakash 2008

For the PCF approach the same is true as for the general LCA approach: The assessment of the whole life cycle is a strength compared to other techniques. But it has to be mentioned that according to PAS 2050 and labels basing on it (e.g. Carbon reduction label from Carbon Trust) only for B2C products the PCF is conducted over the whole life cycle (cradle to grave). For B2B products only a cradle to gate analysis is performed. Furthermore, as there is not yet consistency among the different labels on the market at the moment, there are carbon labels around that not at all consider use and end-of life phase (e.g. Casino Carbon Index does not cover use and end-of-life).

For in-depth PCF studies that aim at giving an overview of a products' climate impact and at identifying the hotspots of a product, it is important that they cover the whole life cycle. When, for example comparing industrially produced convenience food with food that is cooked in the consumers home it would give a wrong picture if the use phase (storage and preparation) was left out. Such an in-depth PCF study is a very good starting point for developing product criteria in the context of a type I label: What are the hotspots? What aspects may be neglected?

If a products' life cycle shows clear-cut hotspots concerning CO2e emissions, e.g. in the usage phase, it can be justified to restrict further PCF studies meant as base for a labelling to that phase and leave out the others. Nevertheless it has to be kept in mind that the fundamental in-depth PCF study may have to be repeated from time to time if e.g. framework conditions change or if there are significant product innovations.

Ability to compare products with similar functions but differing production and/or operating technologies

"LCA-methodology is much better capable of comparing system alternatives and would therefore be able to broaden labelling schemes to much wider defined product groups. Thereby, it would be possible to base product comparisons on the delivered functions instead of the technologies currently present on the market. Such an approach would be much more open to innovations that follow alternative technological approaches.

Nevertheless, it has to be added that even for such applications, LCA does not have to be applied for each individual product covered by the labelling scheme separately. Especially for type I ecolabels it seems much more practical to carry out an initial LCA comparing the different system alternatives, which is than updated periodically. With this initial LCA, the environmentally worst system alternatives can be generally excluded from the labelling schemes. Than for the remaining system alternatives product related criteria[5] can be developed." Prakash 2008

For PCF the same system approach is applicable as for the LCA approach. Also for PCF it usually makes no sense to perform studies on many different single products of the same product group. In order to draw general conclusions and to find the strong and weak points of a solution it is sufficient to study in detail representative types of system alternatives. Of course it has to be kept in mind that – due to the focus on greenhouse gases – the PCF approach is to be complemented by a screening of other environmental impacts in order not to point in the wrong direction. As already mentioned earlier it may be justified to focus on the most relevant life cycle phase or to use alternatively another indicator that correlates to the CO2e emissions (such as electricity demand in the usage phase).

Due to general restrictions and also to the standardisation still being under development, figures on CO2e emissions from different PCF labels – e.g. Casino Carbon Index and Carbon Trust Carbon reduction label – cannot be compared directly at the moment. Moreover, the comparison of PCF studies done by different institutions most likely is not possible as different data bases may be used, different user scenarios may be defined etc. This is a fundamental problem of PCF studies that would be changed partly when the standardisation process is completed. Actually it would be fundamental that Product Category Rules (PCR) were defined as obligatory by standardisation. PCRs define fundamental rules concerning the scoping of a PCF study for products of the same product group (e.g. adequate user scenarios, data bases, relevance of other environmental impacts etc.). Additionally, their development includes stakeholder involvement.

[5] Amendment: those criteria usually are non-LCA indicators and may concentrate on the relevant life cycle phase, such as electricity demand in the usage phase.

Applicability for orientation purposes

"LCA is already widely used for orientation purposes in environmental labelling. Thereby, an LCA is carried out for a typical model of the product group to be labelled. The results give a widely objective overview on the various environmental impacts across the life cycle, and help to identify critical issues that have then to be addressed using production or use phase indicators. Prominent examples are ecolabels and product ratings for cars: These labels and ratings usually exclusively address environmental impacts in the use-phase and leave aside impacts in production and end-of-life stage. This approach is justified with LCA-results showing that the use phase constitutes for at least two thirds of the total environmental impacts (Dauensteiner 2001, Gensch and Grießhammer 2004; Quack and Rüdenauer 2007)." Prakash 2008

Due to the restricted focus of PCF on greenhouse gases, the situation is somehow different to the general LCA approach: Results of a PCF can be used for orientation purposes as well but they do not give an overview on the environmental performance of a product over its life cycle. It only shows the very restricted view on climate impact. As the climate change issue is of such a large relevance this approach is justified if it is somehow backed-up by a screening of other environmental impacts. It must be prevented that a reduction in PCF on the one hand leads to an increase of other significant environmental impacts on the other hand (e.g. switch to electricity from nuclear power instead of fossil fuels). Secondly, it has to be avoided that a product "looks good" but only due to its marginal PCF, leaving out the relevant impacts in other impact categories (e.g. photochemical ozone creation potential, POCP).

4.2 Disadvantages of the LCA/PCF for environmental labelling

Current LCA-approaches do not account for unquantifiable impacts

"LCA is a purely quantitative tool that is based on numeric calculations of environmental impacts across the life cycle. Nevertheless, there are certain environmental issues that cannot be sufficiently expressed with quantitative figures. Although this is in some cases feasible from a purely scientific perspective, the task to conduct this for a whole product life cycle makes the issue too complex to be achieved within usual time and financial resources.

Additional problems arise with environmental topics that are rooted in the precautionary principle: Topics like electromagnetic radiation and the release of many persistent organic pollutants have in common that their precise impacts are not fully understood today. Nevertheless, there is a broad agreement that the sheer likelihood of negative impacts in the future is reason enough to reduce the release. Although some of these issues can be integrated in LCA, the tool does not facilitate the interpretation of such issues and has therefore limited scientific added-value." Prakash 2008

Like LCA also PCF is a purely quantitative tool. As it leaves out *per definitionem* other environmental impacts, the above critics on LCA only apply to a restricted extent: As it has to be requested that at least a screening analyses on other environmental impacts then greenhouse gases has to be performed in a PCF study, the same problems occur as with LCA.

Current LCA-approaches cannot exhaustively cover site-specific aspects

"An aggregation of certain issues across the life cycle of products does only partly give insights into the real environmental impacts. This is the case for environmental and health impacts that are highly site specific. This disregard of site-specific aspects is of conceptual nature and based on the fact that LCA seeks to aggregate environmental impacts over the whole life cycle of products. This demand of comprehensive aggregation is currently only feasible with the use of generic data, which by nature cannot address site-specific aspects." Prakash 2008

As greenhouse gases have a global impact and no site-specific one, this weakness does not apply to PCF studies in the narrow sense. Again, as for the requested screening of other relevant environmental impacts the same problems must be stated as for LCA.

Variability and reliability of data

"In the phase of inventory analysis, main problems are data origin, effort of data acquisition and data quality, especially for comparative assertions. In this case it is absolutely necessary for data quality requirements to fulfil certain qualifications, e.g. definition of time-related, geographical and technology coverage, precision, completeness, representativeness, consistency, sources of data and the uncertainty of the information. But these qualifications are not further specified in the ISO 14040/14044 standards.

Therefore, the individual environmental impact of a product might vary over time. Generally, these issues are subjects to be dealt with in the functional unit of a LCA. In addition, a sensitivity analysis is the appropriate methodology to make judgements whether to include such variations in the LCA-calculations or not. Therefore, such spatial and temporal variations are theoretically no obstacle for the applicability of LCA in product labelling. Nevertheless, the examples illustrate that things can get quite complicated and that a proper definition of the functional unit can be quite critical.

Additionally, the assessment of primary and generic data follows a more or less lengthy procedure, which lies in some cases within the time-range of process innovation cycles.

Furthermore, supply chains become increasingly flexible in modern economy so that even assessments based on primary data can be outdated rather quickly. In some extreme examples, such rapid shifts in supply chains can lead to significant changes in the total

environmental impacts: Such changes are difficult to be accounted for in LCA, since they require a functioning information system on supply chain changes, which is not yet in place. Furthermore, many supply chains are increasingly organised by highly flexible spot markets which make direct contacts between supplier and customer unnecessary. Under such conditions, it is hard to imagine a satisfactory flow of primary process information suitable for LCA-applications." Prakash 2008

As for LCA the acquisition of data on greenhouse gas emissions is time-consuming and cost-intensive. The same problems concerning outdating of data and possibly fast changes of supply chains occur. One advantage is that greenhouse gas emissions at present are highly correlated to energy generation, which is generally covered with relatively good data compared to other impact categories and processes. That way, at least secondary data are available for many basic processes. For other processes, such as agriculture or food processing only fragmentary data are available that are besides highly variable (depending on farm size, farm equipment, storage of food etc.). The effort to gather representative primary data on food production is high, especially as for agricultural products fast changes of the supply chain occur often (e.g. due to weather changes, good or bad harvests) with possibly high impacts on greenhouse gas emissions.

In general it is true that the PCF is subject to variances in the precision and reproducibility of calculations. This comes from the different quality or sources of data used or the definition of certain assumptions in the individual phases of the product's life cycle. Whether all of the uncertainties and assumptions that arise can be remedied by an internationally standardised methodology remains uncertain, if anything. The existence of PCRs would strongly support the comparability of results of different products within one product group. This is something that is of particular importance when communicating the PCF.

As for the calculation rules, there are still methodological questions to be solved and consensus to be found among different existing approaches, e.g.:

- How to deal with storage of CO2e in products?
- How to deal with direct and indirect land use change?
- How to calculate greenhouse gas emissions for (partly) "green" electricity?

Product differentiation is particularly difficult for narrowly defined product groups

"Typically LCA-practitioners use a combination of primary site-specific data and data from existing data-bases. Taking into account the complexity of product systems it is almost unthinkable to conduct LCA without the support of such data bases that help to fill gap and save time and resources. Nevertheless, the use of such data bases has one considerable consequence for environmental labelling: Especially for narrowly defined product groups, in which system alternatives are not considered, many product features like material composition will likely be very similar or even identical.
The subsequent product differentiation will therefore be based on some few environmental impacts like content material and energy consumption in the use-phase. Nevertheless, existing labelling schemes for computers already address these issues and differentiate product models accordingly. Therefore, in such cases LCA will not yield any added-value, but just higher efforts for data collection and compilation." Prakash 2008

Concerning the differences between different products from the same product group, such as two desktop computers or two washing machines, PCF results show small deviations similar to that of LCA results. This is for two reasons:

On the one hand nobody is able to gather primary data for all materials, processes etc. necessary to produce a desktop computer or a washing machine. The costs would be tremendous, studies unaffordable. Therefore the use of secondary data from commercial and non commercial databases (e.g. EcoInvent, GaBi, GEMIS) is common practise. Anyway, supplier–producer relations may change rapidly which also justifies the use of generic data. One disadvantage, however, can be that effective differences of products in some cases cannot be represented by the secondary data and therefore the calculated similarity does not comply with reality and – as for LCA – even may exceed error margin.

On the other hand, it has to be acknowledged that two washing machine models in reality do not deviate so much from each other concerning their content of plastics, metals and even electronics, even if they are from different producers. Additionally, the use phase makes up about 90% of the overall PCF of a washing machine and thus diminishes differences in the production phase again. The same can be stated for many other complex industrial products. Besides that the measurement of the energy consumption of a washing machine is based on very detailed test protocols. Even then the results have a limit of accuracy of 10%. The use of such protocols – which has to be assured by Product Category Rules – is a prerequisite of making even small differences visible.

LCA cannot eliminate uncertainty

"Due to the iterative nature of LCA, decisions regarding the data to be included shall be based on a sensitivity analysis to specify their significance. This analysis may result in exclusion of life cycle stages or of inputs and outputs that lack significance to the results of the study, or otherwise in inclusion of new unit processes, inputs and outputs that are shown to be significant. Nevertheless, there is always a danger of missing important flows. Data gaps of bottom-up LCAs can reach up to 50% of the total environmental exchanges (Christiansen et al. 2006). Another barrier of including all relevant data and primary data origin are the extraordinary charges which implies again (monetary) resources and time. Combined with the problems mentioned in the paragraphs above, this situation provides a severe hurdle to use LCA for product differentiation purposes in environmental labelling: Since it might not be feasible to provide an undisputable data base for product labelling, LCA cannot eliminate uncertainty. This is especially severe when the competitive nature of environmental labelling is considered: Especially in product groups with only little latitude for product differentiation this will very likely lead to inquiries and complaints by disadvantaged producers. While this could on the one side lead to massive additional data flows towards the labelling scheme administration (which might overburden its capacity), judicial steps questioning the scope, system boundaries and data quality are also likely. At best, such legal disputes will slow down the labelling process." Prakash 2008

Uncertainties occur in LCA as well as in PCF studies, there is no principal difference. They result from several sources. According to de Koning et al (2009) three types of uncertainties can be distinguished in LCA models:

- Parameter uncertainty: uncertainty in observed or measured values used as input model.
- Model uncertainty: uncertainty about the way the interaction between technosphere and biosphere has to be modelled.
- Scenario uncertainty: relates to choices made in constructing scenarios. Typical choices include choice of impact assessment method and allocation

Using the example of two detergents de Koning et al (2009) showed for the carbon footprint that depending on the extent different parameters to calculate the PCF are fixed or left open to the person / institution performing the PCF the results differ. The more parameters are fixed the fewer uncertainties could be observed and vice versa. Additionally, the uncertainties are further reduced if the same person actually performs the study for the products to be compared. The actual results of the comparison of one compact and one liquid detergent were quite different depending on the approach and could even lead to contradictory statements.

Against this background it is essential to include Product Category Rules as obligatory elements in standardisation. PCRs allow at least to a certain extent to achieve comparable results within one product group.

It has also to be kept in mind that PCF results will always have a restricted precision. Therefore the display of a single CO2e figure on a product is misleading.

4.3 Conclusions

For the PCF approach the same is true as for the general LCA approach: The assessment of the whole life cycle is a strength compared to other techniques. But if a products' life cycle shows clear-cut hotspots concerning CO2e emissions, e.g. in the usage phase, it can be justified to restrict further PCF studies meant as base for a labelling to that phase and leave out the others.

It must be stressed that – due to the focus on greenhouse gases – the PCF approach is to be complemented by a screening of other environmental impacts in order not to point in the wrong direction.

Due to general restrictions and also to the standardisation still being under development results from different PCF studies cannot be compared directly at the moment. It would therefore be fundamental that Product Category Rules (PCR) were defined as obligatory by standardisation. PCRs define fundamental rules concerning the scoping of a PCF study for products of the same product group (e.g. adequate user scenarios, data bases, relevance of other environmental impacts etc.). Additionally, their development includes stakeholder involvement.

It is generally true that the PCF is subject to variances in the precision and reproducibility of calculations. This results from the different quality of data sources used or the definition of certain assumptions in the individual phases of the product‘s life cycle. Whether all of the uncertainties can be remedied by an internationally standardised methodology may be doubted. The existence of PCRs would strongly support the comparability of results of different products within one product group.

As for the calculation rules, there are still methodological questions to be solved and consensus to be found among different existing approaches on PCF.

Against this background, it cannot be recommended at the moment to use single PCF figures for communication.

5 Identification and prioritisation of consumer information

5.1 General needs of consumers concerning information on Product Carbon Footprint (PCF)

There is consensus among experts that consumers should consider a huge amount of information in order to make an optimal purchase decision. In addition to this *objective need of information* further information should be taken into account by the consumer in order to realise a sustainable consumption. But: Is the consumer willing and able to use this additional information? After all, a general information overload can be observed. Therefore it must be asked, in which way and by which approach the information should be delivered. Priority must be set on clarity, comparability and credibility of information. Against this background vzbv (2004) used the differentiation into *search goods*, *experience goods* and *credence goods* for a telephone survey among consumers on the purchase of five different goods (textiles, food, cars, electricity and investments). It must be pointed out that the terms “search goods” etc. are technical terms from economics. The term “goods” is thereby used in the same way as the term products in this text: both encompass as well products as services. In the following chapter the technical terms “search goods” etc. are used in combination with the term “products”.

A *search good* is a product with features and characteristics easily evaluated before purchase. An *experience good* is a product where product characteristics such as quality or price are difficult to observe in advance, but these characteristics can be ascertained upon consumption. A *credence good* is a product whose utility impact is difficult or impossible for the consumer to ascertain. In contrast to *experience goods*, the utility gain or loss of *credence goods* is difficult to measure after consumption as well. The seller of the good knows the utility impact of the good, creating a situation of asymmetric information.

A product usually possesses features belonging to all three above mentioned categories. For example a cars’ size and colour (search good), its fuel consumption (experience good) and its pollutant emission (credence good) may be relevant for consumers purchase decision. Information on the environmental impact of a product usually belongs to the categories experience good (e.g. consumption of fuel, electricity, water) and credence good (e.g. environmentally friendly production, content of hazardous substances; see also DIN Consumer Council 2008).

PCF in specific belongs to the category *credence good* which makes it all the more important that the delivered information on PCF is credible and plausible (relevance of third party certification) and displayed in a standardised, comparable way.

Although the survey showed that consumers do not read all the information available e.g. on the packages of food, they are not willing to do without. At least they want to have access to information. It was interesting that consumers were more content with the available

information on cars then on food although – objectively – there are more pieces of information available on food then on cars. Vzbv (2004) concluded that the existing uncertainty concerning food leads to an information demand that exceeds the available offer of information. The survey also showed that consumers would appreciate different additional information connected to the environmental impacts of cars (important: declaration of CO_2 and other emissions, less important: environmentally friendly production), textiles (important: allergenic substances, less important: environmentally friendly production), food (important: genetic engineering, allergenic substances, animal husbandry; less important: cultivation, origin of resources) and electricity (less important: environmental impact of electricity supply, display of environmentally friendly electricity offers). Depending on the specific product consumers prefer the information to be delivered preferably in different ways: for food and textiles consumers prefer it on the package, for cars they prefer it at the point of sale as well as in brochures and for electricity the bill is the preferred place for additional information. In general it was interesting that the internet could be observed as a commonly accepted source for consumers to get information from.

Vzbv (2004) points out that it is helpful for consumers if the same piece of information is delivered in a recognisable / standardised way on different products (e.g. the same scheme is used always) (e.g. product with the Blue Angel or without it). Thus the purchase decision is supported by an easy-to-make comparison of products.

Concerning information on cars it can be added from DIN Consumer Council (2008) that consumers are interested most in information on environmental features if they are also cost relevant: Together with reduced fuel consumption and CO_2 emissions a reduction of costs is achieved at the same time. Other aspects (e.g. reduction in particle emissions) were mentioned much less or not at all (e.g. environmental friendly production) in the setting with focus groups.

Concerning general aspects on consumer information DIN Consumer Council (2008) emphasised that comprehensibility is a key feature: well structured display, aggregation of the information, concentration on the gist that helps to make a better purchase decision.

Prakash (2008) also stressed that clear benchmarks or scales have to be provided. The communication of verifiable and accurate information that is not misleading is essential, thereby stimulating the potential for market-driven continuous environmental improvement.

Schmidt and Poulsen (2007) focus on Type III environmental declarations but summarise also some general conclusions from a number of different studies from northern Europe on the communication of environmental information to consumers. Some of the findings mentioned above were also confirmed. Consumers are asking for environmental product information that they can use in purchasing situations. And they want comparable and reliable environmental information on environmental product qualities. Environmental aspects are likely to receive higher attention when they are connected to individual aspects such as

personal health (e.g. organic food products) and private economy (e.g. energy efficiency). Consumers' acceptance of detailed and complex environmental information is higher for more complex and expensive products. Private consumers desire environmental product information in the form of simple symbols, without detailed information and text sections. Selecting environmental information and presenting it in a way which is understandable for common consumers is a challenge. On the one hand, the information should be simple, but on the other hand it should be sufficiently comprehensive and precise for the consumer to make the "right" choice, distinguishing between products with different environmental characteristics. Schmidt and Poulsen (2007) conclude that private consumers in general prefer declarations that are much simpler than those developed in the framework of ISO 14025 and implemented in national or international EPD-schemes.

Interesting is a last aspect to be mentioned here: Schmidt and Poulsen (2007) assess an apparent risk of detailed quantified environmental product declarations creating a false sense of control that could benefit products with an environmental product declaration, regardless of the content of the declaration. The same could be the case for products with a PCF label and one without, making products with some kind of PCF label look better to consumers then others without such a label.

Besides general requirements concerning the communication of environmental information to consumers in the last part of this chapter there will be a focus on the communication of PCF results to consumers. In the German PCF Pilote Project (PCF-Pilote 2009) and in the Memorandum Product Carbon Footprint (Grießhammer and Hochfeld 2009) several requirements for climate-related product labelling were formulated. Among them aspects are included that were already mentioned earlier such as credibility, comparability, consistency and understandability. PCF-Pilote (2009) concluded:

"*Providing a total CO_2 footprint figure in the form of a static carbon label, as is already practiced by some companies, does not make sense and is not very relevant for consumer decision making. A figure of this kind suggests a precision and conclusiveness which cannot be achieved using the current state of methodology.*"

Grießhammer and Hochfeld (2009) added that basing on PCF it is not possible at the moment to perform

- product comparisons of multiple products carried out on behalf of different clients and by different practitioners,
- public comparison with competing products in ways that are acceptable under competition law (e.g. through reporting of CO2e values or use of CO2e labels).

For methodological reasons alone it is therefore at present not possible to use CO2e labels for the purpose of comparing competing products. Even if further development has occurred e.g. in international standardisation and Product Category Rules this will only theoretically be

possible, but in many cases it will continue to founder on the lack of sufficient data or the excessive costs involved.

Against this background Grießhammer and Hochfeld (2009) recommended the retention of eco-labels in accordance with ISO 14024 (Type I), such as the Blauer Engel eco-label, as lead labels. As advantages of ecolabels over CO2 labels the following aspects are mentioned:

- A type I label is easily understood and serves as reliable information for consumers: from an overall environmental perspective an eco-labelled product is clearly better than comparable products;
- all relevant environmental and health aspects are included;
- the criteria are identified on the basis of LCAs and eco-toxicological assessments;
- there is a subsequent discussion of the criteria by a panel of experts;
- the final decision is taken by an "environmental jury" on which relevant stakeholder groups are represented;
- there is a certified award process and checking of the criteria for products marked with the ecolabel.

5.2 PCF information – experiences concerning different label types

Results from a recent survey in Europe on sustainable consumption and production show that consumers take environmental issues into account for purchasing decision using ecolabelling (Eurobarometer 2009): Almost half of EU citizens said that ecolabelling plays an important role in their purchasing decisions; the proportion saying this is important ranged from 22% in the Czech Republic to 64% in Greece. Concerning carbon footprint the survey gives kind of contradictory results: On the one hand information about the total amount of greenhouse gas emissions released by a product – i.e. the carbon footprint – was considered to be the least important information on an environmental label (selected by 10%, compared to 38% for "recycle and reuse"). On the other hand there was a strong support for introducing a mandatory label indicating a product's carbon footprint: Support ranged from 47% in the Czech Republic – the only country where less than half of respondents were in favour of such labelling – to 9 in 10 respondents in Croatia and Greece.

5.2.1 Overview on currently used Carbon Labels

At the present time, there are no consistent regulations for the communication of PCF with consumers or the labelling of PCF on goods and services. Still PCF-Pilote (2009) draw the following conclusions: *If fundamental requirements and recommendations are taken into account in the communication process, Product Carbon Footprints can act as a strong basis*

for conveying product information which can, in turn, encourage carbon-conscious consumption habits. These requirements are presently not fulfilled by a Carbon Label.

In general communication and labelling of PCF-connected information is done in order to address one of the four aims shown in the following table.

Table 2 Overview on different categories of carbon labels available on the market.

Nr.	PCF-connected information is done in order to . . .	Example of according labels on the market	
		Name	Website
1	Display the calculated PCF (with or without benchmarking scale)	*Casino Carbon Index* / Groupe Casino Indice Carbone (Delahaye 2008)	www.produits-casino.fr
2	Display that the product belongs to the best in class products concerning PCF without showing any figures (e.g. in connection with a type I label)	*Climatop* award for low carbon, best in class products (Schmid 2009)	www.climatop.ch
3	Display the calculated PCF and planned or achieved reduction in PCF (as sheer commitment or in the form of figures)	Carbon Trust Reduction label	www.carbon-label.com
4	Display that the PCF generated by the product is compensated, the product therefore is CO2-neutral	Certified *Carbonfree* – a CO2e-neutral label	www.carbonfund.org

The number of international initiatives on CO2 labelling and climate-related product labelling increased sharply in 2008. Against this background only single examples of the most important type of labels will be discussed on the following, this list of examples is not exhaustive. As mentioned earlier, most carbon labels are currently developed for food products. In the following the examples for labels given in Table 2 are described and analysed more detailed:

(1) Casino Carbon Index / *Groupe Casino Indice Carbone* – (Delahaye 2008, http://www.produits-casino.fr):

Description:

The Casino Carbon Index belongs to the category of labels that display the calculated PCF – and in this case – together with a benchmarking scale.

The label is proprietary for Groupe Casino a major French Retail group. Aim of the label – according to its proprietary – is to create transparency and to enable consumers to take informed decisions on climate-aware consumption.

The Casino Carbon Index is symbolised by a green leaf and displayed in grams CO2e per 100 g of product on the front side of the package. On the backside of the package Casino

Carbon Index is shown as a green band which gives the position of the environmental impact of the product on a scale of levels (weak impact – strong impact). The graduations are fixed in partnership with ADEME[6]. However it is not explained on the website what exactly the reference for this benchmarking is.

Background for the index is the calculation of the CO2e emissions of the respective product in the following life cycle phases: stages in production (agricultural for foodstuffs), manufacturing the product, transport from the field to Casino warehouses, packaging from the extraction of the raw materials to recycling, distribution from Casino warehouses to the consumer's home. The use phase (storage and preparation at consumer's home) and end-of life are not included. Casino plans to label all 3.000 food products that they offer with the Casino Carbon Index, currently 32 different products are labelled.

Critical acclaim:

Although the integration of a benchmarking scheme in the Casino Carbon Index in principal is helpful to consumers, the whole approach lacks transparency: Neither is information available on how the displayed figure had been calculated nor where the benchmarking scheme originates from. Does the green ruler show the market range for the very product in question of all competitors or only the range of Casino products? Is it connected to the very product at all? There is no information on the product itself or on the website of Casino that might enable consumers to judge this. Besides that the ruler is mainly green therefore consumers may think that every product / figure is good enough. Anyway it has to be questioned if the available data are precise enough to allow at all for such rating. It remains unclear how other products of the same product group would perform and whether there is a difference at all. Within Casino products one might expect that the same method is applied for the calculation of the PCF of different products and therefore the results may be assumed being comparable somehow. Given labelled products from different retailers (e.g. in France the retailer E.Leclerc also displays PCF figures[7]) this will surely not be true. Additionally, the labelling process does not include stakeholder involvement.

Summing up the Casino Carbon Index cannot be recommended as reasonable consumer information.

6 ADEME: Agence de l'Environnement et de la Maîtrise de l'Energie

7 E.Leclerc bases its calculations on generic but not on specific LCA data which does allow for the comparison of different product groups but not the comparison of single products within one product group.

(2) Climatop award for low carbon, best in class products

(Schmid 2009, www.climatop.ch):

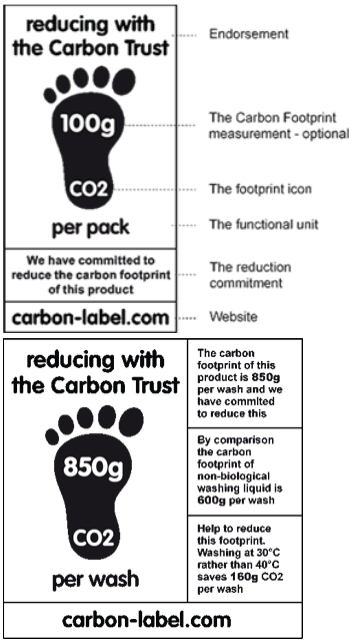
Description:

Climatop belongs to the category of labels that display that the product belongs to the best in class products concerning PCF without showing any figures (e.g. in connection with a type I label).

A good or a service approved with the climatop carbon label has to cause significantly lower CO2 emissions during its life cycle compared to relevant goods or services of the same category. Climatop aims at providing a basis for consumers' decision making. The label bases on LCA data from EcoInvent database. A product can only be labelled if it has an at least 20 percent lower CO2e emission then comparable products of its product group. In addition, the product has to fulfil several other requirements regarding environmental and social standards. The label does not display any figures on CO2e emissions. The number of products awarded the climatop label is increasing continuously, including besides products from Migros also products from other providers. At the moment, five food products are labelled (salt, organic raw cane sugar, organic cane sugar, crème légère, fresh asparagus).

Critical acclaim:

The approach to award only the best product the climatop label without displaying any details, makes it easy for consumers to use it as support for their purchase decision. Also, there is no precision pretended that cannot be redeemed. It has to be positively remarked that the climatop website provides factsheets and critical reviews on the LCA studies the label is basing on. That way it is assured that the calculation is scientifically based and consumers have access to background data (e.g. range of PCF of different products within one product group). The label itself does not display any figures but shows only that the certified product belongs to the best performing products within one product group. In part of the product groups the rating bases only on products offered by one retailer (e.g. washing powder, toilet paper sold by Migros), which bears the risk of ignoring relevant products on the market with a principally better or worse performance. Additionally, there is no stakeholder involvement foreseen in the process of labelling.



(3) Carbon Trust Reduction label (www.carbon-label.com)

Description:

The Carbon Reduction Label belongs to the category of labels that display the calculated PCF and planned or achieved reduction in PCF (as sheer commitment or in the form of figures). The responsible body for the label is Carbon Trust / Carbon Trust Footprinting Company. The label shows the total greenhouse gas emissions in grams per indicated functional unit from every stage of the product's lifecycle, including production, transportation, preparation, use and disposal. For B2B products the PCF is done only cradle-to-gate. The calculation of the PCF builds upon PAS 2050. The Label includes a reduction element whereby the company is committed to further reduce the carbon footprint over the following two years. If the commitment is not met, the company will no longer be able to use the label. Additionally, information can be given on the label concerning the comparison to other products and the possibilities for consumers to reduce the carbon footprint by their behaviour. The label can be placed on the package of the product or alternatively used at the point of sale or in the internet. The Carbon Trust label is the most prominent label at the moment in the carbon reduction category.

Critical acclaim:

The display of CO2e figures can in general not be seen as useful for consumers at the moment: it pretends a precision that is not available at the moment, figures for different products are not comparable and in general such figures are of little or no help to consumers. Additionally, the focus on reduction must be seen as problematic: a fundamental problem is that good performers cannot easily reduce whereas bad performers are able to. As a consequence the “wrong” may get rewarded. Then it is unclear who verifies the reduction. As the reduction is only a commitment, a company may label their products with the reduction label even if they do not reduce their emissions at all. Only after two years they will loose the label. In general it can be added that the choice of products labelled with the Carbon Trust Reduction label is at random, therefore not addressing the most relevant products but products such as crisps. Furthermore the label lacks a benchmark or scaling system that enables consumers to judge the relative performance of a specific product. One single figure alone does not give evidence.

Summing up the Carbon Trust Reduction Label cannot be recommended.

(4) Certified Carbonfree – a CO2e-neutral label
(www.carbonfund.org)

Description:

The label "certified Carbonfree" belongs to the category of labels that display that the PCF generated by the product is compensated, the product therefore is CO2-neutral. Carbonfund, a charitable non-profit organisation is responsible for the Cabonfree label.

The process to certify a product encompasses three steps: first the carbon footprint of the product is calculated. Then the determined amount of greenhouse gas emissions is offset with a project type chosen by the producer (reforestation, energy efficiency, renewable energy). The projects are certified by third party standards. In the last step the partnership is communicated (CarbonFree logo, blogs and newsletter articles, website). Concerning the methodology for the calculation of the carbon footprint Carbonfund refers to the WBCSD/WRI Protocol. There exist a number of different certified products, e.g. mobile phone, T-Shirt, sugar, coffee.

Critical acclaim:

The discussion on offsetting in general is still ongoing and shall not be represented here. PAS 2050 e.g. does not allow offsetting at all when calculating a PCF. Anyway focus must be on the reduction of CO2e emissions over the life cycle of a product and the identification of products that have comparably low CO2e emissions. The compensation of its CO_2 emissions alone does not decrease the carbon footprint of a product. Concerning carbon offset projects used for compensation the main critics are related to the following points: Are the carbon offset projects real and additional, not covered by regulation e.g.? Does offsetting set the right course in developed and developing countries (e.g. concerning infrastructure)? Or does it actually hinder sustainable development for the future in both?

Against this background carbon neutral labels are not recommended as reasonable consumer information and decision support concerning climate relevant emissions.

5.2.2 ISO labels in the context of PCF (type I, II and III)

Differing from the labels described in the previous chapter the following three label types are defined by ISO standards. Subsequently, it is discussed whether the PCF found its way in those labels.

Type I Environmental Labels (ISO 14024)

- Include environmental labels like the Blue Angel, Nordic Swan, EU environmental label.
- The certified products are amongst the least environmentally harmful products in their category, since they meet strict environmental requirements.

- The labels base on a multi-criteria approach, in which the criteria are decided upon by an independent group of interested stakeholders.
- Products are certified by a third party.
- Labels enjoy a high credibility by their target groups, which are consumers and public procurement.

At the moment, information on PCF or CO2e emissions on the bases of an LCA or PCF are used to check the overall impacts of a product over its life cycle. Then, criteria are developed for the identified hotspots. Those criteria usually do not refer to CO2e emissions directly but rather indirectly, setting limits for e.g. electricity demand or excluding certain product solutions at all because of their high PCF value.

There is one prominent example for a type I label that strongly focuses on climate relevant emission: the German Blue Angel was re-launched in 2008 in four different thematic clusters, one of them being the cluster “Blue Angel, protects the climate” (“Blauer Engel, schützt das Klima”). Products belonging to this cluster are of high relevance concerning their climate impact, e.g. energy consuming products like household appliances or energy related products like solar-powered appliances. Figures on the PCF are not displayed or directly used as limit values for criteria. But even for this specific “Blue Angel, protects the climate”, a multicriterial approach is applied which means that all relevant environmental impacts are considered, not only greenhouse gases.

It may generally be concluded that for type I labels

- in-depth PCF studies serve very well as starting point for the identification of hotspots and the development of criteria. The PCF value over the whole life cycle is not suitable as limit, CO2 emission values for single life cycle phases may be suitable for individual product groups (see e.g. EU ecolabel for paper with its CO2e limit for production);
- instead of CO2e limits, the results of the in-depth PCF study will rather serve to identify suitable production and use phase indicators like hazardous substances in production and electricity demand in the use phase. Moreover, hazardous substances in the product (e.g. flame retardants in plastic parts) and quality issues may be added;
- the multicriterial approach has proven successful and will also be followed in the future. As other relevant environmental impacts could be missed, it would be counter-productive and expedient to focus on CO2e emissions alone.

Type II Self Declarations (ISO 14021)

- Are a self declaration of companies on environmental features of their products
- Usually address consumers (B2C)
- Mostly address single properties of the product (e.g. share of recycling material, chlorine free bleaching or CO2e emission)

- Criteria are chosen by the companies themselves and are not necessarily agreed upon on a broader level (e.g. industry associations). A broad stakeholder involvement is not necessary.
- A third party certification does not take place. The credibility of the labels is therefore restricted.

Carbon footprints or CO2e emissions increasingly play a role in type II labels including the aspect of CO2e compensation. The above described Casino Carbon Index is one example of such a label. There is a proliferation of such labels that make it confusing for consumers to try to integrate climate reduction in their purchasing decision. At large, the variety of labels bears the risk that consumers lose confidence, mix up their purchase decisions or even loose interest in considering climate impact in their purchase decisions at all.

It may be generally concluded that for type II labels

- it is problematic that companies can pick one specific aspect – in this case CO2e emissions / the climate change issue – which is then addressed by the label. Concerning other environmental impacts, the performance of that specific product may be significantly worse or the focus on CO2e emission may actually be counter-productive. It even may not be the most relevant environmental impact of the product in question at all;
- there is, besides that, no democratic stakeholder involvement foreseen.

Type III Environmental Product Declarations (ISO 14025)

- EPDs base on the methodology of Life Cycle Assessment (ISO 14040) and give information on the environmental impacts of a product over its whole life cycle together with technical information on the product. Concerning the restrictions of this approach see Prakash et al. (2008) and chapter 5.1 of this study.
- The covered impacts include the classical impact categories of LCA supplemented by additional information on specific aspects of the particular product (e.g. radioactive radiation, leaching behaviour etc.).
- This complex set of information is given preferably to professional customers (B2B), communication to consumers is not yet very relevant.
- The definition of Product Category Rules, which is necessary before generating an EPD includes stakeholder involvement.
- Third party certification is obligatory if communication (B2C) is intended.

The information on CO2e emissions is included in an EPD as standard category among other impact categories and parameters. As the development of ISO standards for the quantification of PCF is still ongoing, it is unclear whether the greenhouse gas emissions calculated in a “traditional” EPD directly correspond to a specific PCF value calculated

according to the current status of standards. Results probably can't just be transferred. An eye has to be kept on this aspect.

It may be generally concluded for type III labels that

- they or EPDs are not suitable for consumer information. As aforementioned, private consumers generally prefer declarations that are much simpler than those developed in the framework of ISO 14025 and implemented in national or international EPD-schemes;
- in EPDs, benchmarking or scaling schemes are not available. Therefore, it is not possible to judge the relative environmental performance of a product compared to another one of the same product group. This also bears the risk that a product appears to be climate friendly only because an EPD is available, hence, misleading consumers and customers.

5.2.3 Mandatory labels in the context of PCF

Mandatory labelling (energy efficiency, CO2-emissions)

For some product groups there exists an established mandatory labelling scheme concerning energy demand and/or CO2-emissions:

- for ***household appliances*** (Directive 92/75/EEC): includes household lamps, washing machines, dishwashers, tumble dryers and cooling appliances: besides the display of the electricity demand per year or per process (e.g. per washing cycle), it is also displayed how much water is used per process (if applicable) and to what extent the aspired function is fulfilled (e.g. cleaning performance). The used A-G rating scheme proved to be very instructive to support consumers in the purchase of energy efficient appliances. After the proposed revision the EU energy label will lose value as for specific products only A grades, like A, A+, A++ and A+++ could be used. The addition of CO2e emission data would not add to the benefit of the EU energy label as they are directly correlated to the electricity consumption. Apart from the risk that the different electric grids of the different EU countries may cause difficulties: a low CO2e emission could be caused by a high energy standard or by a high degree of nuclear power within the power plant mix. Therefore, it would be better – if at all – to use the European electricity mix with its specific CO2e emissions for all EU countries as bases.
- for ***cars*** (Directive 1999/94/EC): besides the demand of fuel per 100 kilometre, the CO2 emissions per kilometre for a new car have to be displayed at the point of sale and in advertisements, brochures etc. The displayed data refer to the so called European driving cycle, which is a defined mixture of inner-city, outer-city and highway driving. Probably no consumer actually will drive according to this driving cycle in reality. Hence, the figures only give limited support to consumers. Furthermore, it has

to be noted that neither precombustion nor non-CO2 greenhouse gases are included. Most important for communication: there is no benchmarking scheme available that would allow consumers to judge the performance of a car by means of a simple colour or letter code.

- for ***electricity*** (Directive 2003/54/EC): electricity suppliers have to deliver their customers' information on the specific CO2 emissions and the amount of nuclear waste connected with the generation of the electricity purchased. Besides, they have to give information on the fuel mix. In order to be able to rank the information, consumers also have to be provided with information on the average country mix and the residual mix of the provider. Altogether the information mix offered seems to be very instructive, concentrating on the relevant aspects concerning an environmentally friendly electricity product. Consumers are enabled to identify an electricity product with low greenhouse gas emissions, that generates no nuclear waste and that bases on a high degree of renewable energy sources and/or cogeneration of heat and power. However, many consumers are still unaware of this chance.

5.2.4 Other forms of information

Besides labels there are also other forms of information that may include PCF results.

One case to be highlighted at this point is the use of PCF data as a base for general recommendations for a specific product group. This case will be discussed using the example of the Swedish proposal for "environmentally effective food choices" (NFA 2009). Aim of these general recommendations of the National Food Administration is to support consumers to take purchasing decisions on food with reduced environmental and also climate impacts. Therefore, these guidelines are not a carbon label but the integration of accomplished knowledge on the climate impact of food into general principles for a recommendable food choice. The Swedish National Food Administration worked out guidelines that integrated – among other relevant environmental impact categories like a *rich diversity of plant and animal life, toxic environment* – also recommendations for a food choice with reduced climate impact. The general recommendations encompass the following food groups:

- Meat – beef, lamb, pork and chicken;
- Fish and shellfish;
- Fruits and berries, vegetables and leguminous plants;
- Potatoes, cereals and rice;
- Cooking fat;
- Water.

The recommendations have a rather simple form like “Eat less meat”, “Prefer locally grown animals, reared on grasslands (in the case of beef and lamb)”, “Chicken and pork have a lower climate impact then beef and lamb”. The background of each recommendation is explained within the text and therefore is comprehensible.

At the moment, the proposal is being revised as the EU criticised the recommendation to prefer regional food as being a potential trade barrier.

5.3 Conclusions

Conclusions concerning the general needs of consumers concerning information on Product Carbon Footprint (PCF):

- In general private consumers prefer declarations that are much simpler than those developed in the framework of ISO 14025 and implemented in national or international EPD-schemes.
- Comprehensibility is a key feature of labels: well structured display, aggregation of the information, concentration on the gist that helps to make a better purchase decision.
- Clear benchmarks or scales have to be provided. Additionally it must be possible to identify superior products.
- The communication of verifiable and accurate information that is not misleading is essential, thereby stimulating the potential for market-driven continuous environmental improvement.
- Providing a total CO2 footprint figure in the form of a static carbon label, as is already practiced by some companies, does not make sense and is not very relevant for consumer decision making. A figure of this kind suggests a precision and conclusiveness which cannot be achieved using the current state of methodology.
- For methodological reasons alone, it is presently not possible to use CO2eq labels for the purpose of comparing competing products. This will only theoretically be possible after further development will have taken place, e.g. in international standardisation. In many cases, however, it will continue to founder due to the lack of sufficient data or the excessive costs involved.
- Therefore, it is recommended to retain eco-labels in accordance with ISO 14024 (Type I) as lead labels. One main advantage of type I ecolabels over CO2 labels is that type I labels are easily understood and serve as reliable information for consumers: from an overall environmental perspective an eco-labelled product is clearly better than comparable products.

Conclusions concerning PCF information – experiences concerning different label types:

The use of PFC in labels is problematic and only recommendable in some cases:

- The currently available Carbon labels are mainly privately owned and are critical from the point of view of methodological questions (e.g. product category rules, precision, comparability, data base), differentiation of products, transparency (e.g. availability of documentation and background studies), and lack stakeholder involvement.

At the moment, mainly two ways of using PCF results for communication purposes seem to be promising and recommendable:

- Using of fundamental PCF studies as a starting point for the development of product criteria in type I labels. The idea is not to use CO2e emission data directly as criteria / limits but to identify hotspots and to set criteria in an adequate manner, considering climate relevant emissions (e.g. addressing energy efficiency by limiting electricity demand).
- Using fundamental PCF studies as a base for general recommendations for specific product groups (e.g. food).

6 Overview of the relevance of PCF in different product groups

6.1 General prioritisation

Due to the focus on PCF in this study and the strong correlation of PCF to energy consumption, a categorisation of products makes sense when oriented at the relation of the products to the energy consumption:

1) Energy consuming products: products that need electricity or other sources of energy to be operated, e.g. cars, household appliances, heating systems.
2) Energy saving products: products that help to reduce energy consumption during their application, e.g. insulation material, time switches, programmable room thermostats.
3) Products with relevance concerning greenhouse gas emissions at production phase: products that do not need energy to be operated and do not influence energy demand indirectly, e.g. food, paper, textiles and electricity.

For each of the above product listed categories, examples for product groups were chosen and further analysed in the chapters 6.2 to 6.8. Subsequently, the rationale for the choices of product fields is elucidated.

The following figure shows the relevancy of the eight most important product fields for private consumption. It bases on a material flow analysis from Quack and Rüdenauer (2007) that analysed the environmental impacts of an average household in Germany in the year 2005. The analysis included the direct impacts from the actual consumption (e.g. emissions from car use or heating) as well as impacts from precombustion processes (e.g. resource depletion, production) and processes at the end of life (e.g. recycling, waste incineration). The latter impacts have been allocated for one year. Example: The average life span of a car is 12 years, therefore 1/12 of the production on one car is calculated for one year. For each of the eight product fields it was defined in detail which processes had to be considered.

Basing on this material flow analysis it can be shown that building & housing with a share of 41% contributes most to the overall 16,5 tons of CO2e emissions per private household in the year 2005 (Quack and Rüdenauer 2007). The supply of thermal energy for heating and warm water is the most relevant cause. => Therefore, insulation material was chosen as one example.

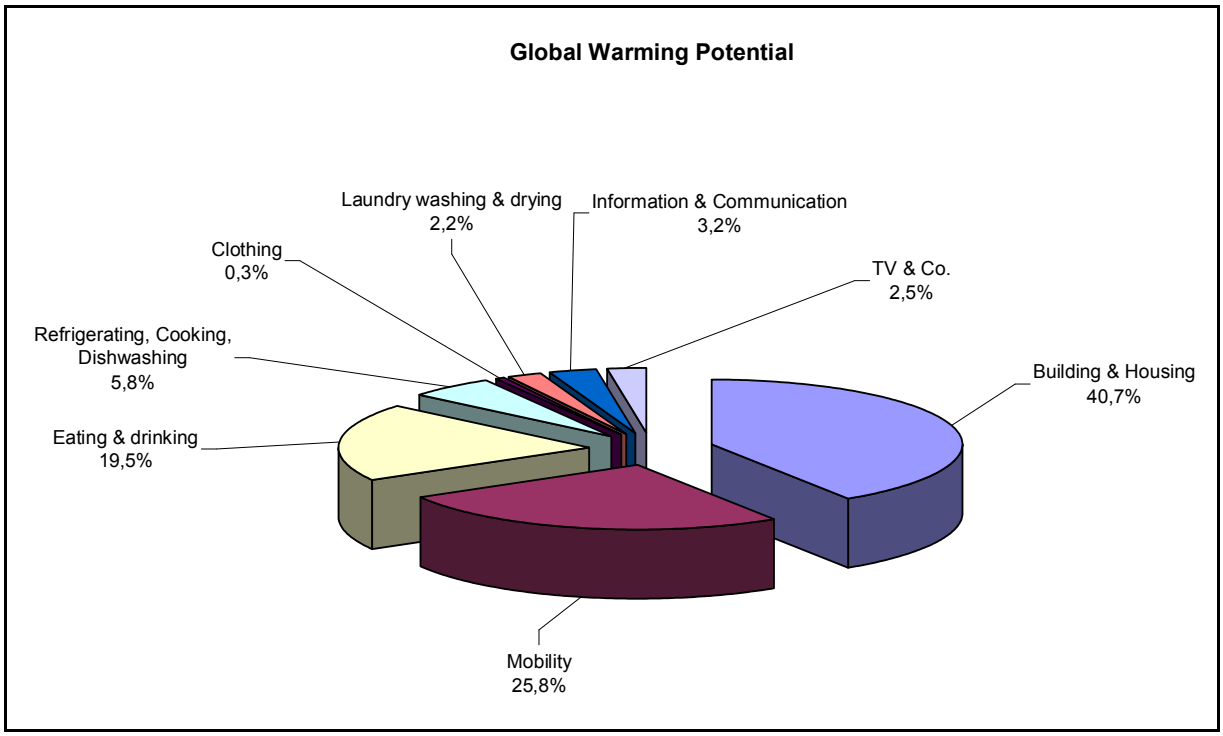


Figure 1 Relative share greenhouse gas emissions in eight different product fields important for private consumption. Functional unit: consumption of one statistical average household (2,1 persons per HH) in Germany in the year 2005 (including production, use and end-of-life in 8 product fields). Source: Quack and Rüdenauer 2007

The product field mobility contributes with 26%, the car use being the most relevant share of it. Above all, it is mandatory to display the CO2 emissions per kilometre at the point of sale,

in brochures, advertisements etc. => Therefore cars were chosen as another product example.

The third most important product field concerning greenhouse gas emissions is food with a contribution of about 20% to the overall greenhouse gas emissions of a household. Moreover, food is the product group for which by far most of the carbon labels are being developed at the moment. => Therefore food was chosen as product example.

Household appliances are responsible for about 8% of the greenhouse gas emissions and are the main consumers of electricity in households. Furthermore, a mandatory energy label for household appliances already exists. => Accordingly, household appliances were also chosen as product example.

In the product group information & communication, paper with an overall share of 3,2% is a significant contributor. => Therefore paper was also chosen as product example.

The product group clothing does not show up with a significant contribution. As the data base for textiles is incomplete, however, the figures seem to be uncertain. Additionally it is a product group where carbon labels already exist (see EarthPositive 2009) and where it can be assumed that consumers are interested in.

For the sake of completeness, in the following figure the share of the greenhouse gas emissions of the private households in the eight product fields are compared with other environmental impact categories (Quack and Rüdenauer 2007). One can see that the overall significance of the product fields does not change much: mobility changes place with building & housing for being most important concerning eutrophication, photochemical ozone creation and the overall environmental burden. Third most important is still food.

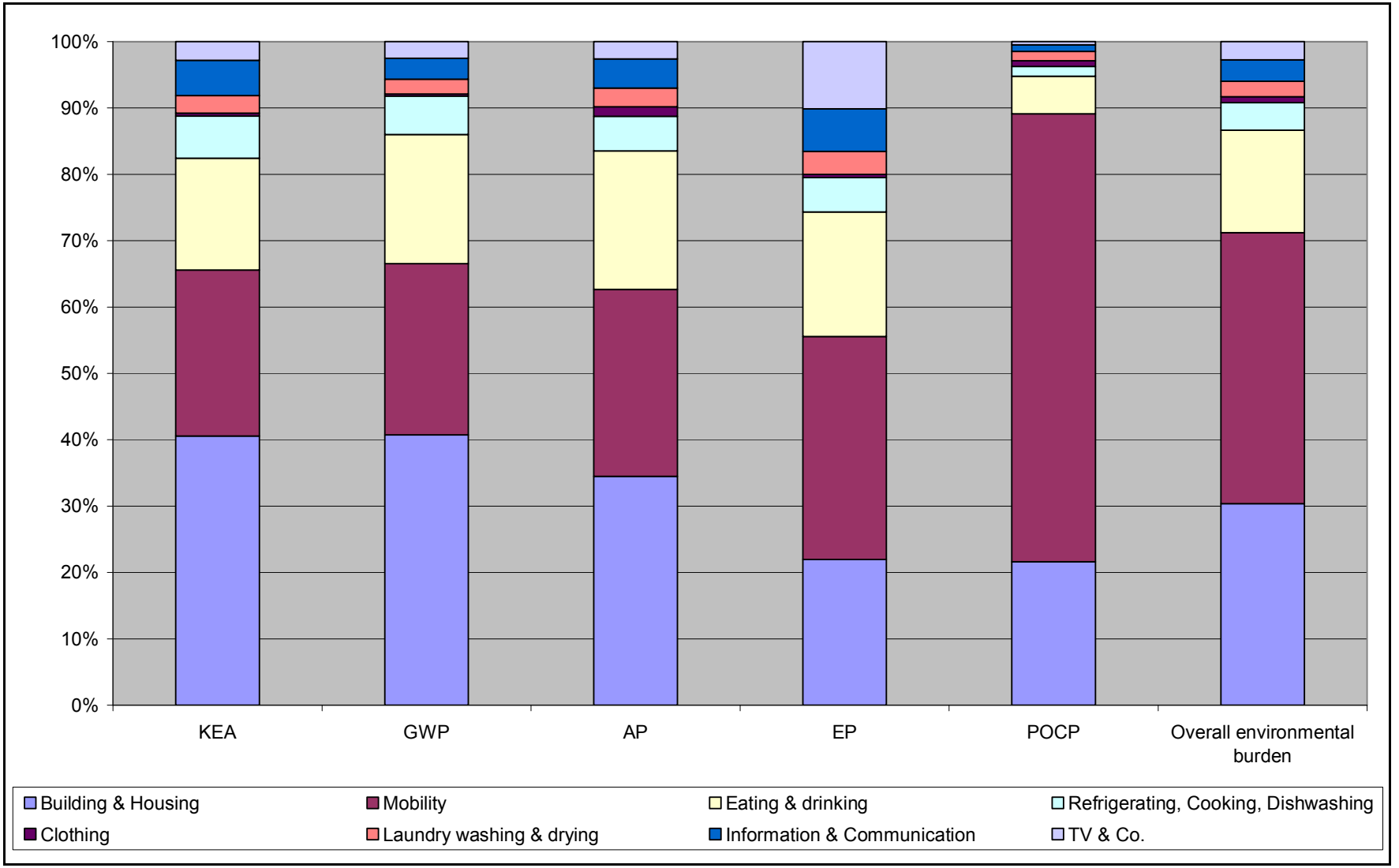


Figure 2 Relative share of environmental impact in different impact categories. Functional unit: consumption of one statistical average household (2.1 persons/HH) in Germany in the year 2005 (including production, use and end-of-life in 8 product fields). Abbreviations: KEA: Cumulated Energy Demand; GWP: Global Warming Potential; AP: Acidification Potential, EP: Eutrophication Potential; POCP: Photooxidative Potential.

In order to complete the picture it has to be stated that other possible impacts on the environment (e.g. toxic impacts, noise, impacts on biodiversity) were not analysed in Quack and Rüdenauer (2007).

Against this background, in the subsequent chapters, the following seven product groups will be analysed in detail:

- *Energy consuming products:*
  1. Cars,
  2. Household appliances;
- *Energy saving products:*
  3. Insulation material;
- *Products with relevance concerning greenhouse gas emissions at production phase:*
  4. Electricity,
  5. Food,
  6. Paper,
  7. Textiles.

6.2 Category 1 (Energy consuming products), Example 1: Cars

The overall relevance of PCF in the product group cars is high. Most important is the usage phase with a contribution of between 80 and 90% to the overall impact of a car, depending on the specific car. The PCF of different car models differ significantly, therefore PCF can support decision making. It has to be added that – although there are also differences in the production phase – the differences in the usage phase are by far larger. Therefore, concerning the communication of car features connected to the carbon footprint, it may be useful enough to concentrate on the usage phase in the first step. But as there is also a difference in the carbon footprint of different cars in the production phase depending e.g. on their size (e.g. small size car versus a SUV), the whole life cycle may be included in later steps.

As cars have a relatively long life time, consumers only rarely have to decide about the purchase of a car. With one single decision the environmental impacts connected with car usage are decided upon for a long period of time. Therefore, consumers are willing to take some time and effort before they decide on the purchase.

There exist a number of approaches to include CO2e emissions in the communication on cars:

- The labelling Directive 1999/94/EC relating to the availability of consumer information on fuel economy and CO_2 emissions in respect of the marketing of new passenger cars (OJ L 12, 18.1.2000) requires the display of a label on fuel consumption and CO_2

emissions on all new cars, the publication of national guides on the fuel efficiency of new cars (for Germany see e.g. DAT 2009), the display of posters at the dealerships and the inclusion of fuel efficiency information in printed promotional literature (EU 2007). It has to be added at this point that the obligatory EU label is disregarding the following points:

  - Most important: there is no benchmarking system (such as for the EU energy label or in the Swiss Energieetikette) that enables consumers to see whether a specific CO_2 emission figure is low or high, resp. whether a specific car performs bad or good. A colour or letter code would help immensely.
  - Precombustion is not included (e.g. production of gasoline).
  - Only CO_2 is considered, no other climate relevant emissions.
  - CO_2 emissions of production and end-of-life are not included.

- In Switzerland, the Energieetikette (energy efficiency label) is mandatory for cars and, apart from the fuel consumption, also displays the CO_2 emissions in gram per kilometre (TCS 2009). For Germany, Verkehrsclub Deutschland e.V. proposed an A-G labelling scheme similar to the energy efficiency labelling related to the fuel consumption (VCD 2007).
- Apart from that, there exist several ranking lists for new cars[8] from nongovernmental institutions that include CO_2 emissions as one criterion among several others (such as noise, emission of NOx).
- There even exists a Product Category Rule for passenger vehicles that would enable the preparation of an EPD for cars[9]. Volvo published an EPD calculator for its two most sold truck models[10].

The extent of improvement potential concerning climate relevant emissions is high. The PCF of the use phase can be reduced significantly by buying an efficient car and by using it environmentally sound.

Also the potential of product differentiation is high. The differences in PCF, especially of the use phase, between the available car models are rather large. The production and end-of-life phase does not vary that much, taking into account the whole life cycle. Still it would make sense in later steps to determine basic data on the production of a restricted number of different size classes of cars (e.g. small, medium, large).

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8 See e.g. www.autoumweltliste.ch (in German), www.ecomobiliste.ch (in french), or www.vcd.org (in German).

9 PRODUCT-CATEGORY RULES (PCR) for preparing an environmental product declaration (EPD) for "Passenger vehicles" PCR 2005:3 Version 1.0 2005-03-15. http://www.environdec.com/pcr/pcr0503_e.pdf.

10 See http://www.volvo.com/trucks/uk-market/en-gb/aboutus/Environment/environmental_product_declaration/epd_calculator.htm.

The use phase of a car dominates its PCF with about 80 to 90% (Quack and Rüdenauer 2004). Besides the principal features of the car (e.g. size, weight, fuel consumption), the PCF is highly variable due to the use pattern: the more kilometres are driven the higher the PCF, the more inner-city driving the higher the PCF, the more anticipatory the driving the lower the PCF. As a consequence the value given by the obligatory label only can be an aid to orientation but will not correspond to specific usage behaviour. Also there is a methodological problem in that the European driving cycle does not correspond to the driving practise of consumers; additionally it is measured under laboratory conditions, which again does not correspond to real life situations[11]. Therefore, it would be important to develop a petrol consumption test that is more in line with real driving. Additionally, an approach for testing has to be defined for electric cars too.

The preparation of a PCF covering the whole life cycle of a car including production and end-of-life for each model or product line of each producer would be far too costly compared to its benefit. The guidelines can be made clear on the basis of in-depth PCF studies covering typical products: In order to reduce the PCF of cars it is important to produce lightweight vehicles with efficient engines and low fuel consumption. Besides that, there are two other reasons not to request for the display of the PCF of the whole life cycle of a car:

- As different car models differ significantly in their CO_2 emissions during the usage phase, expressed in gCO2/km, and there is no indication that this CO2 indicator may point into the wrong direction, in principle, this figure supports consumers buying an environmentally friendly car.
- As the CO_2 emissions support the purchase decision in the “right way” it makes more sense at the moment to concentrate on a better communication of these figures: How to reach consumers in a better way so that they really consider it in their decisions? In later steps one might include other life cycle phases and address then reduction of material, reduction of energy for production, enhanced durability, best recycling options, waste minimization, chemicals, etc.

As fuel consumption is directly linked to the PCF during the usage phase of a car, it would be an alternative to communicate the specific fuel consumption instead of CO2e emissions. However, one has to be aware that different fuels have different values in kg CO2e/liter (diesel: 2,6 kg CO2/Liter; benzine: 2,4 kg CO2/Liter). This would be similar if addressing electric cars.

It has to be kept in mind that also environmental impacts other then climate change are of relevance when talking about cars: Noise, non greenhouse gas emissions (e.g. NOx, particles). Indirect effects due to infrastructure for the use of cars (e.g. roads, bridges): land use, fragmentation of ecosystems, biodiversity losses.

[11] See www.spritmonitor.de (in German) for data on CO2 emissions measured under real life conditions.

Still, the focus on CO2e / PCF does not bear the risk to adversely affect other environmental aspects. As far as information is available, no adversely effects have to be expected by preferring low CO2e emission cars. PCF points in the right direction and addresses one main environmental problem connected with cars.

6.3 Category 1 (energy using products) Example 2: Household appliances

The relevance of household appliances is high as they account for the most relevant electricity consumers (see e.g. white goods like washing machines, tumble dryers, dish washers). Concerning the PCF of the whole life cycle, the usage phase contributes most (≈80-90% share, depending on specific appliance). The PCF of the usage phase is due to electricity consumption and eventually consumption of water, detergents and – to a lower extent – due to repair etc.

The following figure shows the global warming potential of different typical household appliances over their life cycle. Although the share depends on the energy efficiency (see the different results for tumble dryer with energy class C and A), it is obvious that the use phase is most significant.

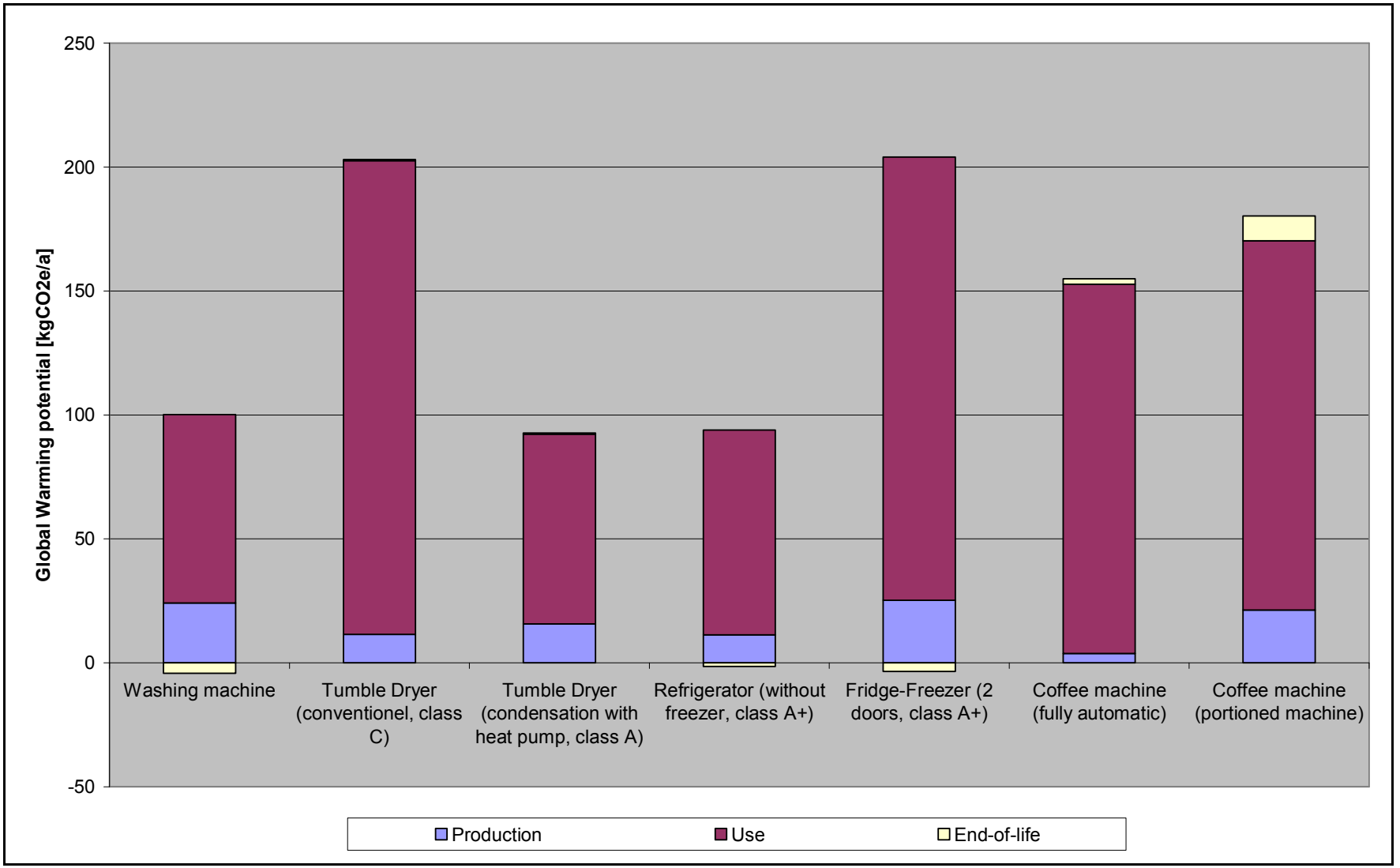

Figure 3 Overview of the annual global warming potential connected with the life cycle of different household appliances. (Source: own calculations Öko-Institut 2009)

As household appliances have a relatively long life time, consumers only seldom have to decide about their purchase. Therefore, with few decisions, environmental impacts are defined for a long period.

The following approaches in the sense of rankings, rating systems etc. already exist:

- Directive 92/75/EEC[12] (ELD) on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances is a framework that mandates the EU Commission (assisted by a Regulatory Committee) to adopt labelling implementing measures for specific household appliances (Refrigerators, freezers and their combinations, washing machines, driers and their combinations, dishwashers, ovens, water heaters and hot-water storage appliances, lighting sources and air-conditioning appliances). The ELD requires retailers to display a comparative label – A to G classes with A being the most energy efficient category – showing the level of consumption of household products to consumers at the point of sale. At the moment the ELD is under revision.
- Several type I labels (e.g. EU Flower, Blue Angel, Nordic Swan) exist for different types of household appliances, e.g. refrigerators, washing machines. Until now, the number of certified products is restricted (EU Flower: only light bulbs, Blue Angel: none, Nordic Swan: dish washers, washing machines).
- Additionally, EPDs exist for a few products (e.g. for a vacuum cleaner and a sewing machine[13]).

In principle, a PCF includes the production, the use and the end-of-life phase of a household appliance and therefore gives a complete picture of the greenhouse gas emissions connected to the specific household appliance under consideration. The current EU energy label only includes the electricity demand in the use phase (potentially completed by the water demand), and existing type I labels do not display the specific PCF of a product. At least for the large household appliances, it is known that the relevance of the production and end-of-life phase is low compared to the use phase. For smaller household appliances, the production phase might be more important, but only very few data are available (see e.g. the EPD example for the sewing machine[13]).

Concerning the energy demand in the use phase of household appliances and the PCF connected herewith, there is still improvement potential. Concerning the other product

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[12] For an overview see http://europa.eu/legislation_summaries/consumers/product_labelling_and_packaging/l32004_en.htm.

[13] EPD sewing machine: ENVIRONMENTAL PRODUCT DECLARATION (EPD): SEWING MACHINE PFAFF 2046 (440). VSM Production, s.r.o. EPD Registration Number: S-EP-00027. Date of EPD verification: 26.10.2005.
EPD vacuum cleaner: ENVIRONMENTAL PRODUCT DECLARATION (EPD): FLOOR VACUUM CLEANER ETA 1450 PROXIMO. ETA, a.s. EPD Registr. Number: S-EP-00026. Date of EPD verification: 3.10.2005.

phases, they must be considered low for large household appliances. This is probably the same for small household appliances.

Various studies show that the differences between product models are large concerning the use phase (e.g. up to 45% less energy demand of class A++ cooling appliances in comparison to class A cooling appliance), but only small concerning the production and end-of-life phase.

Specific usage behaviour can deviate from typical usage behaviour in the sense of use frequency, program choice (e.g. temperature for washing machines and dishwashers), or loading (e.g. full or only half). Therefore, depending on the specific usage behaviour, the PCF of a household appliance in "real life" can differ significantly from the calculated value based on a typical behaviour. Still, the result most probably will be right in the sense that the comparison of different products will lead to the same conclusions, even if usage behaviour is assumed for all products that is deviant from the typical one.

Even more important than the usage behaviour is the variation of greenhouse gas emissions in the use phase connected to the electricity supply in different countries: depending on where an appliance is used, the related greenhouse gas emissions can be very different. The lower the greenhouse gas emissions, the higher the share of renewable energy or – which is more probable – the higher the share of nuclear power can be.

Against that background, the additional benefit of a PCF covering the whole life cycle is restricted: overall, it seems to be sufficient to determine PCF data for representative products of the different household appliances (e.g. typical washing machines, dishwashers, refrigerators etc.). But it is not of much additional help to ask the PCF for each single model.

As the electricity demand usually is directly connected to the greenhouse gas emissions of the use phase, addressing energy efficiency also includes the issue of climate change. Exceptions occur in connection to the electricity supply: depending on the offer, the greenhouse gas emissions can vary between zero and several hundred grams of CO2e per kilowatt-hour.

Additionally, one can address the greenhouse gas emissions due to the ***electricity supply***. Focus should be on the support of low CO2e offers with high share of renewable energies and without nuclear power. The latter not addressing the climate change issue but other environmental risks.

It is useful to have access to data on an in-depth PCF study of representative products of one product group (e.g. washing machines) as one knowledge base for the development of criteria for the type I label. But it is not necessary to have that data for each single model.

Which other environmental issues are relevant? From the point of view of resources, energy efficiency can be added here. Depending on the device, other aspects can also play a role: e.g. water demand during use phase, cooling agents, hazardous substances in production and product.

Overall, the PCF of household appliances does not bear the risk to generate adverse effects. But concerning electricity demand, PCF does not give a complete picture of the impacts of electricity consumption, as impacts connected with nuclear waste e.g. are not considered. A low PCF may base on a high share of nuclear power plants (e.g. in France) with the herewith connected risks.

Altogether, it can be concluded that for household appliances, in-depth PCF studies are useful as background for type I labels in order to the identify hotspots and to derive criteria correlated to the carbon footprint (e.g. electricity demand in the usage phase).

Against the mentioned difficulties, a single PCF label or the inclusion of CO2e figures on the EU energy label makes no sense.

6.4 Category 2 (Energy saving products) Example 1: Insulation material

Insulation materials belong to the group of energy saving products. Energy saving products are characterised in having no or very low CO2e emissions during the use phase. Their main direct impacts occur during the production phase. In the case of insulation materials, the reduction of energy consumption in the system "building" during use due to insulation material is the most important one. Even in most newly built houses, about 80 percent of the overall CO2e emissions that occur over the life time result from the use phase (see e.g. IMPRO 2008 and Quack 2001). Therefore, production and end-of-life of *all* materials needed to build a house only contribute to about 20 percent to the overall result. This makes possible reduction potentials due to the choice of a specific insulation material rather irrelevant.

As every building is different, it is difficult to specify the potential to reduce the thermal energy demand during usage due to e.g. 1 kg of a particular insulation material.

Construction activities are usually done by professional companies; therefore, PCF information, displayed on insulation material, will usually not be realised by consumers. The decision which insulation material is to be chosen will mostly be made by the professional company and not by the consumer himself. Still, consumers decide on the thickness of the installed insulation material (e.g. 10 cm or 30 cm) of private owned buildings and therefore have a crucial influence on the energy performance of the building and thus also on the PCF of the insulation material.

There are several approaches, e.g. in the form of rankings or rating systems:

- Indirect, as not the insulation material but the whole building is addressed: the Directive 2002/91/EC on the Energy Performance of Buildings (EPBD) aims at promoting the energy performance of buildings. Article 7 deals with energy performance certificates (EPC) and declares that a certificate is "to be made available to the owner or to the prospective buyer or tenant when a building is constructed, sold or rented out. […] The certificate is to contain reference values such as current legal standards and benchmarks to allow comparison of the energy performance of buildings. It is to be

accompanied by recommendations for the cost effective improvement of energy performance."

- Type I labels like the Blue Angel (e.g. for insulation material from secondary resources and insulation material for inside application) certify a number of insulation materials.
- There is a number of EPDs of insulation materials published (e.g. foam glass, mineral wool, mineral insulation boards). For an overview of the available EPD in Germany see http://bau-umwelt.de[14].
- Additionally, a variety of other labels from different organisations exist, the most common now being the *natureplus* label[15]. The criteria for the *natureplus* label for part of the products also encompass limits on CO2e emissions for the production phase.

As the PCF in principal covers the whole life cycle of a product, it bears the possibility to include the reduction potential of insulation material during the use phase of a building. However, the consideration of the use phase is difficult from the methodological point of view.

The improvement potentials are not so much related to the different insulation materials themselves but on the amount of insulation installed at the building. In brief: the thicker the insulation layer, the lower the thermal energy demand and the higher the reduction potential.

Focussing only on the production phase of the insulation material, the differences can be significant, e.g. between foam glass and wood fibre. But over the whole life cycle of the building this difference turns out to be marginal. The important point is how much insulation material practically can be applied: materials that insulate better have an advantage as they can be applied in thinner layers to reach the same U-value as others that insulate less.

The variability of PCF results for different insulation materials derives from the amount of insulation material applied by the user and the therewith reached energy standard of the respective building. Depending on the decisions of the responsible person, the energy standard can vary widely between the basic legal requirements and passive house standard. As a consequence, the reduction potential of the insulation material during use phase can differ significantly.

The effort to determine a specific PCF is always significant. Like for other products, it makes sense to generate PCF data for exemplary products of the different types of insulation material (e.g. glass wool, wood fibres, polystyrene) but it would be too great of a demand to request PCF data for each single product.

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[14] For insulation material see: http://bau-umwelt.de/hp545/Daemmstoffe.htm?ITServ=C1036fdb1X124d3bf7960X14ba.

[15] Launched by the Internationale Verein für zukunftsfähiges Bauen und Wohnen – natureplus e.V. (see www.natureplus.de).

As in the context of insulation material a good energy standard of buildings is the crucial point in the avoidance of CO2e emissions, this issue can be addressed directly. Legal requirements concerning insulation and information on the energy standard of buildings that are for sale and for rent, information campaigns on how to renovate best, subsidies etc. are adequate measures to do this.

The PCF of insulation material – also as a starting point for type I labels – is of marginal help as the key issue actually is the energy standard of the building it is built in and its energy demand during use. The PCF connected with the use of the building depends on two aspects: the energy standard of the building (codetermined by the insulation material) and the heating system. The latter can – independent of the used insulation material – have low CO2e emissions (e.g. basing on an efficient wood pellets boiler) or high ones (e.g. basing on an inefficient oil boiler). Instead of PCF labels, it makes more sense to focus on energy certificates of buildings that became obligatory under the EPB Directive and on chemicals.

Depending on the insulation material, other environmental issues may be relevant: resource depletion, hazardous substances, or acidification potential.

The focus on CO2e bears the risk to adversely affect other environmental aspects. The concentration on PCF could – besides the fact that it favours a better insulation of buildings – also favour heating systems that base on renewable energies (e.g. wood pellets, solar energy) and leave measures to improve the energy standard of the building undone. Therefore, the heating system used to calculate the use phase should base on fossil energy sources (e.g. gas, oil) and not on renewable ones.

6.5 Category 3 (products with relevance to climate at production phase) Example 1: Food

As most activities currently flow into the carbon labelling of food products, the analyses of this product group are carried out in more detail as the other product groups.

Meat consumption

Due to the production systems for meat, a high greenhouse gas relevance is immanent, as one kilogram of meat output does not equal the input of one kilogram of feed, but seven (FMHW 2003). On top of that, methane emissions (especially for beef) during animals' life play their part in making meat a highly climate relevant figure (UNFCCC 2005). Between the production of several kinds of meat (e.g. bovine, pig, poultry) there are differences in the greenhouse gas potential. This depends primarily on the high methane emissions of beef and on the different life times of each animal.

A change in the average EU diet, i.e. a shift away from meat, offers potential for sustainability. Factors accounting for GHG emissions, in respect to the aggregated product groups, clearly illustrate where potentials are (see table below).

Table 3 Overview on the average greenhouse gas emissions connected to the production of different types of meat, cereals, vegetables and dairy. Source: GEMIS 2009 (www.gemis.de)

Name	Greenhouse gas potential [kg CO2e/kg]
Meat	
Bovine	13.96
Pig	3.25
Poultry	3.48
Cereals	0.78
Vegetables	0.14
Dairy	8.20

It has to be kept in mind that the production of milk products is also connected to relatively high greenhouse gas emissions. The average greenhouse gas emission of milk production ranges from 0,5 to 1,65 kg CO2e/kg milk, depending on the content of fat, the system boundaries and the cultivation (organic or conventional). The more the milk is converted, the more the CO2e emissions increase. For example, the greenhouse gas emission of butter varies between 22 and 23 kg CO2e/kg (cf. milk 0,5-1,65kg CO2/kg). Furthermore, the production of milk is correlated with the cattle breeding. A female cow has to be reared two years to become a heifer that can become in calf and thereupon gives milk. During upbringing, the cow also emits methane, and the production of the feed issues greenhouse gases. Therefore, the milk production has to include the breeding in the calculation of the greenhouse gas potential.

Additionally, the milk production is linked with the output of meat: the cow has to calve in order to be able to give milk and the majority of the calves (all male calves, part of female calves) are processed as meat and do not stay in milk production.

Organic farming

The little information available concerning greenhouse gas emissions associated with organic farming throughout the EU 27 complicates the compilation of any sustainability potential, loading it with uncertainties. Therefore, no GHG reduction potential for increased organic share can be assumed.

Recently, there were some studies carried out by FiBL (2009) that explicitly compared conventional with organic agriculture. Their results point out that organic agriculture in general has lower greenhouse gas emissions than conventional agriculture. Therefore, PCF would point in the “right direction”, even though it is a very limited approach. For example, the organic agriculture claims more land for cultivation and animal husbandry (IÖW 2008).

Table 4 Overview of the greenhouse gas emissions connected to the production of different types of milk products

	Greenhouse gas emissions [kg CO2e/kg]		
Product	**Conventional agriculture**	**Organic agriculture**	**Source**
Butter	27,59	23,52	FiBL 2009
Yoghurt	0,838	0,734	FiBL 2009
Yoghurt with strawberry	1,186	1,042	FiBL 2009
Camembert	7,210	6,139	FiBL 2009
Beef	15,54	12,25	IÖW 2008
Pork	3,07	2,07	IÖW 2008

Agriculture versus food processing – life cycle view

The life cycle view of food also includes processing. At current status, only a restricted number of data sets on food processing is available. Therefore, general conclusions are not possible. The following table shows some examples of processed food. In general it is important to state that a carbon label would be misleading if it would not contain precombustion from agriculture (see example “Lasagne” below) as these processes proved to contribute significantly to the overall PCF of a food product. On the other side, the use phase must be included, especially if one wants to compare convenient products (see example industrial bread below) with home-made food (see example of home baking bread below). It would be unfair and misleading to include production in the plant on the one hand but not the preparation at consumers’ home.

Table 5 Overview on the greenhouse gas emissions in kg CO2e connected to the life cycle of different types of (more or less) convenience food. Functional unit: 1 kg of food. A "-" indicates that for the respective life cycle phase data are not available.

Specification of food type	Precom-bustion agri-culture	Pro-duction / pro-cessing	Packa-ging	Transport	Use (storage and prepa-ration)	End-of-life	Total PCF	Literature source
Lasagne, cooled with beef	-	0,823	0,036	0,083[a]	0,322[b]	-	1,264	Büsser et al. 2009
Muffins	0,34	0,11	0,47	0,37	0,72c	-	2,01	
Goulash (convenience)	3,3	0,5	-	0,14	0,56	-0,044	4,456	Frosta 2009
Industrial bread (wheat)	0,383	0,213	0,024	0,213	0,136	-	0,97	Anders-son et al. 1998
Home baking bread, oil oven (wheat)	0,291	0,157	0,022	0,045	0,122	-	0,637	Anders-son et al. 1998
Yoghurt Vanilla	1,26	0,07	0,41	0,28	1,04[c]	-	3,06	Casino France 2008
Fishfingers	2,53	1,1	-	0,054	1,77[d]	-	5,454	Frosta n.d.
Tomatoeketchup	0,155	0,44	0,52	0,095	0,135[e]	-	1,345	Defra 2006
Cornflakes	0,32[f]	-	0,65	0,36	0,51[c]	-	1,84	Casino France 2008
Honey	0,01	0,07	0,53	0,46	0,72[c]	-	1,79	Casino France 2008

a incl. retailer
b incl. Shopping tour to the retailer, excl. storage at home
c retailer
d 0,02 retailer, 1,75 use
e ride to the store
f incl. production

The following figure illustrates the table and also shows that the total PCF varies significantly, being highest for meat, fish and milk products, and lowest for cereal products. These results can be seen as tendency, for a general conclusion more data have to be generated.

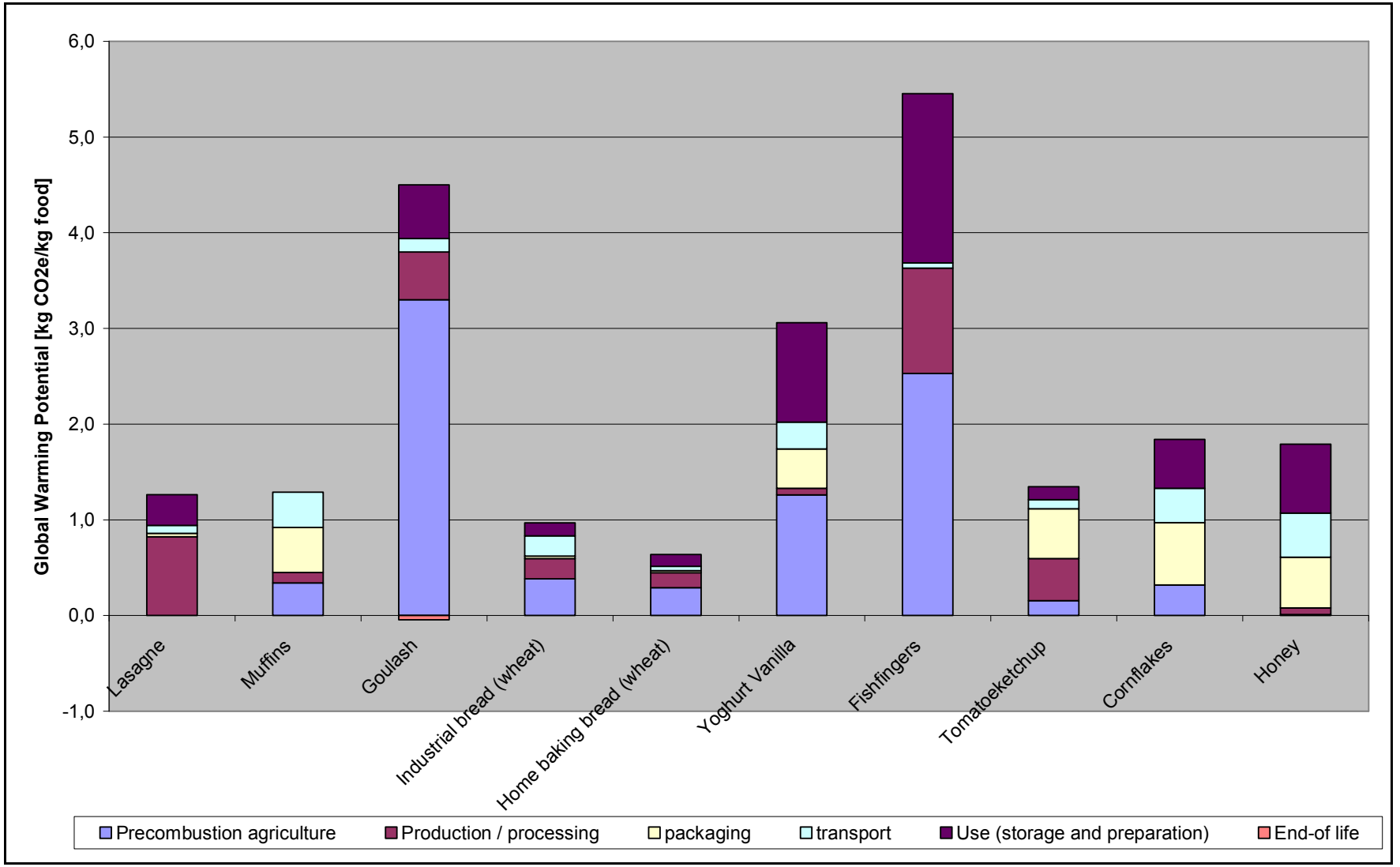

Figure 4 Overview on the greenhouse gas emissions in kg CO2e connected to the life cycle of different types of (more or less) convenience food. Functional unit: 1 kg of food. A missing life cycle phase indicates that the respective data are not available.

General analyses on PCF of food

The overall relevance of the PCF of food is high. Food production (including agriculture) contributes with a relevant share of CO2e emissions to the overall emissions of private households (e.g. approx. 20% in Germany: Quack and Rüdenauer 2007). But there are no simple answers as too many different parameters influence the PCF of products (small or large farm / with or without cooling / dynamic due to time of purchase / usage behaviour (e.g. time of storage)). Generic data e.g. on carrots may be very different from the specific carbon footprint of a product in the shop.

It is important to state that the focus on CO2e emissions alone neglects other important aspects (e.g. pesticides, biodiversity).

The CO2e emissions connected to food are shared among many single shopping acts and many different products. Therefore, consumers make very many single decisions during e.g. one year, each of it influencing the PCF only marginally.

The following approaches (e.g. rankings, rating system) already exist:

- The most widespread and well-known approach is the bio-label for food from organic agriculture based on Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products.
  This label takes into account environmental relevant aspects of cultivation (e.g. use of pesticides and fertilisers, use of genetically engineered plants and animals) but makes no relation to greenhouse gas emissions. Besides the official label, a variety of bio-labels from different associations exist (e.g. Demeter, Naturland, Bioland), having similar targets, but often being partly stricter. In Sweden, it is currently planned to include criteria on greenhouse gas emissions in the criteria for organic agriculture in the future (KRAV).
- Type I labels like Blue Angel, Nordic Swan etc. do not address food.
- There are a few EPDs published on food (e.g. milk, mineral water, sparkling wine[16]).

In general, PCF on food is an interesting approach as it shows a new perspective concerning food resp. agriculture besides the typically addressed ones (such as pesticides, fertilisers, animal welfare). Its importance is also connected to the fact that in agriculture, non-CO2e greenhouse gas emissions occur that are not related to energy demand (see e.g. CH4 emissions in bovine or rice production).

On the bases of the currently available data, one can give simple recommendations concerning general choices of food, e.g. vegetables have a much lower PCF then bovine (see Table 3 above). As a sufficient database is still lacking, it is currently not possible to differentiate the products much further (e.g. different bovine products, different ways of food

[16] For more information see www.environdec.com.

processing etc.). It is especially difficult to cover the variety of farms (e.g. small, large, different equipment) and the huge amount of different food products.

Even though some available studies that compare conventional with organic food (e.g. FiBL 2009, IÖW 2008) come to the conclusion that the PCF of organic food is lower than of conventional agriculture, this result cannot be expected right away for all product groups.

In general, it must be stated that a product differentiation is quite difficult:

- For fruits and vegetables, the PCF is quite similar if the cultivation, production, transport etc. are consistent.
- For other product groups, such as dairy products or meat, is it impossible to categorise the PCFs because there are a lot of different data connected to, e.g. the different number of production phases.
- For converted products, such as frozen vegetables or dried potatoes, it is advisable to categorise them with regard to their level of converting, e.g. frozen, tinned, peeled, or cooked products.

Also, the variability of PCF results is high. Main factors are:

- *Season*. Example: the difference between the production of tomatoes seasonal (= field grown: 0,0857kg CO2e/kg) and tomatoes outside the season (= grown in the greenhouse: 1,5672kg CO2e/kg) (Taylor 2000).
- *Farm* size, farm equipment. (See above.)
- *Location*. The transport distance and the means of transportation influence the total PCF of a product (share of contribution between below 1% and 57% (apples from New Zealand; ifeu 2009).
- *Cultivation*. In (at least some) conventional agriculture, more GHG emissions occur (primarily because of the use of mineral fertilizer, that emits a lot of GHG during production and use), whereas in organic agriculture, more land is used, which also leads to more CO2e emissions (IÖW 2008).

A PCF is cost-intensive but very helpful for exemplary products / production chains as it allows drawing general conclusions and guidelines in the sense of “regional and seasonal is better” / “ready made or home made is better” / “beef or pork is better”, etc. It will not be useful and feasible to do specific PCF studies (on the bases of primary data) on all kinds of different food products.

As outlined before, PCF serves very well as a basis for general conclusions which then can be part of general food guidelines like the ones from the Swedish “National Food

Administration's environmentally effective food choices"[17]. The Swedish guidelines aim to support food choices that lead to a "reduced climate impact, non-toxic environment, varied agricultural landscape and rich diversity of plant and animal life." Therefore, greenhouse gas emissions are one important aspect, but by far not the only one: land use, water demand, eutrophication, acidification, toxic substances, biodiversity, soil erosion.

The focus on CO2e probably does not bear the risk to adversely affect other environmental aspects. But this is still unclear due to the lack of data. Until now, no eye-catching adversely effect could be identified.

It can be concluded that guidelines like the Swedish ones on environmentally effective food choices – eat less meat in general and less beef in particular etc. – are more appropriate than CO2 figures on products. Besides that, such guidelines can focus on the important issues and the relevant products. Such information could also complement existing bio labelling. Perhaps graphical illustrations of typical food CO2 patterns as shown in Table 5 and Table 6 (maybe placed in supermarkets) will be also useful.

6.6 Category 3 (products with relevance to climate at production phase) Example 2: Textiles

Due to the lack of data (statistical data on textile consumption and PCF data on different textiles), a concluding statement concerning the overall relevance of textiles and home textiles in the context of climate relevant emissions cannot be given.

According to the available data, the PCF of textiles is relatively low compared to other product groups like cars, food etc. (see e.g. Quack and Rüdenauer 2007). Additionally, a high share of the PCF of textiles (except for some home textiles) occurs during the use phase (see e.g. ISR 2009) which is already covered elsewhere (household appliances: washing machines, tumble dryers, vacuum cleaners).

There already exist the following approaches (e.g. rankings, rating system):

- With the EU flower, textiles can be labelled that are manufactured in an environmentally friendly way and that cause less water pollution then conventionally manufactured ones. There is a variety of different products currently labelled.
- In Australia too, a type I Australian Ecolabel e.g. Woven Image (2009) exists, that takes into account the whole life cycles of textiles.

[17] The National Food Administration's environmentally effective food choices. LIVSMEDELS VERKET NATIONAL FOOD ADMINISTRATION. Proposal notified to the EU 15.05.09. Download available under: http://ec.europa.eu/enterprise/tris/pisa/cfcontent.cfm?vFile=120090292EN.DOC

- There exists a variety of other labels from different organisations, the most common are OEKO-Tex Standard 100 / OEKO-Text 1000 / OEKO-Tex 100plus[18] that focus on chemicals harmful to human health (dyes, finishing) and/or on an environmentally friendly production.
- There also exist some EPDs for textiles (e.g. Eurojersey 2009, see also Nieminen-Kalliala 2004 for a discussion of relevant environmental indicators for EPDs).

The additional value of PCF is small. From the point of view of the picture's completeness, the PCF of textiles is helpful as it is one (small) piece of the whole puzzle concerning the slowing down of climate change. Due to the lack of data, it is unclear what improvement potential can be expected. Furthermore, it is unclear how large product differentiations are. Taking into account the information in the catalogue from EarthPositive (2009), which indicates that all clothes listed are made of organic cotton, it seems that the different amounts of CO2e are due to different weights of the clothes, a T-Shirt being lightweight compared to a Sweat Shirt. Hence the choice can not be done on the basis of the PCF as one either needs a T-Shirt or a Sweat Shirt. It would be more interesting to see a comparison between products from organic and non-organic cotton and also synthetic materials. Until now a clear recommendation for consumers concerning the choice of material – e.g. natural versus synthetic fibres – is not possible.

Variability due to different wearing and washing behaviour would lead to a different PCF. The lifetime of a textile product, for example, can be very different due to different usage behaviour. This can lead to conflicts as a T-Shirt with a long life time will be used and washed more often, which results in a higher PCF then for a short-lived product. Although unclear at the moment, it is to be expected that the farming system influences the PCF results of natural fibres (e.g. size of farm, application of chemicals versus manual work etc.).

As in other product groups it is important to determine the PCF of exemplary textile products in order to get principal conclusions concerning the life cycle and the overall relevance. It does not seem to be helpful for consumers to request the PCF for each single textile product.

The issue of climate change alternatively can be addressed at the following points (targeting different groups): energy consumption in the textile chain (manufacturing processes), application of agrochemicals in cotton production, life time of textile products. Probably the application of certain chemicals (e.g. non-iron finishing) helps to reduce the PCF for washing and ironing (see e.g. BASF 2009).

As other environmental aspects are more relevant, PCF must not be addressed directly as a criterion but should be kept in mind in order to identify possible adverse effects early enough.

There is a variety of other environmental issues relevant in the context of textiles such as water consumption (e.g. 7-20 m³ water/kg cotton) and use of pesticides for cotton production

[18] „Öko-Tex International – Prüfgemeinschaft umweltfreundliche Textilien“ (Öko-Tex).

as well as application of chemicals for textile dyes and finishing (water emissions, hazardous substances on the textile). For a discussion of the possible role of LCA in textile production see also Jödicke (2001), for an environmental assessment of textiles see Laursen et al. (2007).

At the moment, there is no evidence suggesting that adverse effects occur when optimizing according to PCF. However, data are still incomplete.

In summary, it can be concluded that a PCF label does not make sense, but that it is more reasonable to concentrate on type I labels with their multicriterial approach (e.g. focus on water, pesticides, chemicals) on the one hand and on organic agriculture resp. textiles from organic grown fibres on the other hand.

6.7 Category 3 (products with relevance to climate at production phase) Example 3: Electricity supply

The CO2e relevance of the electricity production is high. The electricity consumption is caused by many different energy using products in one household (e.g. washing machine, dishwasher, computer, heat pump etc.), the electricity, however, being delivered by one supplier. Therefore, consumers have to make one decision and contract concerning their supplier and the specific electricity product they want to purchase.

The following approaches (e.g. rankings, rating system) exist:

- According to EU Directive 2003/54/EC, electricity suppliers have to specify the contribution of each energy source to the overall fuel mix of the supplier over the preceding year in or by means of the bills and in promotional materials made available to final customers. Furthermore, they have to indicate at least the reference to existing reference sources, such as web-pages, where information on the environmental impact, in terms of at least emissions of CO2 and the radioactive waste resulting from the electricity produced by the overall fuel mix of the supplier over the preceding year is publicly available […] (see §3, 6.).
  - ⇨ Remark: Within the project “Consumer Choice and Carbon Consciousness for Electricity (4C Electricity)” it was analysed which kind of information is useful for consumers and SMEs and in which form it should be presented (for more information including project reports etc. see www.electricitylabels.com).
- Concerning type I labels, the Blue Angel for green electricity is currently under development.
- There exist a variety of other labels from different organisations, focussing on the certification of green electricity with proved added value for the environment (for

Germany see e.g. ok power[19], Grüner Strom Label[20]), the latter meaning that it contributes to the increase of the share of renewable energy in the electric grid beyond existing legal requirements (e.g. proved by share of newly built power plants basing on renewable energies).

- Additionally, there exist market surveys that aim to give consumers orientation concerning "good" green electricity products (for Germany see e.g. www.ecotopten.de or www.energie-vision.de).

The additional value of PCF compared to existing approaches is that it encompasses all greenhouse gases and not only CO2.

Although there may be large differences in the electric grid between several European countries, the improvement potential to increase the share of renewable energies in the electric grid is generally still high. The differences between different electricity "products" for consumers can be large. However, "green" alternatives are not available in all EU countries.

Against the background of legal requirements and available data bases, the effort to determine the PCF of electricity products is still not to be underestimated. Moreover, there are some methodological questions which are unsolved so far, at last referring to the tracking of the CO2e emissions of electricity from renewable energy sources (e.g. double counting must be avoided as well as the contrary). PCF should relate to a defined period of time (usually one year, which corresponds to the existing labelling scheme). Then, no seasonal problems should occur. One has to be aware that besides CO2e emissions, also other environmental issues are relevant: nuclear waste, other emissions (e.g. SO2, particles). For the latter it can be stated that they are somewhat connected to CO2e emissions in the sense that low CO2e emissions most likely relate to low SO2 emissions. For nuclear waste this is not the case.

CCS (Carbon Dioxide Capture and Storage) is currently discussed as one means to reduce CO2e emissions of power plants. The technology is still not mature, but it is clear that CCS will reduce efficiency of the power plants.

In addition to PCF, there are other means to address climate change: fuel mix information, information on share of newly built power plants for renewable energies. Indirectly, there should be a focus on energy efficiency (not used electricity is the most environmentally friendly one).

Overall, it can be concluded that the PCF is one crucial criterion a type I label for electricity products should base on. In order not to be misleading, other criteria have to be considered as well: share of newly built power plants basing on renewable energies[21], exclusion of

[19] http://www.energie-vision.de/?show=infos&sub=okpower

[20] www.gruenerstromlabel.de

[21] Only newly built power plants for renewable energies that exceed the legally requested share ensure an added value for the environment.

electricity from nuclear power plants, cogeneration of heat and power, restriction of electricity from coal and lignite power plants etc.

To exclusively communicate CO2e emissions bears the risk to favour electricity from nuclear power plants. Therefore it must strictly be avoided to communicate solely CO2e figures.

6.8 Category 3 (products with relevance to climate at production phase) Example 4: Paper

Paper belongs to the category of products that do not use energy in the usage phase and that do not influence energy demand of other products during their usage phase. However, they are still CO2e relevant due to impacts of production.

The production phase dominates the life cycle, during use impacts are marginal (e.g. printing). There are hints that meanwhile virgin paper production in some cases of best available technology may even have a lower carbon footprint then recycling paper.

Consumers purchase ready made products like newspapers and books (purchase decision bases on content), as well as paper for printing or copy purposes (purchase decision bases on quality of the paper itself).

There exist approaches, e.g. rankings and rating systems:

- Type I label like EU Ecolabel, Nordic Swan and Blue Angel certify paper (e.g. tissue paper). Focus is on the derivation of fibres relating to forestry, on recycling paper (Blue Angel) resp. the use of chemicals. In the EU Ecolabel there is a limit set for CO2 emissions from non renewable sources in production (including electricity). The currently valid criteria limit CO2 emissions to 1000 kg/t for integrated paper mills and 1100 kg/t for non-integrated paper mills. They are under revision at present.
- Forest Stewardship Council (FSC) also certifies paper.

CO2e emissions connected to the life cycle of paper are of additional help as they indicate e.g. the share of renewable energy sources used for paper production.

The improvement potential from virgin to recycling paper has decreased in the last years but is still significant (see Ifeu 2006). However, there are some new enzymatic techniques that seem to significantly reduce the demand of energy and chemicals of virgin paper production (Skals et al. 2008). Therefore, in the future the distance might even further diminish.

At the moment, generic data are available that allow a rather general but significant distinction of different paper grades, e.g. a distinction between recycling paper and virgin paper or groundwood paper. Product specific data are not available at the moment and therefore it is difficult to judge the range of product differentiation within one paper grade.

The variability of PCF results due to seasonal changes etc. should be low. There is probably some variety between different paper mills.

In general, it is helpful to know the CO2e emissions over the life cycle of a product and the range of possible differences among different product types (e.g. virgin paper versus recycling paper). However, it does not seem to be useful – having the therewith connected costs in mind – to request a PCF for each single product.

By promoting recycled paper in contrast to virgin paper and by addressing the reduction of paper consumption by consumers in general (e.g. by printing double sided) the climate change issue can also be addressed.

PCF is one starting point for the development of criteria in type I labels. Other aspects are: resource demand (wood / recovered fibres) and herewith connected land use, water consumption (e.g. according to ifeu 2006 recycling paper needs 32 m³ less water per ton of paper for production than virgin paper), water emissions due to use of chemicals for processing (e.g. COD, AOX).

However, as far as data are available, no adverse effects are to be expected by focussing on low CO2e paper, PCF pointing in the right direction.

Overall, it can be concluded that in-depth PCF studies can serve as a starting point for the development of criteria. A single CO2 centred label covering the whole life cycle of paper, however, would leave out too many important issues (like water consumption, chemicals) and include too many uncertainties resp. variables (such as. transport). Still the approach of the EU Ecolabel to address the production phase with a CO2 limit seems to make most sense.

6.9 Conclusions as how global warming is best addressed in the analysed product groups

Against this background it can be concluded in general that PCF is particularly useful in the three following cases:

Type I labels should include in-depth PCF studies as starting point for the development of criteria. It should then be checked whether the setting of CO2e values as a direct limit, makes sense for single life cycle phases (e.g. as for paper production) or if this is not the case. The same can be stated for labels such as organic food label.

General recommendations on purchase behaviour and usage can be developed on the bases of the results of in-depth PCF studies and then be communicated to consumers (example: food).

Existing mandatory labels using CO2 values for communication (e.g. cars, electricity) should be continued and be improved concerning their outcome, in order to convince consumers to purchase climate friendly products. The EU energy label in contrast should not be expanded to CO2 figures.

PCF figures are not suitable for being displayed on a product.

The following table summarises the results on how global warming is best addressed for the specific product groups that have been analysed.

Table 6 Overview of the conclusions concerning how global warming is addressed best

Product category	Product group	Best options to address global warming
Energy consuming products	Cars	The existing mandatory label on CO_2 communication for the marketing of new passenger cars should be complemented by a benchmarking system e.g. in the form of a colour or letter code. Petrol consumption tests should be developed that are more in line with real driving and including also electric cars. Adequate measures to improve the outcome of the label in the sense of climate friendly purchase decisions by consumers. In later steps: include non CO_2 greenhouse gases and precombustion of fuel as well as production (in the from of average data for different size classes of cars)
	Household appliances	EU energy label addresses energy efficiency and therefore indirectly also CO2e emissions. An addition of CO2 values on the label is not helpful. Type I labels should include in-depth PCF studies as starting point for the development of criteria. To set CO2e values as a direct limit makes no sense.
Energy saving products	Insulation material	Instead of focussing on the PCF of insulation materials it will be more successful to concentrate on energy certificates for buildings. About 80 percent of climate relevant emissions relate to the usage phase and correlate with the energy standard of the building!
Products with relevance concerning greenhouse gas emissions at production phase	Electricity	The obligatory information of customers concerning of at least CO_2 emissions and radioactive waste resulting from the electricity production is purposeful. Adequate measures to improve the outcome of the obligatory information in the sense that more consumers buy green electricity. Type I labels should include in-depth PCF studies as starting point for the development of criteria (CO2e, nuclear waste). Measures to reduce electricity consumption (e.g. communication measures) are also beneficial.
	Food	Development and communication of “simple” general recommendations taking into account climate change issues (PCF based) concerning food purchase and preparation. In order to do so, further in-depth PCF studies are necessary. Basing on in-depth PCF studies integration of climate change issues in the development of the standards for organic agriculture. The communication of CO2e figures on the product makes no sense and is not helpful to consumers.
	Paper	Type I labels should include in-depth PCF studies as starting point for the development of criteria. To set CO2e values as a direct limit makes sense concerning the production processes.

Product category	Product group	Best options to address global warming
	Textiles	Inclusion of CO2e issues in the multicriterial approach of type I labels. Promotion of a label awarding textiles made of fibres from organic agriculture. A PCF label makes no sense.

7 Recommendations for input into standardisation or legislation

7.1 Open methodological questions concerning PCF

The following list of open methodological questions bases mainly on the findings of PCF-Pilote (2009) and Grießhammer / Hochfeld (2009). They have to be dealt with in standardisation and possibly legislation as different approaches might lead to quite different results.

Certified green power from renewable energy sources

There still is not a good, broadly accepted method for including green power in the calculation of a PCF. This not only applies to the PCF, but also for company-related GHG inventories. The emission factor for green power is often assumed to be zero, which generally does not constitute a correct evaluation. Currently recommendations are worked out as to how certified green power should be evaluated with respect to its additional benefits for the environment. In the PAS 2050, green power is included in the national electricity mix in order to avoid it being accounted for twice unless it can be proven otherwise.

Emissions from aviation

Not only CO2, but also other substances such as water vapour and nitrogen oxides contribute to the global warming effect of air traffic. The effect is described using the so-called Radiative Forcing Index (RFI). That is why the use of the more extensive RFI instead of CO2e emissions is so important in the case of air traffic.

Significance of the shopping tour

There is no systematic reason to leave the shopping tour involved in buying a product out of the assessment, something which was proposed in the PAS 2050. When communicating information to the consumer, the significance of the shopping tour and the effect this has on a product‘s CO2 footprint is by all means an important aspect.

Direct and indirect Land use changes

The change of land use due to agricultural and forestry use of area changes the greenhouse gas emissions due to the changed amount of carbon stored in the soil. Direct land use changes (e.g. coffee is grown on an area that was natural wood before) contribute to the PCF as well as indirect land use changes (e.g. cultivation of plants for biofuels on places where food was produced before may lead to the use of land for food production where natural wood was grown before). Direct as well as indirect land use changes influence the PCF of affected products. Experiences show that indirect land use changes can be significant and should therefore be considered. In contrast PAS 2050 proposes only to include direct land use changes.

Storage of CO2 in products

PAS 2050 proposes to subtract CO2 stored in products according to a specified formula. Examples are products made of wood (e.g. furniture, construction material), paper (e.g. books) or geogenic carbon (e.g. cement/concrete, quicklime). As it is difficult to foresee the real life time of a product, and therefore its real storage function, this is problematic. According to the understanding of IPCC and UN-FCC (United Nations Framework Convention on Climate Change) the intermediate storage of biogenic carbon is not seen as carbon sink. Carbon emissions are only postponed to the next generation. Geogenic carbon could instead be more likely to be seen as sink, as it is more probable that constructions (really) last long and thus justify such a proceeding. Still in order to insure comparable proceeding, a product category rule should be requested.

Significance of capital goods

In general, capital goods are seen to be of little significance for the PCF and are therefore often neglected when undertaking life cycle assessments. Capital goods may very well be relevant for the result of PCF calculations for certain products, product groups or services. If this is the case, they should be included in respective product-specific guidelines (potentially in Product Category Rules, PCR).

Allocation in cases of co-production

Emissions should be allocated to their actual source in accordance with the specifications of the ISO 14040ff standard and then substantiated in product-specific rules. The reasons for choosing a particular allocation method must be outlined. What is more, it makes sense to use at least one other method and then present and analyse the differences in the results.

Allocation in open loop recycling

When using materials and products for new production processes and their transformation into other, new products (open loop recycling), a 50:50 allocation should be applied, unless different assumptions have been taken based on product-specific aspects.

7.2 General recommendations to legislation and standardisation

Even though the interest of consumers and other stakeholders in PCF is not necessarily focussed on the communication of specific PCF figures there can still be observed a general increasing concern regarding climate change and possible – individual – courses of action.

General recommendations to the legislator should therefore consider the following points:

Other environmental effects should not be disregarded

As stated before the narrow approach to only focus on greenhouse gas emissions bears the risk to overlook relevant other environmental impacts or even lead to wrong conclusions that increase negative environmental effects in the worse case (e.g. in the case of electricity). Therefore screening analyses of other environmental impacts must be included in a PCF.

The PCF is a fundamental indicator for some products or product groups. Still a comprehensive sustainability assessment of products cannot be carried out on the basis of the PCF alone. Other useful evaluation tools like life cycle assessments, eco-efficiency analyses and sustainability analyses can be used to complete the picture.

The screening of relevant other environmental impact categories besides global warming potential must thus be an obligatory component of a Carbon Footprint study.

ISO 14024 Type I labels like the Blue Angel should be retained as lead labels

The above considerations clearly support retention of eco-labels in accordance with ISO 14024 (Type 1), such as the Blauer Engel eco-label, as lead labels. The advantages of ecolabels over CO2 labels are summarized again below (the arguments apply both to the Blauer Engel and by analogy to other national eco-labels and the European eco-label):

- easily understood and reliable information for consumers: from an overall environmental perspective an eco-labelled product is clearly better than comparable products;
- inclusion of all relevant environmental and health aspects;
- identification of criteria on the basis of LCAs and eco-toxicological assessments;

- subsequent discussion by a panel of experts;
- final decision by an “environmental jury” on which relevant stakeholder groups are represented;
- certified award process and checking of the criteria for products marked with the ecolabel.

Drawing up of Product Category Rules for particularly relevant products is essential

The main challenge of PCF meant for communication is to define the whole framework in a way that all products belonging to one product group can be calculated in an as much as possible defined way to assure the same approach even if the studies are performed by different experts. This requires e.g. the same goals, the same system boundaries, the same calculation rules and similar data quality for different studies. With a general ISO standard this can not be achieved as it only provides generic rules. Therefore it is essential for the future that product category rules (PCRs) will be developed that ensure a comparable proceeding within one product group. Such PCRs would have to be defined and adopted at the European level. Given the many different product groups this will take time and needs prioritisation.

Basing on PCF it is not possible at the moment to perform product comparisons of multiple products carried out on behalf of different clients and by different practitioners as well as public comparison with competing products in ways that are acceptable under competition law (e.g. through reporting of CO2e values or use of CO2e labels).

Methodological restrictions when using the LCA / PCF approach

For the PCF approach the same is true as for the general LCA approach: The assessment of the whole life cycle is a strength compared to other techniques. The approach can be used to compare products with similar function but differing production and/or operating technologies. Still the methodology has some restrictions that have to be kept in mind when applying it: Like LCA also PCF is *per definitionem* a purely quantitative tool. As it has to be requested that at least a screening analyses on other environmental impacts then greenhouse gases has to be performed in a PCF study, the same problems occur as with LCA. Current LCA-approaches cannot exhaustively cover site-specific aspects: as greenhouse gases have a global impact and no site-specific one, this weakness does not apply to PCF studies in the narrow sense. As for LCA, the variability and reliability of data may represent a problem concerning data quality (e.g. time-related, geographical and technology coverage), data origin, effort of data acquisition and possibly fast changes of supply chains. Spatial and temporal variations are theoretically no obstacle for the applicability of LCA / PCF in product

labelling. Nevertheless, the things can get quite complicated, and a proper definition of the functional unit can be quite critical. Fast changes in supply chains are difficult to be accounted for in LCA / PCF since they require a functioning information system which is not yet in place. As for the calculation rules, there are still methodological questions to be solved and consensus to be found among different existing approaches (see chapter above). Concerning the differences between different products from the same product group PCF results may show only small deviations similar to that of LCA results. LCA as well as PCF cannot eliminate uncertainty. Due to these uncertainties (e.g. parameter or model uncertainty) PCF results will always have a restricted precision. Therefore the display of a single CO2e figure on a product is misleading.

Current CO2 labels neglect consumer comprehensibility, benchmarks and indication of excellence

In order to be useful to consumers a CO2 label would have to

- ***be comprehensible***, e.g. by a well structured display, aggregation of the information, concentration on the gist. Additionally a standardised look thus enabling consumers to quickly comprehend the information, compare different products and include the information on the climate impact in their purchasing decision.
- ***include a rating scheme***, enabling consumers to recognise if the products' Carbon Footprint represents a relatively low greenhouse gas emission for the resp. product group or a relatively high emission. It must be possible for consumers to recognise excellent products. Only then an effective reduction of the climate impact due to "the right" purchasing decision can be achieved. Consumers are already well acquainted with the A-G labelling scheme of the EU energy label, so this could be a promising starting point.
- ***be third party certified***. As credibility is of high importance for consumers, it is crucial that a third party review should be requested for the PCF when used in product-related communication.
- ***be backed-up*** by easy to access and transparent documentation of the PCF study the label is basing on. This includes the motivation for calculating a PCF and assumptions and quantifiers used in the calculations. Any publication of the data must be clear, understandable, conclusive and open to scrutiny. It should ne noted to what extent PCF calculations are reliable and/or uncertain and whether other important environmental impacts have been taken into consideration.

Single number CO2 labels make no sense

A static PCF stand-alone label providing a total CO2 footprint on products does not make sense and is not very relevant for consumer decision making. Although consumers are increasingly aware of the relevance of climate impacts resulting from their purchasing behaviour and usage of products, the display of a total CO2e footprint figure alone would not be of much help to them. It has to be stressed that a figure of this kind suggests a precision and conclusiveness which cannot be achieved using the current state of methodology. At the current state with only few products being labelled this even bears the risk that the sheer display of such a label makes consumers believe that the product might be better then another without label.

Climate change might be addressed by other means then PCF

It is not always necessary to use PCF to address climate change issues. As CO2e emissions are at the moment often highly correlated to the demand of electric and thermal energy and fuel consumption (e.g. in cars) climate change issues can be more easily addressed by energy efficiency parameters. The latter is also cheaper and more reliable as it addresses a key parameter that can be directly measured and restricted e.g. by legislation. In other cases, like food for example, PCF is a good base for the development of general recommendation for consumers taking into account climate change issues (e.g. "*eat regional and seasonal food*", "eat less meat" etc.) but needs not be communicated as PCF.

Overall it can be concluded that in some cases there is no added value to the use of PCF and in other cases PCF should only serve as base for general recommendations.

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