Environmental product indicators and benchmarks in the context of environmental labels and declarations

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Executive Summary

Introduction

The newly published "Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan" of the European Commission has clearly emphasised the need to harmonise the various European labelling instruments of product policy. The aim is to improve the overall environmental performance of products throughout their life cycle, to promote and stimulate the demand of better products and production technologies and to help consumers make better choices through a more coherent and simplified labelling. However, there are some fundamental methodological and socio-political issues that need to be addressed in order to ensure the legitimacy of the harmonisation process. For instance, disagreement on the scientific reliability of various aggregation methods building the basis for labelling remains largely unresolved. Also, the current focus on purely CO_2-emissions-based labelling systems engenders new possibilities but also risks for the environment. As examples, these risks include the negligence of environmental impacts other than CO_2, a disregard of product-quality aspects and the distortion of competition caused by insufficiently detailed or asymmetric life cycle data.

In this context, ANEC commissioned the Öko-Institut e.V. and Ökopol GmbH as subcontractor to conduct a research study on various issues related to environmental labels and declarations which are of particular relevance to the consumers, and to support ANEC and its member organisations in their position finding processes to enable them to shape the upcoming discussion processes on these issues.

Life Cycle Assessment (LCA) – Usefulness of the approach for environmental Labelling

LCA can either be used for orientation purpose in labelling schemes or applied to each product model under the scheme which is currently discussed in various new attempts to display environmental product footprints (LCA-results as basis for product differentiation). Contrary to many existing environmental labelling schemes which focus on some selected product criteria that provide information for only selected environmental impacts in selected life cycle stages, LCA is capable of dealing with all stages of a product life cycle. Another clear advantage of LCA is the ability to compare system alternatives, i.e. products with similar functions but differing production and/or operating technologies such as PCs and laptops or different types of fuels.

Application of LCA would therefore help in broadening labelling schemes to much wider defined product groups.

However, LCA does not account for unquantifiable issues like biodiversity and soil erosion and also does not sufficiently address site-specific impacts, such as indoor/outdoor emissions of volatile organic compounds, which depend on more factors than just the inputs and output of a system. For this reason, LCA cannot replace other product specific assessment methodologies. 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. Although there are some attempts to tackle this problem in the field of ecotoxicity by working with typical emission-exposure scenarios (e.g. ecotoxic components of washing powder being typically emitted into the waste-water system, where further transport, treatment and subsequent exposure are principally known), this is only feasible for a small share of all toxic emissions, so that for most products, current LCA-approaches cannot exhaustively cover certain environmental impacts.

For narrowly defined product groups, LCA-methodology does not offer any added-value for product differentiation. This is due to the fact that product design and production technologies are usually quite similar. Hence, the only differentiating features will mainly result from issues already addressed by traditional labelling schemes and the differences in the national energy-mix. Furthermore, reliability of data used in LCA-methodology can be questioned, as many product systems and supply chains are more flexible than the LCA-databases and -calculations, leading to situations where LCA-results do not necessarily represent the actual environmental impacts at a given time.

Therefore, it can be concluded that LCA has some considerable weaknesses for application in product model differentiation. Nevertheless, there is an increasing tendency to introduce footprint schemes aiming at a higher comparability between system alternatives and different product types. These schemes are primarily focused on greenhouse gas emissions and have an inherent necessity to apply LCA-methodology. Although these schemes can also be questioned in terms of completeness and informative value, they are a main reaction on the ongoing public and political debate on global warming and will soon form an additional type of product information.

FORCE-Technology proposed the so-called Environmental Data Sheets (EDS) based on a methodology that is supported by LCA-results for average product models of various product groups and that are normalised using average annual environmental impact of a European citizen. With this normalisation, the LCA-results for each impact category are transformed into the unit “milli Person Equivalents” (mPE), which then form the basis for a colour-matrix that enables a comprehensive overview on this cross-product-group comparison. For the proposed application in EDS, the limitations of LCA related to temporal and spatial variations in the product life cycle (changes in logistics, variations in supply chains etc.) are much less significant since the aim is not to differentiate between product models of one product group, but to establish comparisons between typical models of different product groups of our daily lives. With this focus, an LCA would be much less dependent on product model specific primary data. Instead, widely secured average data – as compiled in the generic datasets – would be preferable since they are more representative and therefore better meet the goal of calculating the environmental impacts of an average product.

Methodologies for aggregated evaluation of environmental product performances

One of the critical steps in the LCA-methodology, among others, is the selection of appropriate impact categories and the definition of an appropriate category indicator as well as an impact indicator unit for each impact category. The major dispute exists on how the impact categories are to be grouped and weighted in order to calculate an aggregated estimated impact. EcoGrade and Eco-indicator represent two methodologies that address this issue, albeit in different ways. EcoGrade starts with the inventory results and tries to interpret them. The environmental impact of a product is inventoried in ten impact categories. On that basis aggregation is performed, applying normalisation, grouping and weighting within one step. In EcoGrade, the various environmental impacts are weighted on the basis of socially agreed quantitative environmental targets. Each category of environmental impact is expressed in environmental target impact points (ETP) in accordance with its contribution to national or international environmental targets. These target values indicate the emission level, to which a certain environmental impact has to be reduced. Impact categories for which no quantitative environmental targets have yet been formulated are integrated within the overall result by means of a set percentage weighting. The higher the number of points, the greater is the environmental impact. On the other hand, Eco-indicator first defines the required results such as the “environment” and the weighting of different environmental problems. The rest of the process (e.g. definition of impact categories) is set up to accommodate the best weighting procedure. For the purpose of providing weights to the identified damage categories, Eco-indicator used the panel approach, i.e. a group of LCA-experts was asked to weight and rank the damage categories according to their importance. This weighting of damage categories is set as a basis for the calculation in Eco-indicator.

In EcoGrade, although ten impact categories are selected, the aggregation step is restricted to only four impact categories – Global Warming Potential, Acidification

Potential, Nitrification Potential and Photochemical Ozone Depletion Potential. Other categories are excluded from aggregation because they are difficult to quantify and operationalise. Taking these shortcomings into account, results from aggregation with EcoGrade are always accompanied with additional information for all impact categories.

In Eco-indicator, uncertainties originate from the differences in the perceptions/ world views regarding the significance of certain environmental impacts. Although the process of weighting and ranking the damage categories involves participation of LCA-experts, the variability in the interpretation of damage categories by different people, experts or societies makes the results of Eco-indicator vulnerable to legal complaints. Furthermore, method of Eco-indicator is based on the assumption that causal chains linking the inventory data via mid-point indicators (such as climate change, ozone layer depletion etc) to the end-point indicators (such as damage to human health) are well established. However, data basis and logical cause-chain linkages for many categories are not homogenous and far from convincing. As for instance, it is impossible to predict the exact damage caused by climate change on human health. The fixation of the methodology on the functional unit approach, such as Disability Adjusted Life Years for human health, could lead to results whose scientific reliability could be questioned.

Therefore, it is recommended not to present aggregated information as stand-alone information but always accompanied with additional information for individual categories. This can be executed in an interactive manner, involving not only people from the LCA-community but also important stakeholders, such as consumer organisations, environmental NGOs and independent research institutes. It is suggested to apply an integrated 3-step simple peer review. This would specifically mean that any aggregation methodology should be reviewed and revised during or after – (1) the goal and scope definition, (2) the data collection, and (3) the conclusion.

Qualitative / semi-quantitative indicators in product assessment / environmental labelling: focus on environment and health

Many qualitative and semi-quantitative environmental aspects, such as biodiversity loss, noise and direct exposure to chemicals and radiations, have been left out of the LCA-methodology because of the strong focus of LCA on functional unit approach, data availability and quantification of data. When such aspects represent significant environmental impacts, their coverage becomes a key requirement for achieving the overall goal of environment labels and declarations.

In order to ensure that all significant environmental aspects of qualitative and semi-quantitative nature are integrated in the product assessment, it is necessary to define the goal and scope of the study with the help of mandatory, collateral, third-party critical review, involving experts (such as consumer organisations) outside the LCA-community. The aim of mandatory, collateral, third-party critical review could be to expand the system scope beyond the process chains existing in conventional LCA-models. While defining the system boundaries, it has to be kept in mind that people's professional and personal values will determine what aspects have to be measured and modelled. Therefore, it is recommended to identify and include all perceptions on relevant environmental aspects that can be attributed to a specific product, company or system. Importantly, criteria for defining the system boundaries should not be based on the availability of data, as it is generally done in LCA-studies. The demarcation of the system should be strongly based on the criteria of damage potential, i.e. all environmental aspects that cause significant environmental damage should be included.

One of the approaches to focus on significant unit processes and environmental aspects could be to conduct a hotspot analysis. The criteria for selecting the hotspots could include – environmental damage potential, environmental sensitivity, magnitude and frequency of the environmental aspect, importance for the local community, indigenous populations, employees and consumers, and existence and requirements for relevant environmental regulations.

If quantitative generic data related to the significant environmental aspects is not available, as for instance on the extent of biodiversity loss, exposure and noise damage etc., but if these aspects are graded as hotspots by the stakeholder groups, it is not recommended to leave out such aspects instantly. Rather, the approach should be to develop a realistic methodology to counter this problem. In some cases, collection of site-specific data (qualitative, semi-quantitative and quantitative) for some significant environmental aspects might be indispensable.

In order to determine significant environmental aspects, the methodological approach should incorporate a systematic collection and evaluation of the damage potential of environmental aspects .This would specifically mean that potential damage factors for each environmental aspect can be listed, their mode of damage creation is determined and then the extent of damage is estimated through multistakeholder expert judgement, literature review, interviews, desktop screening and internet research (cf. chapter 4.1.3 for detailed description). The qualitative and semi-quantitative (impact) assessment of environmental aspects may range from specific to general, depending on which level of precision is reached in the summarisation and the interpretation, which in turn is also influenced by data availability. It could include steps of basic aggregation as well as meaning assessment. A useful method could be to provide summaries and qualitative interpretations of the environment significance of the data collected at the inventory phase.

Impact categories (such as ecosystem quality) shall be selected carefully, and should ensure that the environmental model clearly describes the causal chain linkages. It is not necessary to describe this link quantitatively. Furthermore, it is important that the aim of the assessment is not made directly proportional to the quantification of data, and to a common functional unit. This is due to the fact that not all LCI results will have a characterisation factor (e.g. it is well known that the GWP of methane is 21, and that of nitrous oxide is 310 with respect to CO_2. However, it will be impossible to measure the equivalents or characterisation factors for the aspects leading to biodiversity loss and land use changes). Secondly, some cause-effect relationships are not simple enough or sufficiently known with enough precision to permit quantitative cause-effect modelling. In such cases, it will be relatively easier to work with qualitative and semi-quantitative indicators because the results are presented in a disaggregated way. Or in case of quantitative indicators, such as noise, it might be better to build a separate (individual) category for them, without trying to aggregate them with other indicators. However, it might be necessary to present the disaggregated results and separate (individual) categories along with the aggregated ones (achieved by using LCA-indicators), in order to avoid any loss of information, and build a sound basis for the product declarations. It is recommended to focus on different instruments, such as environmental impact assessment, chemical risk assessment etc for measuring the non-LCA-indicators. Furthermore, it has to be accepted that the widely used quantitative functional units might not represent the total quantitatively calculated environmental burden. So, the need to supplement this information with additional quantitatively calculated categories, and descriptive and argumentative interpretation, becomes indispensable. The characterisation models in such cases would be rather formalised and not mathematical operationalisation of the environmental mechanisms. They may be a basic aggregation step, bringing text or qualitative inventory information together into a single summary, and/or summing quantitative inventory data within a category.

Finally, in the interpretation phase, the evaluation can use a range of qualitative, semi-quantitative and fully quantitative approaches. Some key requirements regarding the evaluation process include the mandatory, collateral, third-party critical review, the participation of relevant stakeholders, the documentation of the evaluation process, actions taken to ensure transparency, and the verifiability of results.

Energy- versus CO_2-indicators

Within the last two years, several attempts have been started to calculate and display the carbon footprint of products and services. However, beside the problems of using LCA for product differentiation, there are considerable concerns regarding the use of CO_2-equivalents as key indicator. Alternatively, it is possible to use an energy indicator that sum up the amount of primary energy used within the life cycle of a product. Furthermore, better primary data availability for energy indicators is much better than for CO_2-indicators since almost every company needs energy figures for its own economic calculations.

Generally, global warming and greenhouse gas emissions receive a high level of public and political awareness so that a general cause-effect understanding can be presupposed for a large part of the population. Furthermore the measurement unit for CO_2 (grams) is quite straightforward and corresponds with everybody's the day-to-day knowledge. With this measurement, consumers would be enabled to make simple cross-sector comparisons and rough judgements on their consumption behaviour. The various energy measurement units (VA x h, Watts x h, kWh, Joules, litres diesel per 100 km, litres gasoline per 100 km) are comparably complex and require a certain scientific understanding, which cannot be presupposed for all population parts. Furthermore it can be observed that CO_2-indicators are increasingly applied in fiscal and legal procedures (e.g. carbon taxes in countries like Finland, the Netherlands, Norway and Italy, and bonus malus system based on CO_2-emissions in France) so that product carbon footprint will tap many synergies with these efforts.

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. Assuming that the CO_2-indicators of a product carbon footprint scheme allow emission deductions for the use of green electricity, such deductions could reduce the total product carbon footprint to a level that makes efforts for higher efficiency unattractive:

With CO_2-indicators there is also a certain danger to unintentional promotion of CO_2-extensive but unsustainable forms of energy like nuclear power. This would be the case if the CO_2-emissions across the life cycle of a product are the only means of differentiating "green products". Since nuclear power is inevitably connected to other especially severe sustainability risks, it can be concluded that a strong focus on CO_2-indicators bears the risk of severe unintentional side-effects and another form of "greenwashing".

A more realistic problem with CO_2-indicators is the vague definition of green electricity: In many cases, suppliers offer "green electricity" that was formerly part of the general electricity mix: Since this practice does only lead to a demixing of the electricity supply and has no influence on the share of renewable energies, it should be carefully considered, which supplier specific emission data should be allowed for CO_2-indicator schemes. Furthermore, every European country features its own characteristic electricity-mix. If product carbon footprints are calculated using national average data for the use phase of electric and electronic equipment, CO_2-product-values would be different for each EU-country. In this case, thresholds for the EU Ecolabel and the EU Energy Label would have to be negotiated separately in each member country. The use of European average data would solve this problem.

There are some aspects to be considered with both types of indicators: Both indicators only represent a certain part of the environmental impacts of a product or service, while others are ignored. Furthermore, they only provide guidance for purchasing decisions and not for environmentally friendly user behaviour. Additionally, the calculation factors for both types of indicators are dependent on the energy mix of the EU, which is changing over time. Therefore, both footprint-schemes need to be updated on a regular basis, even if there are no changes in product composition and production processes.

It is proposed to design CO_2-footprint schemes according to the following principles:

- To calculate the carbon footprint of electric and electronic equipment, EU average emission data should be applied for the product use phase. National data would lead to a situation, where the each product is rated with a different carbon value in each member country.
- It should be considered to allow credits for the use of certified green electricity. Although this could partly reduce the incentives for higher efficiency, it would help to promote renewable energies.
- Carbon footprint should not be used as standalone product information but shall be combined with information on environmentally sound use and disposal as well as information on other environmental impacts.

Quality benchmarks for environmental data sheets

Type I labels, such as the European Ecolabel (EU-flower), the Nordic Swan and the Blue Angel, are much appreciated by the consumer. The requirements for the type I labels are developed in a broad stakeholder dialogue, and cover any issues that appear relevant to the stakeholder experts. This brings in an independence from the methodological restrictions of LCAs. On the other hand, type III labels are based on an LCA covering the entire life cycle. Type III labels are usually complex and not easy to read as the presented environmental performance of the product is not set in relation to the impact of other products.

Environmental Data Sheets (EDS), as proposed by the FORCE-technology, seek to combine information of type III label with those of type I label. An important feature of EDS's is that they compare the product to the "average" product within the product group and compare between product groups. Of major importance as additional information in EDS is the potential compliance with ecolabel (e.g. European Ecolabel, Blue Angel, and Nordic Swan).

The concept of the EDS anticipates that an appropriate type I ecolabel with updated requirements exists. However, the European Ecolabel exists only for a limited number of products. Although national type I labels can be taken as reference in such cases, differences in scope and requirements of various national type I labels could alter the results of EDS. Taking the example of fax machines with thermal paper, which is not covered by the European Ecolabel, but by the Nordic Swan and the Blue Angel, it was proved that both label largely cover the same issues. However, it was seen that details of some of the requirements differ between the two labels. Therefore, it is deemed necessary to indicate in the EDS whether the product fulfils the respective requirements of both the labels. However, since the respective requirements of the Blue Angel and the Nordic Swan only slightly differ it most likely does not change the overall picture of the EDS whether one or the other label is used as reference. When referring to a type I label for another product group, it has to be carefully checked, which differences between the product groups exist and to which extent they might have environmental or health impacts.

Contents

1 Introduction

Within the EU Sustainable Development Strategy, the Commission published a "Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan"[1] to serve as a framework to harmonise the various industry and product related environmental policies. The Action Plan emphasises that several European labelling instruments of product policy, such as the European Energy Label and the European Ecolabel, which are of particular relevance to the consumers, will be revised. Furthermore, following a review of the Ecodesign Directive in 2012, the Energy Labelling Directive and Ecolabel Regulation are to be complemented "by an Ecodesign Labelling Directive to provide consumers with information about the energy and/or environmental performance of products" [EU COM, 2008 (397/3); 4].

While these initiatives aim to tap the synergies from the product-specific scientific input worked out in the EuP-preparatory studies covering various energy using products, a well synchronised review of policies and strategies also provides the possibility to align the manifold regulations and to come to a comprehensive European product policy. The key challenges, as stated in the Action Plan, involve "improving the overall environmental performance of products throughout their life cycle, promoting and stimulating the demand of better products and production technologies and helping consumers to make better choices through a more coherent and simplified labelling" [EU COM, 2008 (397/3); 3].

Generally, this process should open great possibilities to improve the existing product related legislation, to rework the partly outdated labelling schemes and to integrate further product groups and sustainability criteria into legislation. However, there are some fundamental methodological and socio-political issues that need to be addressed. For instance, there is a strong desire for aggregating environmental effects to arrive at an overall environmental performance rating. Whilst the debate on the scientific reliability of various aggregation methods continues, development of a practical approach to environmental performance ranking is sought. Furthermore, a high level of public and political awareness regarding climate change and greenhouse gas emissions provides the unique opportunity to bring forward more demanding pieces of legislation. However, the current focus on CO_2-emissions would not only provide possibilities, but also bear some risks that might as well weaken environmental labelling approaches in the future. As examples, these risks include the negligence of environmental impacts others than CO_2, a disregard of product-quality aspects and

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1 Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. See http://ec.europa.eu/environment/eussd/pdf/com_2008_397.pdf.

the distortion of competition caused by insufficiently detailed or asymmetric life cycle data.

In this context, ANEC commissioned the Öko-Institut e.V. and Ökopol GmbH as subcontractor to conduct a research study on various issues related to environmental labels and declarations, which are of particular relevance to the consumers. The issues involve: (a) the usefulness of life cycle assessment methodology for product labelling schemes (chapter 2), (b) feasibility of aggregation approaches, such as EcoGrade and Eco-indicator, for assessing the environmental performance of products (chapter 3), (c) inclusion of qualitative indicators not covered by the LCA-methodology (chapter 4), (d) the advantages and disadvantages of energy versus CO_2-indicators (chapter 5), and (e) quality benchmarks for environmental data sheets (chapter 6). The purpose of the research will be to support ANEC and its member organisations in their position finding processes and to enable them to shape the upcoming discussion processes on these issues.

2 Life Cycle Assessment (LCA) – Usefulness of the approach for environmental Labelling

2.1 Pros and cons of LCA for environmental labelling

The ISO 14040 standard defines an LCA as a "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle".

The following paragraph highlights those aspects of the LCA-methodology that have significant implications for its application in environmental labelling. Therefore, the following aspects provide no exhaustive list of all pros and cons of LCA in general, but rather a specific collection of issues for this specific application purpose. Thereby, it has to be noted that numerous of the undisputed positive aspects of LCA-methodology are not discussed in detail. It is presupposed that these aspects are widely known to the interested public and that a repetition of these aspects would unnecessarily overstretch the scope of this study.

The following collection of pros and cons is based on the initial position that LCA can either be used for orientation purpose in labelling schemes (screening of environmental hot spots, which are then addressed by product specific criteria) or applied to each product model under the scheme, which is currently discussed in various new attempts to display environmental product footprints (LCA-results as basis for product differentiation). Other forms of LCA-applications in labelling as proposed by Schmidt and Brunn Poulsen (2007) are discussed in chapter 2.2.

2.1.1 Pros

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.[2] In contrast, existing environmental labelling schemes focus on some selected product criteria that provide information for only selected environmental impacts in selected life cycle stages. Although these indicators are typically chosen after conducting an orientation-LCA, this approach does not account for many other environmental impacts. 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.

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

Current labelling practices almost exclusively address very narrowly defined product groups. One reason for this practice is the fact that the type of product criteria used in labelling schemes does not allow the comparison of different technologies.[3] As an example, many existing labelling schemes address the product group "desktop PCs" and conduct the product differentiation using specific criteria tailor-made for these products. Nevertheless, such labelling does not consider system alternatives like notebook PCs, which are – from an efficiency perspective – more favourable than desktops, but also feature additional environmental impacts caused by rechargeable batteries. LCA-methodology is much better capable of comparing such 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.

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2 This only applies for those environmental impacts that are covered by existing impact categories. Other environmental impacts like noise emissions or impacts on biodiversity are generally not considered by current LCA approaches (cf. chapter 3).

3 Nevertheless, there is also a principle aspect with this practice: So far, most type I and III environmental labelling schemes did not want to interfere with the consumer demand for a certain type of product. Only after choosing type, size and technology, environmental labels enter the scene to support purchasing decisions.

A topic where such function-orientated comparisons are indispensable is fuels: With the latest discussion on the advantages and problems of different kinds of bio-fuels, it is not sufficient to make comparisons for each individual type of bio-fuel, but to conduct system alternatives comparisons. This will amongst others include the comparison of Indonesian palm oil, European rapeseed oil, Brazilian ethanol, BtL[4]-fuel of the so-called second generation and conventional fossil fuel. Such comparisons are impossible to conduct without strong support from LCA.

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 systems alternatives can be generally excluded from the labelling schemes. Than for the remaining system alternatives product related criteria can be developed.

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).

2.1.2 Cons

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

[4] BtL.: Biomass to Liquid.

for a whole product life cycle makes the issue too complex to be achieved within usual time and financial resources.

A very clear example is biodiversity loss, which could theoretically be measured by monitoring the diversity of species in the sphere of the product life cycle in comparison to similar environments without the industry under research. Nevertheless, such surveys are extremely time and resource intensive and can therefore impossibly be carried out within the scope of a conventional LCA. Other examples can be found in agriculture, which has manifold interactions with ecosystems: LCA is only capable of addressing few selected impacts like water use and greenhouse gas emissions, eutrophication and acidification from energy- and fertiliser input. Issues like soil erosion, conservation of soil organic matter, biodiversity and indirect effects on other forms of land-use (leakage) cannot be dealt with in LCA with currently available methodology. In contrast, some environmental labels already manage to integrate such 'difficult' issues by formulating specific criteria to reduce this specific environmental impact of the product. Prominent examples are bio-labels in the food sector: Specific criteria for the farming practices aim to reduce biodiversity loss, soil erosion and other aspects not covered in LCA. Also in the recent discussions on bioenergy, it soon turned out that for these reasons LCA can only be one out of several tools to assess and compare the sustainability of the different forms of bioenergy (WBGU 2008).

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.

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. The health impacts of volatile organic compounds (VOC) for example do depend on several factors encompassing emissions, local (indoor) accumulation and exposure. LCA-methodology only gauges and aggregates the emissions and can therefore only yield a sketchy overview on related risks in the life cycle of products, which has then to be backed up and specified by other assessment methodologies. Another example is water use: While water use is routinely quantified in many LCAs, the information on the local environment where the water is extracted does not influence the results. Nevertheless, it makes a huge difference if water is taken from a humid region with sustainable water management, or from an arid environment facing water scarcity.

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. Although there are some attempts to tackle this problem in the field of ecotoxicity by working with typical emission-exposure scenarios (e.g. ecotoxic components of washing powder are typically emitted into the waste-water system, where further transport, treatment and subsequent exposure are principally known), this is only feasible for a small share of all toxic emissions, so that for most products, current LCA-approaches cannot exhaustively cover certain environmental impacts (for more details cf. section 3).

Variability and reliability of data

In the phase of inventory analysis, main problems are data origin,[5] 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 standard. An example is a comparative LCA of two different apples, one from New Zealand and one from a regional farm in Europe: the results are depending i.e. from the different data during the time of the year. It is likely that the apple from New Zealand is the better ecological choice during summer in Europe because the regional one is stored in a refrigerated warehouse since picked in autumn, while in winter, the European apple is the better choice due to reduced transport distances. Such problems can also arise with non-seasonal products: Due to logistical reasons, some consumer products are brought to the market by various means of transportation – dependent on the price and availability of the services. 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 an 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

[5] at best elicitation of primary data

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. Today's most recent LCA-data for electronic microchips for example date back to scientific publications from 2004 and 2002. These publications again partly refer to primary data from the years 1993-1999 (ecoinvent 2007; Williams et al. 2002). With respect to the innovation pace in microelectronics (doubling of process speed doubles every two years), this LCA-data is insufficient to gauge latest product developments and to judge on individual product models.[6] 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: Oranges for orange juice for example are usually sourced from the Mediterranean. In phases of delivery bottlenecks from this region, a likely alternative supplier region is South America, where orange production is not merely restricted to existing agricultural land but also a push factor for new land clearances. 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.

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. Notebook computers, for example, all require about the same amount of printed circuit boards, microchips and casing material. If no sit-specific data for these sub-

6 The main reason for these delays is the highly competitive nature of the industry, which leads to a low level of transparency and a widespread reluctance to publish process specific input- and output-data.

products are collected, all models to be compared will yield the same LCA-results for these sub-products. And even if only primary data is collected and used, the physical nature of these production processes makes it likely that the data are so similar that the identified differences are smaller than the error margin[7] (cf. 'Info box' below for a discussion of LCA error margins).

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.

Info box

The error margin of an LCA

There is a long and ongoing debate on uncertainties and error margins in the LCA-community. While it is undisputed that LCA-methodology has numerous sources of uncertainty (uncertainties from choices like functional unit and allocation procedure, data gaps, spatial and temporal variations, error margins of input data etc.), calculations of error margins are rarely carried out in practical applications. This is mainly due to the high complexity of the issue and the unresolved methodological debate. Reap et al. (2008) stresses that the results of an uncertainty analysis vary depending on the used calculation method, so that even quantitative error figures can be questioned.

Generally, some sources of uncertainty can be resolved by stakeholder engagement and transparency: The definition of the functional unit and the allocation procedures for example can be done jointly with major stakeholders so that the subsequent analysis is building on a broad consensus. In this case it can be argued that the error resulting from these choices is reduced to 0. Such a process has already been formalised in the establishment of Product Category Rules (PCR) that lay down the basic product specific LCA-rules within the framework of the international Environmental Product Declaration system (EPD 2008). Nevertheless, it has to be considered that for environmental labelling purposes, a complementary system would be needed to insure the consistency of the approach and the choices for all products under the scheme. Depending on the scope of the labelling scheme, this would require significant financial resources.

7 Additionally, one significant distinction might result from different energy-mixes in different production countries.

Other sources of uncertainty cannot be resolved that way. Especially uncertainties resulting from the error margins of input data need separate assessment methodologies that are less feasible in practical applications. One of the few systematic quantitative assessments of these uncertainties revealed that the most significant uncertainties result from the estimated product lifetime (uncertainties in the range of 45–75%) and the unknown end-of-life treatment (uncertainties in the range of 10–30%). Uncertainties from other input data rarely exceed 10% (Huijbregts 1998).

In reaction to these findings, LCA-practitioners routinely carry out a sensitivity analysis, which – amongst others – elaborate how strong changes in lifetime- and end-of-life assumptions would affect the final results. The results of this sensitivity analysis are presented together with the other LCA-results.

In addition, many LCA-practitioners use the rule of thumb that the error margin resulting from the individual error margins of other input data besides lifetime and end-of-life ranges around 10% for primary energy use and greenhouse gas emissions and 20% for all other impact categories – presupposing high data quality requirements. Nevertheless, these figures can be challenged by the fact that measurement requirements for the use-phase energy consumption of electric and electronic products usually allow deviations of 10% of the producers' figures. So over the life cycle of EuPs, energy and greenhouse gas related uncertainties are likely to be higher than 10%. Also for complex products that require a large amount of input data, final LCA error margins can easily surpass 10% for energy and greenhouse gases and 20% for other impact categories.

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.

2.1.3 Summary and conclusion

Sections 2.1.1 and 2.1.2 show that LCA features some distinct advantages and disadvantages for environmental labelling.

First of all it can be noted that LCA is indispensible in the initial phase of environmental product labelling. Although LCA cannot give an exhaustive analysis of all environmental impacts of a product, the life cycle approach enables a good overview on the occurrence of some key impacts like the emission of greenhouse gases and toxic substances. Based on these orientation-LCAs and other risk assessment methodologies, further labelling criteria can be developed.

Nevertheless, within the emergence of various product footprint schemes, the application of LCA is increasingly discussed for product model differentiation itself, which brings some additional methodological challenges: First of all, the fact that LCA does not account for unquantifiable issues like biodiversity and soil erosion and does also not sufficiently address site-specific impacts that depend on more factors than just the inputs and output of a system. Two examples are mentioned: The emissions of volatile organic compounds and the use of water. The severity of both impacts depends on the local situation, which is not accounted for in LCA. For this reason, LCA cannot replace other product specific assessment methodologies.

For the application in narrowly defined product groups, it seems unlikely that LCA for product differentiation provides significant added-value: Since product design and production technologies are usually quite similar, the only differentiating features will mainly result from issues already addressed by traditional labelling schemes and the differences in the national energy-mix. This situation changes with wider defined product groups: While currently there is no labelling scheme that compares desktop and notebook-PCs with the same set of criteria, this could be achieved by integrating LCA-results into labelling criteria. Another example is fuels: In order to make sound judgements on the sustainability of biofuels, it is not enough to differentiate between different batches of one sort of biofuel, but to compare between the various system-alternatives. Nevertheless, even in such cases the application of LCA seems more promising for extended orientation purposes: As worked out for a proposed directive to safeguard the sustainability of biofuels in Germany, this could be achieved using standard LCA-values for every major sort of system-alternative. With this approach, the $CO_{2\text{-eq}}$-emissions of every batch of biofuel seeking tax abatement would be calculated using preset default values. This default values can only be replaced by delivering well compiled and plausible primary data[8] (cf. Table 1) (Bundesregierung 2007).

Table 1 Preset default values to calculate greenhouse gas emissions of major types of biofuels (table incomplete), Source: Bundesregierung 2007

Biofuel	**Ethanol**				**Biodiesel**			
Biomass	**wheat**	**corn**	**sugarcane**		**rapseed**	**soy**		**palmoil**
Origin	Europe	North America	Latin America	Europe	Europe	Latin America	North America	SE Asia
Direct land-use change	26.2	19.8	158.8	15.6	32.8	289.6	54.5	112.8
Production	22.3	17.8	19.5	11.3	29.1	289.6	54.5	112.8
Transport	0.7	0.7	1.5	1.7	0.4	0.5	0.5	0.1
Processing step 1	–	–	0.8	6.6	7.6	7.3	9.2	6.9
Transport between process steps	–	–	–	–	0.2	3.8	3.4	4.3
Processing step 2	34.3	25.0	1.0	48.9	7.6	7.7	7.7	7.7
Transport to refinery, storage, mixing	0.4	4.8	5.5	0.4	0.3	0.3	0.3	0.3
Sum	**83.9**	**68.0**	**187.1**	**84.4**	**78.1**	**322.0**	**90.7**	**138.7**

All measures in kg CO_2-equivalents per GJ.

Further problems are rooted in the fact that many product systems and supply chains are more flexible than the LCA-databases and calculations, leading to situations where LCA-results do not necessarily represent the actual environmental impacts at a given time. This issue combined with other sources of uncertainty can also lead to organisational and legal problems: It has to be kept in mind that environmental labelling has significant impacts on the success or failure of products.

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8 The results are then compared to those of the fossil system alternatives (gasoline, diesel). According to the draft directive, biofuels should only be supported by tax abatement if greenhouse gas emissions are 30% below those of the fossil alternatives (40% starting from 01.01.2011). Although the directive was approved by the German Cabinet in December 2007, it is now up to the European Commission to come up with an EU-wide regulation on this issue.

Therefore, companies will take high efforts to make the most out of such product ratings. Ideally, they will improve their products and provide well compiled data to the labelling scheme administration, but it cannot be ruled out that some parties will use less constructive means to achieve their goals.

Taking all these aspects into account, it can be concluded that LCA has some considerable weaknesses for application in product model differentiation. Therefore, it should carefully be considered if these weaknesses are outbalanced by its advantages and whether it is worth to extend an existing labelling scheme by criteria that refer to LCA-based (threshold-) values. Generally, it is believed that for most of the current labelling schemes, the potential gains do not outweigh the described efforts and risks. This is especially due to the fact that most existing labelling schemes have an individual set of criteria for each narrowly defined product group, a situation where LCA cannot provide any added-value for product differentiation. Nevertheless, there is an increasing tendency to introduce footprint schemes aiming at a higher comparability between system alternatives and different product types. These schemes are primarily focused on greenhouse gas emissions and have an inherent necessity to apply LCA-methodology. Although these schemes can also be questioned in terms of completeness and informative value, they are a main reaction on the ongoing public and political debate on global warming and will soon form an additional type of product information. Therefore, the methodological challenges cannot be pushed aside but in turn need further attention in order to come to a quick standardisation for applications in product footprint.

2.2 LCA and comparative product assessment: selectivity possible?

In the following chapter it is analysed whether it is from a methodological point of view feasible to integrate normalised LCA-result of various product groups into environmental data sheets as this has been proposed by FORCE-Technology consultants (Schmidt and Brunn Poulsen 2007).

2.2.1 Background

On behalf of ANEC, FORCE-Technology made a proposal for a new way of communicating environmental information by using so-called Environmental Data Sheets (EDS). Amongst various environmental characteristics of the product addressed by the EDS, it was also envisaged to provide easy-to-understand information that informs consumer on environmental impacts of the product type in question, in relation to other products. As outcome, FORCE-Technology proposed a methodology that is based on LCA-results for average product models of various product group and that are normalised using average annual environmental impact of a European citizen. With this normalisation, the LCA-results for each impact category are transformed into the unit “milli Person Equivalents” (mPE), which then form the basis for a colour-matrix that enables a comprehensive overview on this cross-product-group comparison (cf. Figure 1).

Nevertheless, in the light of the issues discussed in chapter 2.1.2, there is the need for a feasibility study addressing the question, whether the reliability of LCA-results allow such a differentiation. Therefore, the following chapter 2.2.2 analyses the implications of the findings from chapter 2.1.2 for this specific LCA-application. Conclusions and recommendations are presented in chapter 2.2.3.

Table 3
Normalised life cycle environmental impacts of different products

	Energy Consumption	Global warming	Acidifi-cation	Eutro-Phication	Waste	POCP
Energy-using products						
Dishwasher	20,6	15,9	10,9	29,9	1,7	
Television	9,7	7,6	5,0	0,0	0,6	
PC	23,1	19,3	13,2	0,2	4,7	
Fridge-freezer	22,9	18,0	12,2	0,2	2,7	
Mobile phone	0,9	0,8	0,7			0,2
Building products						
Sealant[1]	0,3	0,3	0,2	0,1	0,1	
Wood flooring[2]	12,2	2,9	6,0	5,7		39,2
Insulation[3]	0,7	0,9	0,9	0,5	1,7	1,0
Comparison product						
10 km in an average car	71,8	82,6	15,4	58,5	3,8	104,2

Environmental impact in mPE	Concern level
≤ 0.1	Almost insignificant
0.1-0.5	Very low
0.5-1	Low
1-5	Some
5-20	Significant
20-50	High
> 50	Very high

Figure 1 LCA-based cross-product-group comparison as proposed by Schmidt and Brunn Poulsen (2007)

2.2.2 Key issues affecting selectivity

Accuracy of LCA-results

As discussed in chapter 2.1.2, LCA has some severe practical limitations for routinely application in product labelling. These problems mainly result from varying environmental impacts due to temporal and spatial variations in the product life cycle (changes in logistics, variations in supply chains etc.) and the difficulties to differentiate between relatively similar product models.

For the proposed application in EDS, these problems are much less significant, since the aim is not to differentiate between product models of one product group, but to establish comparisons between typical models of different product groups of our daily lives. With this focus, an LCA would be much less dependent on product model specific primary data. Instead, widely secured average data – as compiled in the generic datasets – would be preferable, since they are more representative and therefore better meet the goal of calculating the environmental impacts of an average product.

The problems of temporal and spatial variations are also less significant: In order to achieve representativeness, an LCA would have to be based on average regional data. Taking the examples of oranges for juice production used in chapter 2.1.2, this means that it would have to be analysed where oranges for juice sold in the EU are produced or imported from. The resulting market shares would complete the information basis for the impact assessment. Although this approach cannot fully anticipate future shifts in market shares, it can be presumed that such shifts are much more gradual than the potential shifts in supply chains of individual companies. This can again be visualised be the orange-example: While it is possible for one juice-producer to completely switch sourcing from one region to another, this is impossible (or at least very unreasonable) for the whole orange-juice industry. Therefore, temporal and spatial variations play a less important role in LCA for EDS so that they can be dealt with in periodical updates.

After all, for many product groups, the most significant uncertainties will result from calculations that are based on consumer behaviour in the use-phase and product disposal. The environmental impacts of energy-using products like TVs and computers for example, largely depend on consumer behaviour. Questions like "how long is the device used daily?" and "is the equipment switched into stand-by or off-mode after use?" are much harder to answer than questions around the technical details of a product life cycle. The same holds true for end-of-life stage of products containing hazardous substances: While there are sound recycling and disposal systems in place in the EU, there is limited knowledge on exact waste streams and the question how many consumers really use the official collection schemes.[9] The necessary assumption on such issues will undoubtedly lead to significant uncertainties in the results.

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[9] The lack of knowledge results amongst others from the difficulties of measuring the collection rate of hazardous product waste. This collection rate is usually calculated using the theoretical and actually registered waste volume of a certain type (e.g. refrigerators, mobile phones). Thereby, the theoretical waste volume is based on sales figures and the average product life time. This calculation method ignores the fact that many products are not immediately discarded after the end of the use phase but often stored away in private households or reused within or without the EU.

Issues around defeasibility

As laid out in chapter 2.1.2, uncertainties in LCA can lead to complaints and legal disputes between (apparently) disadvantaged parties and the labelling scheme. Nevertheless, this issue is more important for LCAs used for product model differentiation, where product labelling interferes with the competition in one product group. For cross-product-group comparisons, appeals and disputes from individual producers seem less likely.

Despite this, there is the need to predefine a uniform approach for all LCAs carried out for the comparison. Besides aspects already described in ISO 14040 and 14044, this should encompass the issues of system boundaries, data requirements, allocation rules and stakeholder engagement. Such a common LCA-approach would also help to deal with the problem of excluded inputs and outputs that lack significance for the overall results. By applying a uniform standard for the sensitivity analysis it can be assured that data gaps are kept to an extent that still allow comparability.

Significance of impact categories

As discussed in chapter 2.1.2, LCA does not cover all environmental impacts, which is due to the fact that some of the impacts cannot be quantified or sufficiently addressed by the current form of quantification. These problems are to a large extent inherent to LCA and therefore do not depend on the field of application. For all applications, it has to be kept in mind that LCA is not an all-round methodology for all environmental impacts. Depending on the research question, LCA has to be completed by other assessment methodologies.

Nevertheless, the EDS as proposed by FORCE-consultants leaves room for additional text information that can further specify the product specific environmental impacts and the underlying assumptions.

2.2.3 Conclusion and recommendations

The proposal by FORCE-consultants on how to carry out cross-product-group comparisons for environmental data sheets (EDS) appears reasonable and methodologically feasible. Especially for such comparisons of products with very different environmental impacts across the life cycle, an LCA-approach seems indispensable. The problems addressed in chapter 2.1.2 are no major obstacles for this form of application and are believed to be manageable with reasonable efforts. Therefore, a uniform basis for carrying out the various LCAs is of special importance and should be given high priority. Within this process, also questions relating the involvement of stakeholders should be considered. Generally, the currently running EuP process can be seen as a positive example on how to integrate scientific input – including its uncertainties – in complex product policy without ignoring the position of different stakeholder groups. The EuP process is based on the Eco-design of Energy-using Products Directive (2005/32/EC) that provides the framework for product specific eco-design requirements of energy using products (EuPs). While the Directive only provides a framework to establish eco-design requirements, such requirements are developed on the basis of product specific 'preparatory studies' and then laid down in 'implementing measures'. In order to come to incontestable implementing measures, the process follows a quite unique series of steps that guarantee a common scientific methodology and an ongoing stakeholder involvement. Following this approach, a cross-product-model comparison for EDS would need the following steps, which should each be accompanied by stakeholder consultations:[10]

- working out of a common LCA-approach including method of normalisation;
- selection of product groups to be compared against each others;
- carrying out of the LCAs and the normalisation.

Thereby, it has to be kept in mind that LCA-results are always dependent on decisions like the definition of system boundaries, the data requirements, the allocation rules and certain assumptions (e.g. on user behaviour) so that there is no such thing as an 'absolutely right'. Taking advantage of a structured approach as laid out above will not change this fact fundamentally but will create a situation where these decisions are not taken by one individual party alone, but broadly discussed and agreed upon. Therefore, a constant stakeholder engagement is recommended to guarantee a high level of acceptance and to insure that the final results cannot be easily challenged by individual interest groups.

[10] It has to be added that the EuP process is quite complex and therefore endowed with considerable resources. The proposed approach for cross-product-group comparisons for EDS is by far less ambitious so that less process steps are needed. Furthermore, time and monetary resource needs are comparably lower.

3 Methodologies for aggregated evaluation of environmental product performances

3.1 Introduction

The process of performing an LCA can be split in four phases – (1) Goal and Scope Definition, (2) Inventory Analysis, (3) Life Cycle Impact Assessment (LCIA), (4) Interpretation. Having defined the goal and scope of the LCA (phase 1) and having inventoried input / output data (phase 2), an impact assessment (phase 3) is carried out. The LCIA aims at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system.

As specified in ISO 14044, it is recommended to follow three mandatory steps to assess the impact of the inventory data:

- Selection of impact categories, and characterisation methods and models;
- Linkage of inventory data to particular LCIA category indicators and impact categories (classification);
- Determination and/or Calculation of category indicator results (characterisation)

The impact categories need to be selected carefully and dependent on the specific LCA. To do so, issues of environmental concern are defined (so-called endpoints; e.g. biodiversity or aspects of human health). Following the cause-effect chain from the inventory (e.g. water pollution) to the endpoint (e.g. local diversity of fish species), so-called midpoints (e.g. ecotoxicity) aim to aggregate inventory data. The selected impact categories link the inventory data with at least the midpoints and – in case the cause-effect chain can be clearly described – to the endpoints of the LCIA.

For each impact category an appropriate category indicator as well as an impact indicator unit needs be defined. For several impact categories these indicators and units are widely accepted and in use. Example: for the Global Warming Potential (GWP) the impact indicator usually is CO_2 equivalents measured in kg.

The following steps of interpretation are optional (according to ISO 14044) and methodologies are not (yet) as well established as for the mandatory elements.

Within the step of normalisation, the results of the inventory (LCIA profile) are set into relation to a reference point. Thereby, for each impact category, the magnitude of impact of the analysed product (system) is calculated as a fraction of a standard system. For example, the GWP of the product system is set into relation to a total (real or targeted) emission of greenhouse gases in Europe.

The next (optional) steps of grouping and weighting combine the normalised results to a single conclusion. Obviously in these steps very different impacts are merged (e.g. loss of biodiversity, climate change and human health).

Although hurdles and constraints exist when defining appropriate impact categories the more controversial part of the LCIA is within the optional section aiming at interpretation of the LCIA profile.

In order to relate the magnitude of environmental impact of the product, different “scales” are used as reference points for normalisation. The major dispute, however, exists on how the impact categories are to be grouped and weighted in order to calculate an aggregated estimated impact.

The methodologies trying to solve these problems can be divided in theme-oriented (bottom-up) and damage-oriented (top-down) ones. The bottom-up-approach starts with the inventory results and tries to interpret them. This idea also underlies ISO 14040 and 14044. In contrast, the top-down approach first defines the required results such as the “environment” and the weighting of different environmental problems. The rest of the process (e.g. definition of impact categories) is set up to accommodate the best weighting procedure.

In the following one bottom-up approach (EcoGrade) and one top-down approach (Eco-indicator) are presented.

3.2 EcoGrade

3.2.1 Methodology and reference points for normalisation

EcoGrade is based on a bottom-up LCIA-methodology. The environmental impact of a product is inventoried in ten impact categories (cf. chapter 3.2.2). On that basis aggregation is performed, applying normalisation, grouping and weighting within one step.

For the step of weighting it is necessary to get information on the views of society.[11] In principal, two approaches are feasible: the first method involves relating to choices the society takes in related situations. This method is referred to as „Revealed preference approach“, and forms the basis in EcoGrade (“choices” here are the political decisions). The other method is to directly assess the views with a questioning of a representative stakeholder group. This so-called “panel approach” is applied in Eco-indicator (cf. chapter 3.3).

In EcoGrade, the various environmental impacts are weighted on the basis of socially agreed quantitative environmental targets. Each category of environmental impact is expressed in environmental target impact points (ETP) in accordance with its contribution to national or international environmental targets (depending on the geo-

[11] Questions arise like: “What is worse: the loss of species or damage to human health?”

graphical scope of the analysis). These target values indicate the emission level, to which a certain environmental impact has to be reduced. For example, for Global Warming Potential (GWP),[12] the target emission in 2010 is calculated by subtracting 21% from the baseline emissions in 1990, as determined for Germany, in the scope of burden sharing according to Art. 3.1 of the Kyoto Protocol (UNFCCC, 1997). 2010 is the average value for the envisaged target horizon (2008–2012) of the Kyoto Protocol (Möller et al. 2006). The following Table 2 explains the methodological background (reference values for normalisation, grouping and weighting) for calculating ETP for the impact category GWP.

Table 2 Methodological base for calculating ETP for the impact category – Global Warming Potential (GWP) (Möller et al. 2006)

	Characterisation Factor	Baseline Emissions 1990 [kgCO2-eq.]	Target Emissions 2010 h_y [kgCO2-eq.]
CO_2	1	1,02E+12	8.02E+11
CH_4	23	1.53E+11	1.21E+11
N_2O	296	7.78E+10	6.15E+10
H-CFC	5,47E+03	1.64E+09	1.30E+09
CF_4	1,80E+03	6.39E+08	5.05E+08
C_2F_6	1,19E+04	5.00E+08	3.95E+08
SF_6	2,22E+04	3.62E+09	2.86E+09
total		1.25E+12	9.90E+11
ETP	9.90E+11 CO_2 eq. = 1.00E+06 ETP → 1 CO_2 eq. = 1.01E+00 µETP		

In the same way, environmental impacts of other impact categories, such as acidification potential (AP), eutrophication potential (NP) and photochemical ozone depletion potential POCP), are calculated (Möller 2006). The environmental target impact points of the individual impact categories are added to a total environmental burden

[12] The global warming potential represents the contribution of anthropogenic emissions to the radiative forcing or heat radiation absorption in the atmosphere and therefore a measure to express the so-called "greenhouse-effect" (CML 2001). Pollutants, which contribute to the global warming phenomenon are inventoried and aggregated taking into account their *G*lobal *W*arming *P*otential (*GWP*). The GWP denotes the pollutant impact of the different substances in relation to carbon dioxide (CO_2). As an indicator for the emission of greenhouse gases the global warming potential is expressed in terms of CO_2 equivalents. 100 years are set as the inventory period for calculating values.

(Figure 2) (this step is not in line with EN ISO 14044)[13] without any further weighting – it is assumed that all environmental targets agreed by societal consensus or legislative statute have equal weight.

	CER cumulated energy requirement	GWP	AP	NP	POCP	Aggregate environmen-tal impact
	GJ	kgCO2eq	kgSO2eq	kgP04eq	kgETHeq	micro UZBP
PF1 Building and housing	100,0	7.065	11,5	0,93	0,98	23.858
PF2 Mobility	56,5	3.959	10,9	1,26	5,39	32.640
PF3 Food	20,9	3.758	3,8	0,11	0,61	8.686
PF4 Kitchen appliances	15,6	953	1,9	0,20	0,06	3.631
PF5 Textiles	2,0	97	0,8	0,04	0,08	935
PF6 Washing machines & driers	6,1	360	1,0	0,07	0,07	1.581
PF7 Communications equipment	14,6	462	1,3	0,29	0,07	2.713
PF8 Consumer electronics	5,2	323	0,7	0,06	0,02	1.293
Total	220,9	16.977	32,0	2,98	7,27	75.338

Figure 2 Environmental impacts attributable to German households (PROSA 2007)[14]

Due to the application of internationally negotiated and binding targets, this approach considers the overall relevance of the different impact indicators and thus incorporates the elements of normalisation, grouping and weighting within a single step.

Impact categories for which no quantitative environmental targets have yet been formulated are integrated within the overall result by means of a set percentage weighting. The higher the number of points, the greater is the environmental impact.

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[13] EN ISO 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines. See also DIN EN ISO 14040:2006: Environmental management – Life cycle assessment – Principles and framework.

[14] Micro UZBP means Umweltzielbelastungspunkte which is referred as Environmental Target Impact Points (ETP) in this chapter.

3.2.2 Which information gets lost?

Though EcoGrade covers ten impact categories, the aggregation step is limited to four categories:

- A_2 Global Warming Potential (GWP),
- A_3 Acidification potential (AP),
- A_4 Eutrophication potential (NP),
- A_5 Photochemical ozone depletion potential (POCP).

The other six categories are excluded:

- A_1 Cumulative Energy Demand,
- A_6 Ozone depletion potential (ODP),
- A_7 Waste accumulation (WA),
- A_8 Water Use (WU),
- A_9 Land Use (LU),
- A_10 Hazardous substance potential (HSP).

The reason for excluding these categories is that they are difficult to quantify or difficult to operationalise:

For the *Cumulative Energy Demand* (A_1) no politically accepted reduction targets existed when developing EcoGrade 2.0. Since this changed during the past years, in a revision of EcoGrade this category might be included in the step of aggregation.

The target for *Ozone Depletion Potential* (A_6) is set as zero, i.e. the aim is to eliminate substances which have the potential to destroy ozone gas entirely from the market. Calculating a portion of this target is not possible.

Waste accumulation (A_7) is not included for aggregation since clear reduction targets are missing and the environmental impact is highly site specific.

The environmental impact of *water use* (A_8) is highly dependent on the condition at the location (dry area vs. area abundant with water).

For *Land Use* (A_9) the major problem is that data for this category are not consistently gathered by the inventory tools. Therefore, including this category in the aggregation step would lead to unbalanced results.

Within *Hazardous substance potential* (A_10) the impact of thousands of substances are subsumed. Therefore, no common reduction target is available.

The information of the impact in these categories therefore is lost and aggregation might result in misleading interpretations when the product has important impact in one or more of the neglected categories.

Neglecting the category of Cumulative Energy Demand (CED) is in many cases acceptable, since energy use of fossil resources is also taken into account in the category Global Warming Potential (GWP).

Among the impacts difficult to quantify are those related to the use of chemicals. Whilst some are considered (e.g. in the category POCP), Ozone depletion potential and hazardous substances potential are excluded. Since products may or may not contain more or less hazardous substances the latter category needs particular attention.

Taking these shortcomings into account results from aggregation with EcoGrade are always accompanied with additional information for all impact categories.

3.3 Eco-indicator

Eco-indicator[15] is a tool for performing an LCIA using the top-down approach. It starts by defining the damage a product might cause. The following environmental damage categories were defined:

- Damage to *Human Health* :
  DALY (Disability Adjusted Life Years): respiratory and carcinogenic effects; effects of climate change, ozone layer depletion, ionising radiation;
- Damage to *Ecosystem Quality* :
  Percentage of species that have disappeared in a certain area due to the environmental load (ecotoxicity, acidification / eutrophication, land-use and -transformation);
- Damage to *Resources*:
  quality of remaining mineral and fossil resources.

[15] cf. www.pre.nl/eco-ind.html.

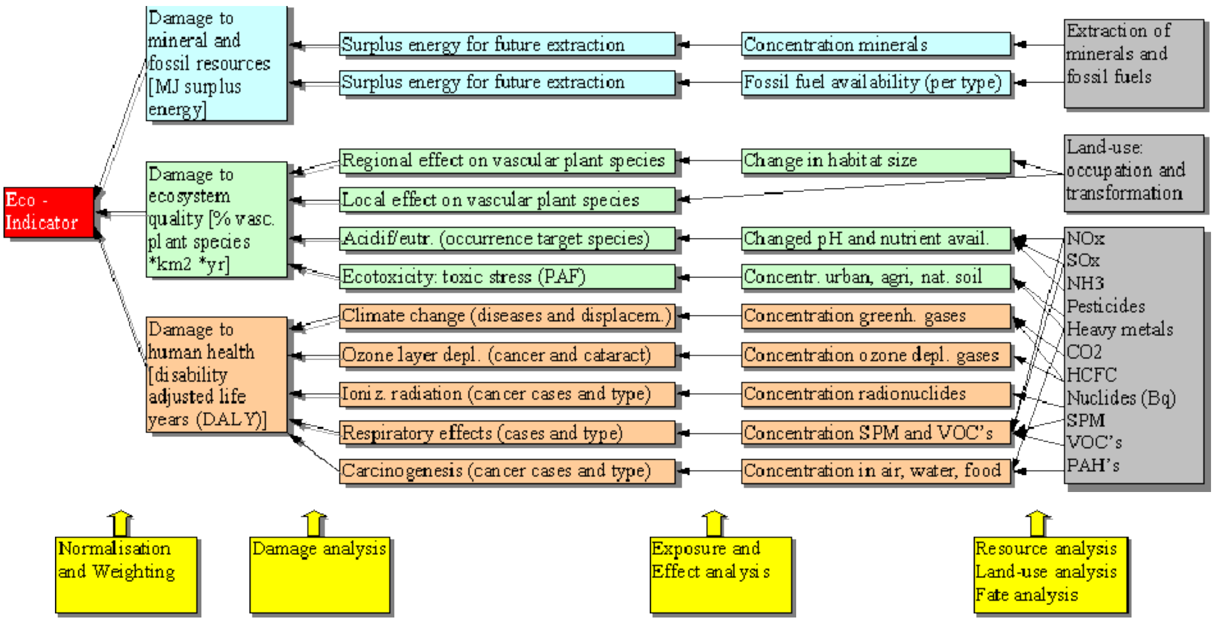

Figure 3 Diagram explaining the approach of the Eco-Indicator

For the purpose of providing weights to the identified three damage categories, Eco-indicator used the panel approach. A questionnaire had been developed and spread via a discussion platform on LCA. The recipients were presented the damage categories described above and were asked to weight and rank them according to their importance. The three damage categories were weighted by the panel as follows (Table 3):

Table 3 Average weights of the damage categories of the Eco-indicator method

	Mean	Rounded	St. Deviation	Median
Human Health	36%	40%	19%	33%
Ecosystem Quality	43%	40%	20%	33%
Resources	21%	20%	14%	23%

This weighting of damage categories is set as a basis for the calculation in Eco-indicator. It is, however, possible to perform calculations with other weightings depending upon the archetypes of societies, i.e. different attitudes and perspectives related to different societies. Three different perspectives depending on the archetypes defined in the cultural theory of Thompson (1990) have been described (Table 4) to demonstrate the possible differences in the overall result.

Table 4 Archetypes of societies

Perspective	Time view	Manageability	Level of evidence
Hierarchist	Balance between short and long term	Proper policy can avoid many problems	Inclusion based on consensus
Individualist	Short time	Technology can avoid many problems	Only proven effects
Egalitarian	Very long term	Problems can lead to catastrophe	All possible effects

The following weighting percentages (Table 5), depending on the perspective of a society, are used for the three damage categories.

Table 5 Weighting percentages for each perspective for the three damage categories

	Hierarchist	Individualist	Egalitarian
Ecosystem Quality	37.7%	25.9%	47.4%
Human Health	30.2%	53.0%	32.6%
Resources	32.0%	21.0%	20.0%

Damage factors per unit of resource extraction, emissions and land-use are calculated and corrected to normalised factors and finally to weighted damage factors.

Such damage factors are given for

- *Human Health* (carcinogenic effects, respiratory effects caused by organic substances, and by inorganic substances, damages to health caused by climate change, effects caused by ionising radiation, effects caused by ozone layer depletion);
- *Ecosystem quality* (effects of ecotoxic emissions, combined effect of acidification and eutrophication, damage caused by land occupation and land conversion);
- *Resources* (extraction of minerals, extraction of fossil fuels).

3.3.1 Which information gets lost?

Uncertainties originating from the differences in the perceptions regarding the significance of certain environmental impacts put a question mark on the legitimacy of the Eco-indicator as an absolute value reflecting the overall environmental impact. Although the process of weighting and ranking the damage categories does look like an ideal transparent stakeholder process, the variability in the interpretation of damage categories by different people, experts or societies makes the results of Eco-indicator vulnerable to legal complaints.

Secondly, method of Eco-indicator is based on the assumption that causal chains linking the inventory data via mid-point indicators (such as climate change, ozone layer depletion etc) to the end-point indicators (such as damage to human health) are well established. However, data basis and logical cause-chain linkages for many categories are not homogenous and far from convincing. For example: the functional unit for the damage category – Damage to Human Health, is represented by Disability Adjusted Life Years (DALY). The DALY is a measure of overall disease burden. It is designed to quantify the impact of premature death and disability on a population by combining them into a single, comparable measure. Thus, mortality and morbidity are combined into a single, common metric reflecting the potential years of life lost due to premature death and loss of equivalent years of healthy life in a state less than full health. One DALY is equal to one lost year of healthy life. It can be calculated as: DALY = YLL + YLD; where YLL is the number of years of life lost due to mortality and YLD is the number of years lived with a disability, weighted with a factor between 0 and 1 for the severity of the disability.

Looking at the Eco-indicator, climate change, ozone layer depletion, ionising radiation, respiratory effects and carcinogenesis altogether are supposed to provide the data base for calculating DALY. Considering the issue of climate change, a number of related future health effects (tick-borne diseases, allergies causing plants etc.) are hard to predict because the reaction of nature to climatic changes has not yet sufficiently been investigated. Secondly, it is impossible to take adaptation strategies to climate change into account as they evolve. Although many assumptions and indirect reference data such as heat related casualties of elderly people in 2003 in Europe or heat induced hospital admissions in Europe or Global Climate Risk Index developed by German Watch can be used, uncertainty related to the actual number of heat related health problems, costs of ambulant treatment and damage by natural disasters remain very high. Furthermore, it stays unclear how data on events of one year can be causally linked to the damage in the subsequent years. For instance, how a gradual increase in the drought-proneness of various regions or frequent floods due to climate change, and hence loss of land productivity, consequent food crisis, out-migration and displacements will be quantified and contribute towards calculating the total loss in healthy life years when the actual phenomena of climate change affecting human health has not yet been empirically and systematically agreed upon in the scientific community.

Furthermore, it is still a matter of widespread discussion how climate change affects flora and fauna, and hence damage ecosystem quality. In Eco-indicator approach, however, the causal linkage between climate change and the damage category “Ecosystem Quality” is missing. This is probably due to a methodological limitation which foresees that any impact category is linked only to one damage category (e.g.

climate change to human health) in order to avoid double-counting. The functional unit of the damage category “Ecosystem Quality” – potentially disappeared fraction (%) of vascular plant species per km^2 per year – is deemed to be effected directly or indirectly by climate change phenomena, and hence should be linked somehow.

The above mentioned examples illustrate that persistence with a methodology which is inflexible in its application, for instance with its fixation on a functional unit, rigid cause-chain linkages and inconsistent data base, could result in a loss of important information which may be key to estimate true environmental burdens of products, services or systems.

3.4 Requirements on aggregation methodologies

Interpretation of LCIA profiles highly depend on views of the person performing this interpretation. Therefore, the following requirements should be met by any aggregation methodology:

- the method needs to be transparent;
- categories need to be defined broadly enough;
- aggregated information should never be presented as stand-alone information but should always be accompanied with additional information for individual categories.

The above mentioned points hold true for the step of weighting as well as for establishing objective quality criteria necessary for the critical review. Since, both weighting and critical review, can be subjective and depend upon the professional experience of the experts executing them, they can not be said to be true or false. It is, therefore, recommended to carry out the steps of weighting and critical review in an interactive manner, involving not only people from the LCA-community but also important stakeholders, such as consumer organisations, environmental NGOs and independent research institutes. Especially for the aspect of critical review, it is suggested to apply an integrated 3-step simple peer review. This would specifically mean that any aggregation methodology should be reviewed and revised during or after

- the goal and scope definition;
- the data collection;
- the conclusion.

The major advantage of such an approach would be that problems and conflicts can be corrected and addressed at an early stage, thus making the methodology more legitimate. Another important point to consider would be to define, again in a broader stakeholder platform, the so called Key Performance Indicators (KPI) for each product group, service or system for the purpose of product comparison.

Finally, it is recommended, as also mentioned in EcoGrade methodology, to supplement the aggregated information with additional information on all other impact categories and environmental impacts if they are relevant for a certain product, service or system, or have been identified as KPI.

4 Qualitative / semi-quantitative indicators in product assessment / environmental labelling: focus on environment and health

Generally, there is a broad consensus on the inclusion of those environmental aspects in LCA that cause significant damage to the environment and health. Such aspects include – air pollutant emissions, water discharge, resource consumption, energy use, solid waste production etc. There are myriad methodologies, such as EcoGrade, Eco-indicator, and MIPS etc., to map, calculate and model such aspects quantitatively throughout the life cycle.

Critics have been consistently questioning the comprehensiveness and reliability of an LCA-based system of imparting environmental information for the purpose of estimating the true environmental burden of a product. Such an approach, which leads to the process of product labelling (e.g. ecolabel criteria) and environmental product declarations (EPD), seems to ignore those environmental aspects whose availability in general and integration in the LCA-methodology is difficult. For this reason, many important aspects, mostly qualitative and semi-quantitative,[16] but also some quantitative have been left out. Biodiversity loss, noise, particles, risk assessment of direct exposure to chemicals and radiation, are few examples. In some of these cases, as for instance for the aspect of noise, it is methodologically possible to quantify and aggregate the noise emission levels expressed in Decibels [dB(A)].[17] However, aggregation of noise emissions (using the LCA-methodology) at the company level during production, transport and use makes little sense because it is the local concentration of noise which leads to a significant effect. Empirical evidence

[16] In this study the term semi-quantitative is used for environmental impacts that – from a scientific base – are quantifiable, but due to severe constraints in data availability and insurmountable hurdles in life cycle related data collection cannot be dealt with quantitatively in LCA practice.

[17] The noise disturbance increases with the intensity of the undesirable noise emission. The most important assessment factor for the evaluation of noise emissions is, therefore, expressed as the acoustic pressure, measured with the help of a microphone. The noise pressure level is measured through the conversion of the acoustic pressure in the logarithmic decibel scale, and is expressed in Decibels d(B). Mostly, the noise emission is calculated using the A-curve, which provides an adjusted assessment of the human hearing properties at different pitch values. The noise pressure level is then expressed in d(B)A. In principal, this value provides an approximate correlation with the human perception of different noise levels.

suggests that noise emissions from different sources (such as industry, traffic, sports) at the same equivalent continuous noise level do not always produce the same impact (State Office for Nature, Environment and Consumer Protection, North Rhine-Westphalia, 2008).[18] For instance, a certain noise level at a busy and intensively used shopping street would be acceptable, whereas the same noise level in a residential area would be unacceptable. Secondly, according to the EU-Directive 2002/49/EG and number of measurement guidelines (VDI 2571, VDI 2714, VDI 2720, DIN ISO 9613-2 E), the intensity of noise covers only one-third of the total impact of noise emissions. The further one-third of the total impact is calculated by considering the sociological factors, while the causing factors for the remaining one-third of the total impact are unknown. LCA-methodology, which seeks to aggregate the emissions using a functional unit approach (e.g. dB(A) noise emission per kg of the product), can not integrate the local differences and variations in sociological perceptions. The same holds true for toxic effects. The release of formaldehyde from a wood based panel outdoors will have a relatively lower toxicity impact than when it is released indoors. The overall (aggregated) release of formaldehyde per functional unit (e.g. using 1 m^2 of a wood product with defined function for a defined period of time), which does not consider the aspect of local concentration, will therefore produce an incomplete and biased assessment.

Furthermore, debate continues on the inclusion of those indirect and “faraway” environmental impacts that are not necessarily attributed to the main product, but could emerge as a result of the incorporation of other sectors / industries in the end-product. For instance, analysis of a cotton shirt containing brass buttons. Some LCA-experts would, based on certain threshold values, such as the total weight of brass buttons with respect to the total weight of the shirt, include / exclude brass buttons from the analysis. On the other hand, others would always tend to integrate the brass buttons in the analysis, considering significant environmental impacts during the raw material extraction (copper, zinc) for brass buttons.

Moreover, type of consumer behaviour in the use phase could also be pivotal in estimating the true environmental impact of a product. For example: while the environmental impact of PCs in the use-phase can be estimated by applying numerous assumptions, the true estimation will depend upon how individual consumers handle this equipment, as for instance, use in the stand-by modus, installation of energy-consuming screen savers etc. Thus, the critics argue that many LCA-studies are generally not cradle-to-grave studies as they rarely cover all stages and actors throughout the life cycle. Additionally, the criteria for the selection of environmental

18 http://www.lanuv.nrw.de/geraeusche/grundlagen3.htm. Accessed: 15.09.2008.

aspects seem to be too much focussed on the availability of data, rather than on the extent of environmental impact.

The wide disagreement on the selection of the most important environmental aspects and impact categories in LCA can be attributed, apart from cost and time constraints, to three main reasons – (1) limitation of LCA-methodologies to capture other important environmental aspects (2) different "world-views" and sensitivities of the experts, societal preferences and values, and (3) inability of the LCA-experts to agree on a well accepted methodology to quantify such aspects, and integrate them in the LCA-methodology.

Thus, realising the limitations of the LCA-methodology (ISO 14040, clause 5.4.3) in assessing the true environmental burden of a product, ISO 14025 has introduced the requirement for additional environment information.[19] Furthermore, the emphasis has been laid on the need to cover the complete life cycle of a product, and the obligation to involve consumer and environmental interest representatives in the development of type III declarations (also referred as Environmental Product Declaration – EPDs). In the same way, ISO 14044, clause 4.4.5, calls for additional environment information in case of "comparative assertions" (environmental claims regarding the superiority or equivalence of one product versus a competing product that performs the same function) disclosed to the public.[20] Likewise, the need to include significant indirect environmental aspects in the corporate environment management system has been emphasised in the Annex VI of EMAS II (Nr. 761 /2001).

Consequently, coverage of other significant environmental aspects not dealt with in pure LCA-based methodologies (as for instance in EPDs), becomes a key requirement for achieving the overall goal of environment labels and declarations, i.e. to encourage the demand for, and supply of those products that cause less stress on the environment, through communication of verifiable and accurate information that is

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[19] Although ISO 14025 provides a list of possible additional impact categories, this list is not mandatory. Generally, this means that each company may choose a different list of impact categories, thus limiting comparability between EPD programmes and/or product groups. More difficult environmental issues, such as biodiversity impacts from land use, injuries, and toxicity, have often been neglected in current LCA practice, which means that the impact categories that are included in current EPD programmes are not necessarily chosen for their environmental importance, but rather for their availability. Thus, it will be important to define generic and sector specific minimum performance requirements in order to differentiate good performers from bad ones and of course to highlight the products with excellent performance.

[20] Apart from presenting additional environmental information for the purpose of comparative assertions, it is extremely necessary, especially in B to C context, to present this information in an easily understandable manner. Current EPDs include environment data for a number of environment impact categories, typically in tabular form, but no information is provided on whether the scores are high or low compared to other similar products.

not misleading, thereby stimulating the potential for market-driven continuous environmental improvement. Quite clearly, effectiveness of such standards will require that the environmental performance of products, systems and companies is based on a well-established set of criteria and guidelines, and is NOT evaluated only on the basis of widely used indicators from LCA-studies where no clear benchmarks or scales are provided. Rather, a democratic process involving balanced representation and decision-making should build the basis for any meaningful environment information scheme, which combines elements of all types of environmental declarations in a systematic manner.[21] The next step should be to define generic and sector specific benchmarks and minimum performance requirements, based on the documents citing best industry practices, ecolabel criteria for products, current developments in the legislation (e.g. in RoHS directive) etc.

Development of the Environmental Data Sheets (EDS) as suggested by the FORCE Technology study (chapter 2.2), and suggestion of a generic minimum list of mandatory impact categories,[22] as proposed by Christiansen et al. (2006) support the demand for additional environmental aspects. It can be noticed that suggestions for some of the important environmental aspects mentioned in both the studies can not be covered using the standard LCA-methodology. Here, there is a need to strongly favour the line of thought expressed in ISO 14025 on “additional environmental information” and use of other instruments than LCA to measure and present the true environmental burden of a product in EPDs. However, even the ISO 14025 gives a large degree of freedom with respect to what environmental impact categories and information can be included under headings such as "life cycle inventory analysis", "life cycle impact assessment" and "additional environmental information". While this gives high flexibility in preparation of the Product Category Rules[23] and good opportunities to adjust the presentation format to the specific product groups, it reduces the comparability of different products (Christiansen et al. 2006).

The question is, how the current basis for product labelling and environmental product declarations can be expanded and elaborated so that – (1) true environmental burdens of a product can be accurately estimated; (2) proper and measurable benchmarks to facilitate product comparisons are set; and (3) consumers are

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[21] For example, options for combining Type I, II and III label criteria or different information systems, such as EMAS, Eco-Label and EPDs for product assessment should be explored.

[22] (1) nature occupation; (2) global warming; (3) acidification; (4) nutrient enrichment; (5) photochemical ozone formation; (6) human toxicity; including particles and carcinogens; (7) injuries.

[23] Product category rules (PCR) set of specific rules, requirements, and guidelines for developing Type III environmental declarations for one or more product categories [ISO/FDIS 14025].

provided with comprehensive, but easy-to-understand product information to facilitate sustainable purchasing decisions.

As the basic methodological procedure of LCA, i.e. goal and scope definition, life cycle inventory, life cycle impact assessment and interpretation of results, has proven to be a useful stepwise approach for encompassing and assessing various environmental aspects, we suggest persisting with same procedure. However, considering the numerous problems inherent to LCA-methodology, as mentioned in chapter 2 and in the section above, the next sections proposes some key changes, adaptations, additions and extensions in the methodology stipulated to design the basis for product labelling and declarations.

4.1 Methodology for the possible integration of qualitative, semi-quantitative and other quantitative information in product assessment

While not changing the well-established methodological structure of LCA, it is intended to provide recommendations for changes/ adaptations in each step so that more environmental indicators can be included in the product assessment. Importantly, other complementary instruments are reviewed and proposed that enable the measurement of additional environmental aspects, and facilitate their integration in labelling and declaration processes.

4.1.1 Goal and Scope of the study

The goal and scope of the study should always be formulated with the help of mandatory, collateral, third-party critical review, involving experts (such as consumer organisations) outside the LCA-community. This would ensure that the goal and scope definition is not left to the LCA-practitioners, but are rather defined in a democratic process. Moreover, such an approach would facilitate definition of the scope in such a way that “the breadth, depth and detail of the study are compatible and sufficient to address the stated goal” (ISO 14040). The aim of mandatory, collateral, third-party critical review could be to expand the system scope beyond the process chains existing in conventional LCA-models. Utilising the ISO 14044 which prescribes a list of items that need to be considered and described while defining the scope of the study, the critical review group, depending on the goal and nature of the study, could include additional items, such as (1) types of environmental aspects and impacts to be considered, (2) inventory data related to those aspects and impacts, (3) methods for impact assessment, and (4) societal preferences and values. A helpful procedure while expanding the system scope could be to, first define the ideal system,[24] then the actual system[25] to be modelled, and finally to select the processes to gather primary data for, and the processes to model with generic data. As a practical matter, ISO 14044 also states that, "the goal and scope of the study may be revised due to unforeseen limitations, constraints or as a result of additional information. Such modifications, together with their justification, should be documented."

4.1.2 System Boundaries

In defining the ideal system, it has to be accepted that even if we had an unlimited research budget and unlimited time and were omniscient, different people could still disagree about what should be included in the boundary of a product life cycle for LCA. Therefore, in order to go beyond personal and cultural subjectivity or political orientation, it is helpful to support the definition of system boundaries with proper references to international instruments. For instance, by building on the Convention on Biodiversity (CBD), issue of biodiversity loss at a far supplier level can be included in the system, if it represents a significant environmental aspect. Even in this phase, it is important to persist with the collateral, third-party critical review to achieve the legitimacy in defining system boundaries. As people's professional and personal values will determine what aspects have to be measured and modelled, it is recommended to identify and include all perceptions on relevant environmental aspects that can be attributed to a specific product, company or system (including administrative, transport, infrastructure, service inputs capital investments, supplier and subcontractor level etc.).

According to EMAS principles, the environmental aspects (article 2 paragraph f of the Regulation (EU) No. 761/2001) of the activities of an organisation lead to environmental impacts. If an environmental aspect of a product or an organisation leads to considerable environmental impacts, then this aspect has to be considered *significant*, and has to be integrated in the environment management system. The same principle should be valid for the product-specific LCA-methodologies too. Here the question arises on the criteria to decide which environmental aspects to be graded as

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[24] The processes or activities that are considered part of the idealised or total product life cycle. An example could be notebooks: a notebook contains about 1,800 to 2,000 components, which are produced by many different companies situated in different parts of the world. Ideally, all components can be included in an LCA if resources, time and personnel were unlimited.

[25] In the actual system, only those components or production processes will / shall be included that lead to significant environmental impacts. Cf. chapter 4.1.2 on System Boundaries and chapter 4.1.3 on data collection.

significant, and which as *insignificant*. It leads us to the definition of the actual system, which according to ISO 14040, specifies that the product system should be modelled in such a way that only elementary flows cross the system boundaries, i.e. that no product or intermediate product flows (economic flows) enter or exit the product system. It is suggested to apply iterative refinement to system boundary setting. Iterative refinement is recommended by ISO 14040 calling for sensitivity assessments of system boundaries during modelling (rather than after the study is done). Importantly, criteria for reducing the system boundaries from an ideal system to an actual system should NOT be based on the availability of data, as it is generally done in LCA-studies. The demarcation of the system should be strongly based on the criteria of damage potential, i.e. all environmental aspects that cause significant environmental damage (based on threshold values) should be included.

One of the approaches to focus on *significant* unit processes and environmental aspects could be to conduct a hotspot analysis. The hotspot analysis will have to be based on an initial analysis of the environmental impacts of the products and will identify the important aspects using a variety of different tools. This could include desktop screening, internet research, literature surveys, interviews as well as multistakeholder expert judgement to determine for which unit process hotspots are found and hence prioritise where data needs to be collected on-site. Hotspots assessment also provides information about where it is more likely to find controversies and where more effort should be allocated to study, for instance, biodiversity loss and local effects such as eutrophication. It should be possible to draft a checklist of criteria, based on the community law to select *significant* unit processes and environmental aspects or hotspots. The criteria could include – environmental damage potential, environmental sensitivity, magnitude and frequency of the environmental aspect, importance for the local community, indigenous populations, employees and consumers, and existence and requirements for relevant environmental regulations. The key point is that the definition of criteria is consistent and uniform for each product group, thus facilitating a product comparison. Secondly, criteria should be defined in such a way that it is applicable irrespective of the geographical boundaries. For instance, criteria for a production process in Germany should also be valid in China. Of course, by conducting hotspot analysis, measurement and modelling of the environmental impacts of a product or a system might be limited only to the hotspots, and not to the entire life cycle stages.

4.1.3 Data Collection

Depending upon the definition of the goal and scope of the study, and system boundaries, practitioners might have to meet a trade-off in data collection between the comprehensiveness of and concentration on the most significant data. Data on certain environmental aspects, especially qualitative and semi-quantitative ones, might not be easily available or its collection might encompass considerable costs and time investments.

As long as it is possible, it is recommended to work with generic data which could be collected from other manufacturers of the same kind of product, or from statistical offices, environment agencies, media reports or NGOs operating in the same region / country as one of the life cycle stage being studied. Quite possibly, even though generic data or reports are available for a certain environmental aspect, there is no guarantee that the data will always be in a quantitative form. If quantitative generic data related to the significant environmental aspects is not available, as for instance on the extent of biodiversity loss, exposure and noise damage etc., but if these aspects are graded as hotspots by the stakeholder groups, it is NOT recommended to leave out such aspects instantly. Rather, the approach should be to develop a realistic methodology to counter this problem. In some cases, collection of site-specific data (qualitative, semi-quantitative and quantitative) for some significant environmental aspects might be indispensable.

However, there might still be a need for prioritisation in handling the data. However, a rule of thumb could be to include at least all the hotspots and *significant* environmental aspects of the product life cycle. It will be important to define a common EU standard with minimum performance requirements/ indicators for each product group. If a mandatory common EU standard with minimum performance requirements for each product group is established and institutionalised, every product or products with similar function (e.g. PCs and Laptops) have to undergo the same assessment procedure. For instance, one of the criteria for the electrical and electronic equipments could be to assure sustainable indium extraction because 79% of the world's mine production of indium goes to the electrical and electronic industry. Similarly, manufacture of car catalysts will have to assure sustainable extraction of platinum group metals.

In order to determine *significant* environmental aspects, ideas from the ABC analysis developed by the Federal Environment Agency of Germany (Umweltbundesamt) can be embraced. The method is published in the handbook “Environment Controlling”[26] and is actually applicable to direct and indirect environmental aspects. The focus of the methodology lies in the systematic collection and evaluation of the damage potential of environmental aspects. In the adapted ABC analysis (cf. Table 6), potential damage factors for each environmental aspect can be listed, their mode of damage creation is determined and then the extent of damage is estimated through multistakeholder expert judgement, literature review, interviews, desktop screening and internet research. In this step, weighting and ranking could also be applied as the tools.

Table 6 ABC Analysis to assess the damage potential of environmental aspects

Environmental aspect	Damage factors	Damage through	ABC Analysis
Biodiversity Loss	Use of pesticides	Acidification Ecotoxicity	A. High impact due to high biodiversity loss
	Use of heavy machines	Soil Compaction Noise	C. Low impact
	Use of monocultures	Soil Erosion	B. Comparatively low impact
	Habitat fragmentation	………..	A. High impact due to high biodiversity loss
	Use of genetically modified crops	………..	………..
	………..		

Thus, using the above mentioned methodology, the essence for defining product specific minimum performance requirements, and carrying out labelling, could be to include both the “A” damage factors, i.e. “use of pesticides” and “habitat fragmentation”. Furthermore, if generic data for these damage factors is not available, it will be necessary to collect a comprehensive site-specific data.

This concept is helpful in identifying options of strategic decision-making for the companies. It is helpful in demonstrating / highlighting areas in which a company should invest in environmental friendly practices. Such an approach fosters competition among companies to engage in (voluntary) eco-innovation activities by showing how they are to be differentiated from the competitors. Secondly, the principles of above mentioned methodology emphasise to include all “hotspots” of the product life cycle

[26] Umweltbundesamt (Hg.); Handbuch Umweltcontrolling, 2. Auflage, Berlin 2001 http://www.umweltbundesamt.de/u cumulation ba-infodaten/daten/uin/index.html

in order to provide legitimate statements on its true environmental burden. This could well build the basis for product labelling, and separate good performers from bad performers (who exclude certain parts of the product life cycle). The use of conventional LCA for such a purpose is very limited, as it can't capture all environmental aspects in their totality. So, it is important to rely on other environmental tools and additional environmental information (ISO 14025), as described above.

Another advantage of such prioritisation is that time and financial constraints can be integrated in the labelling procedure. In case of demands for the inclusion of ALL environmental aspects, it might still be possible to arrange temporal and financial resources for the initial identification of best and worst performers in terms of their total environmental burden, and hence imparting an environmental label. However, monitoring and verification procedures which need to follow in order to assure compliance will also demand tremendous financial and temporal investment. Such a scenario will be extremely detrimental especially to the development and existence of small and medium-scale enterprises.

4.1.4 Life Cycle Inventory

Once the system is mapped, boundaries are set and decisions have been made about where site specific data needs to be collected and for which unit processes generic data are sufficient, practitioners can start with the main data collection. It is suggested to "triangulate" data in the case of qualitative and semi-quantitative inventory analysis. ISO 14044 requires that "a check on data validity shall be conducted during the process of data collection to confirm and provide evidence that the data quality requirements for the intended application have been fulfilled".

As discussed in the previous sections, qualitative and semi-quantitative environmental aspects, but also some easily quantifiable environmental aspects, such as noise, can not be aggregated following the functional unit approach of LCA. In such a case, it is still recommended to include such environmental aspects if they represent the hotspots (as identified and confirmed in previous steps), and appear to contribute considerably towards the total environmental burden. Such a step goes well in line with the aspect of "additional environmental information" described in ISO 14025. In the next step, appropriate methodologies and instruments to measure the additional environmental information that lies outside the scope of LCA-based approach, should be identified.

An important step in the inventory stage could be the refinement of the system boundaries. This could be done with the help of a sensitivity analysis. Sensitivity analysis is a technique to assert whether a change (e.g. the inclusion or exclusion of a unit process) to the system would change the result above a certain threshold (in quantitative sensitivity analysis a 1% or 5% change is often regarded as a significant change). Sensitivity analysis may also be performed on qualitative data, essentially estimating if the inclusion of a process would affect the overall result. Also here, it is important to discuss the proposals of a sensitivity analysis in a democratic process with the help of the collateral, third-party critical review. The initial system boundary could be revised, if required, in accordance with the cut-off criteria established in the definition of the scope. The results of this refining process and the sensitivity analysis shall be documented. This analysis serves to limit the subsequent data handling to that input and output data that are determined to be significant to the goal of product assessment.

4.1.5 Life Cycle Impact Assessment (LCIA)

Life cycle impact assessment is defined as the phase in the LCA-aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system. As specified in ISO 14044, it is recommended to follow three mandatory steps to assess the impact of the inventory data:

- Selection of impact categories, and characterisation methods and models;
- Linkage of inventory data to particular LCIA category indicators and impact categories (classification);
- Determination and/or Calculation of category indicator results (characterisation)

If greenhouse gas emission has been identified as a significant environmental aspect (or a hotspot) in a certain product group, as for instance mobility sector in the German households, by the multistakeholder expert group, then the LCIA steps (as mentioned above) could be performed easily by aggregating the CO_2 and CO_{2eq} emissions per km to estimate the GWP of the German households in the mobility sector. However, for indicators that can not be aggregated using the functional unit approach of LCA, other methods need to be identified. For instance, if the local concentration of formaldehyde or VOC emissions in indoor paints has been found to cause a significant health damage (again a hotspot), then health or chemical risk assessment should be applied, and play an important role in the product assessment which leads to labelling or EPDs for indoor and outdoor paints.

The qualitative and semi-quantitative assessment of environmental aspects may range from specific to general, depending on which level of precision is reached in the summarisation and the interpretation, which in turn is also influenced by data availability. It could include steps of basic aggregation as well as meaning assessment. A useful method could be to provide summaries and qualitative interpretations of the environment significance of the data collected at the inventory phase.

The third bullet point of the above mentioned LCIA steps related to the characterisation step can only be applied in the case of LCA-indicators, such as GWP, acidification potential etc. For non-LCA-indicators, such as noise, local emissions (indoor paints), biodiversity loss etc the characterisation step might not be possible or meaningful. Thus, it is recommended to leave out this step in case of non-LCA-indicators.

An important step, however, is the selection of the appropriate impact categories. The choice is guided by the goal of the study, expert judgement and target audience. This would imply that a description of the environmental relevance of the impact categories selected is essential for each product assessment. An important help in the process of selecting impact categories is the definition of so called endpoints and midpoints. Endpoints are to be understood as issues of environmental concern, like, extinction of species, availability of resources, aspects of human health etc. Midpoints aim to cover an environmental problem that stands somewhere between the inventory (i.e. emission) and the final damage to an area of protection. The evaluation of the impact follows a cause-effect chain from the inventory flows to at least midpoint indicators, and then optionally continuing with further cause-effect modelling to assess endpoint results. Finally, impact categories can be selected, as long as the environmental model that links the impact category to the endpoint is clearly described (classification). It is not necessary to describe this link quantitatively. The following figure illustrates an example:

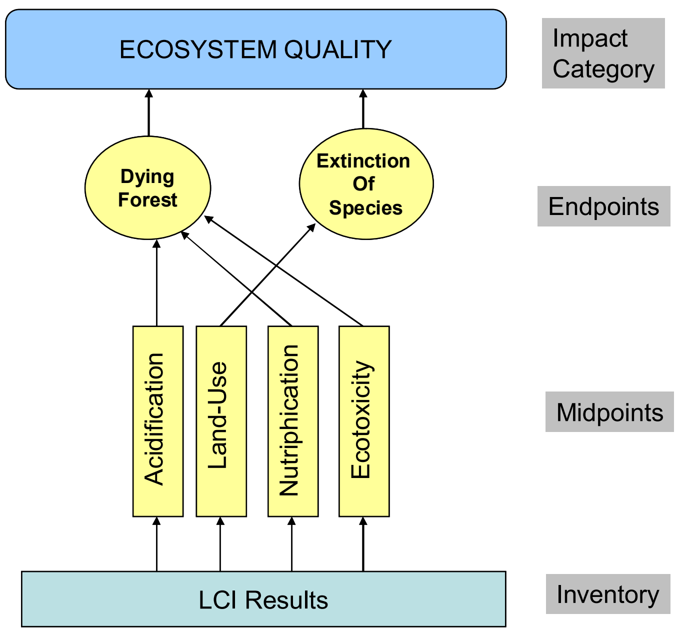

Figure 4 Selection of appropriate impact categories

Some common problems might emerge in the implementation of the above mentioned steps, if the aim of the assessment is made directly proportional to the quantification of data, and to a common functional unit. Firstly, not all LCI results will have a characterisation factor (e.g. it is well-known that the GWP of methane is 21, and that of nitrous oxide is 310 with respect to CO_2. However, it will be impossible to measure the equivalents or characterisation factors for the aspects leading to biodiversity loss and land use changes). Secondly, some cause-effect relationships are not simple enough or sufficiently known with enough precision to permit quantitative cause-effect modelling. For instance, it is almost impossible to say if a decrease in biodiversity or extinction of species is caused by the use of pesticides, fertilisers or otherwise. If certain midpoints, such as ecotoxicity is combined with other midpoints, such as nutriphication or land-use, a double count can be introduced which might lead to wrong aggregated results. In such cases, it will be relatively easier to work with qualitative and semi-quantitative indicators because the results are presented in a disaggregated way. Or in case of quantitative indicators, such as noise, it might be better to build a separate (individual) category for them, without trying to aggregate them with other indicators. The methodology for the measurement of such indicators, in this case noise, should be uniform to the EU legislation (EU-Directive 2002/49/EG). However, it might be necessary to present the disaggregated results and separate (individual) categories along with the aggregated ones (achieved by using LCA-indicators), in order to avoid any loss of information, and build a sound basis for the product declarations. It is recommended to focus on different instruments, such as environmental impact assessment, chemical risk assessment etc for measuring the non-LCA-indicators. Furthermore, it has to be accepted that the widely used quantitative functional units might not represent the total quantitatively calculated environmental burden. So, the need to supplement this information with additional quantitatively calculated categories, and descriptive and argumentative interpretation, becomes indispensable[27] (Figure 5).

[27] For instance, information related to biodiversity loss might not necessarily be qualitative or semi-quantitative. There are well established methods, such as economic valuation of biodiversity through willingness-to-pay or calculated payment for ecosystem services, which might be helpful for the assessment. Such an assessment will not add quantitatively to the overall impact expressed in “potentially disappeared fraction”, but can be used for the overall interpretation of the impact category “ecosystem quality”.

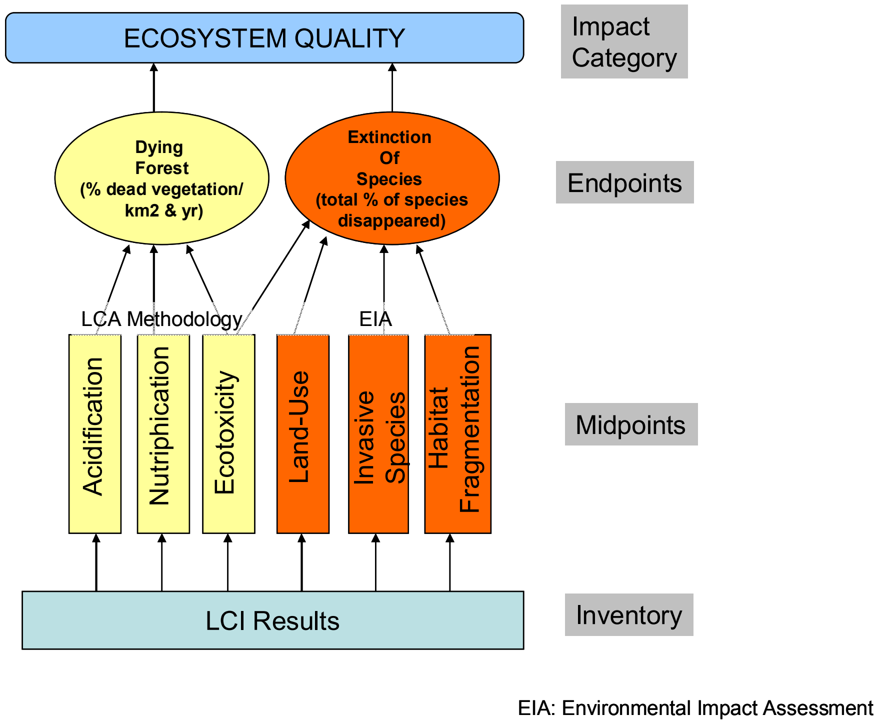

Figure 5 A possibility for combining various methodologies for calculating real environmental burden of a product

It is, however, recommended to segregate qualitative and semi-quantitative indicators in quantifiable specifications / requirements by formulating several sub-indicators for each qualitative and semi-quantitative indicator. Example: expert judgement of biodiversity loss can be complemented by collecting (site-specific or generic) data on important damage factors, like pesticide use, habitat fragmentation, invasive species, measureable habitat destruction etc (cf. ABC analysis explained earlier). Such a step might also be important in the wake of an extremely noteworthy aspect – the validity of a qualitative (often subjective, thus with high uncertainty) assessment of inventory data flow towards building midpoint / endpoint indicators or impact categories, can be strongly debated. If the assessment took place only by means of an expert judgement, certain parties, as for instance companies who fear a loss in overall competitiveness due to poor rating of their products, might think of lodging judicial complaints.

While assessing the inventory data that was collected over technosphere, ecosphere and valuesphere processes, it should be kept in mind that such data will vary from one case to another as it depends upon the type of expert panel, audience expectations, socio-cultural subjectivity and data availability. However, in order to facilitate an easier understanding for the audience, especially consumers, it might be appropriate to screen possibilities to link additional inventory results to an expanded set of midpoint / endpoint indicators, while at the same time keeping the impact categories to a minimum possible number. Example: if noise and radiation[28] are identified as additional important factors,[29] leading to sleeping problems and cancer respectively, it is recommended to identify their link to an impact category, as for instance to Human Health. As explained above for the impact category – ecosystem quality, even in this case, the quantitative results have to be supplemented by qualitative information that interprets the overall possible effects on human health.

The characterisation models in such cases would be rather formalised and not mathematical operationalisation of the environmental mechanisms. They may be a basic aggregation step, bringing text or qualitative inventory information together into a single summary, and/or summing quantitative inventory data within a category. Characterisation models may also be more complex, involving the use of additional information such as performance reference points. Performance reference points may be internationally set thresholds, goals or objectives according to conventions and best practices, etc. Performance reference points needs to be transparent and documented.

When evaluating qualitative or semi-quantitative information, a scoring system may be used to help assessing the "meaning" of the Inventory data, based on performance reference points, and hence, providing an estimation of the impact. The scoring and weighting step might be undertaken at the characterisation step (instead of interpretation), which can also be designated as the meaning assessment step. The models and criteria used to define the Characterisation Factors as well as the scoring and system must be well defined and transparent.

4.1.6 Interpretation

Finally, in the interpretation phase, the evaluation can use a range of qualitative, semi-quantitative and fully quantitative approaches. Some key requirements regarding the evaluation process include the mandatory, collateral, third-party critical review, the participation of relevant stakeholders, the documentation of the evaluation process, actions taken to ensure transparency, and the verifiability of results.

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[28] There is no need to enforce the definition of characterisation factors for noise and radiation, if this causes high level of uncertainty, lack of precision and accuracy. Instead, noise and radiation effects can be calculated using existing methodologies, and then can be presented and interpreted along with the quantitatively measured human health impacts.

[29] These factors can stimulate different impacts on different people, depending on sociological factors, subjective sensitivities and some physical aspects, such as presence of noise barriers.

Regarding the significant issues, it is important to identify the key concerns, limitations and assumptions made during the study and resulting from the study. Particularly, it will be important to stress system boundary choices and the level of detail (from generic to site specific, reached for each of the processes of the product system). It is suggested to structure the results so that the significant issues based on the goal and scope, may emerge. The purpose here is to be able to include any assumptions made and the consequences of decisions made throughout the study.

In addition, it is important to establish the reliability of the findings, including issues arising from any significant topic. This is referred to as the evaluation phase. Finally, conclusions will have to be drawn and recommendation made, based on the goal and scope of the study. It may be best to start with preliminary conclusion, and verify if they are consistent with the requirements set out for the study. If these are not consistent, it may have to be necessary to return to previous steps to address the inconsistencies. If the preliminary conclusions are consistent, then the reporting of the results may proceed. The reporting should be fully transparent, implying that all assumptions, rationales, and choices are identified.

4.2 Concluding Remarks

Insights and description from this chapter have shown that LCA is definitely not the tool to detect all environmental burdens associated with a product or system throughout the life cycle. It is also not necessarily the tool to consider all attributes or aspects of natural environment, human health and resources. On the other hand, as there is still no tool in the world that can fulfil the claim of "complete life cycle perspective" and "comprehensiveness, we wanted to demonstrate with this study how to address the shortcomings of LCA and the need to utilise a combination of complementary tools to capture the true environment burden of a product. This goes in line with ISO 14025 which calls for the requirement for additional environment information, complete life cycle assessment of a product, and the obligation to involve consumer and environmental interest representatives in the development of type III declarations.

As shown in this chapter, the approach of LCA can be used to look for potential trade-offs while assessing a product or system. These trade-offs have to be met due to costs, time and human capital constraints. These trade-offs enable the practitioners to focus on the assessment of most significant environmental burdens of a product or a system, while avoiding the overflow of information. Thus, it can be said that LCA is an appropriate tool to conduct a structured and precise assessment of only those aspects, which it can cover._For non-LCA-indicators, it is important to use additional environmental and health assessment methodologies, as demonstrated in this chapter.

Small number of indicators used in LCA provides a limited picture of the environmental burdens of a product or system. Mostly, these indicators are related to those aspects where quantifiable data is easily (or more or less easily) available. This approach brings in a certain bias in the overall assessment as possibly many important issues are left out because of the unavailability of data or the inability of LCA-practitioners to transform them into measurable quantitative terms.

This chapter has shown that indeed many more environmental aspects and indicators, including qualitative and semi-quantitative indicators, and also other quantitative ones, can be assessed using a variety of tools. However, this requires a fundamental change in the way how the basis for product labelling and EPDs is constructed and made transparent to the public. For instance, if many more important environmental issues are identified during the hotspot analysis than actually covered by the widely used LCA-indicators, more flexibility is called for refraining from the practice of grouping everything under a common functional unit. As illustrated in some examples in this chapter, qualitatively descriptive summaries and disaggregated results can be presented along with the aggregated results for interpretation. Another important point to consider in such cases is that the definition of the scope, system boundaries, cut-off criteria and choice of indicators has to take place in a democratic wider stakeholder consultation, and should not be left only to LCA-practitioners.

As already specified in 14044 for comparative assertions, complementary instruments should be used to cover other aspects that might still be left out of LCA. For example: multistakeholder workshops, product-specific expert judgement and sustainability reports can be used to identify key aspects related to a product. Or different types of environmental declarations and product-specific regulations can be combined to achieve a comprehensive environmental information system, as envisaged in the environmental data sheets. The appropriate benchmarks will have to be defined in a transparent process that balances public and economic interests in a credible way.

5 Energy- versus CO_2-indicators

Within the last two years, several attempts have been started to calculate and display the carbon footprint of products and services. These initiatives originally emerged from the UK, for example from the Carbon Trust and from retail chain Tesco. Tesco has announced its intention to declare the carbon footprint of all 70,000 products in its own sales range. The Carbon Trust has produced an environmental life cycle assessment for three product items (potato crisps, shampoo and juice) showing how much CO_2 is emitted in the course of producing and selling the products. Nevertheless, it soon turned out that such footprint schemes also raise far-reaching methodological questions. Beside the problems of using LCA for product differentiation, which is discussed in chapter 2.1.2, there are considerable concerns regarding the use of CO_2-equivalents as key indicator. Alternatively it is possible to use an energy-indicator that sum up the amount of primary energy used within the life cycle of a product. Both approaches have specific advantages and problems that have to be carefully considered for such footprint schemes.

The following chapter gives an overview on the pros and cons of the two types of indicators aiming to support decision making in the respective methodology-development.

In the following chapter the term CO_2-indicator is used for an indicator that covers all greenhouse gas emissions by converting the different greenhouse gas intensities into CO_2-equivalents. Therefore, the term “CO_2-indicator” is treated synonymously with “CO_{2eq}-indicator”.

5.1 Arguments pro CO_2- and contra energy-indicators

CO_2-indicators meet a high level of public awareness

Within the last months, the topic of global warming moved into the centre of public and political debate. After tremendous media coverage, it can be assumed that most European citizens now know roughly about the connection between CO_2-emissions and global warming. A CO_2-indicator would therefore meet a high level of public awareness and understanding of a major environmental problem. Furthermore a CO_2-quantification for each product could have a strong educational effect: Even people with little scientific education would be enabled to judge and compare on their specific purchasing decisions. They would learn for example that meat consumption has significantly higher environmental impacts than a comparable vegetarian diet. Furthermore CO_2-indicators would also enable easy cross-sector comparisons: If CO_2-labelling is done properly, people would be able to make judgements on their daily action alternatives like "is it better to take the car and drive 10 km to a supermarket for organic products, or is it better to walk to the conventional supermarket round the corner?"

<u>CO_2-indicators are easy understandable</u>

Although energy figures have a long tradition, it often turns out that there is limited public knowledge on the presented data. Especially the connections between the different versions and measurement units (VA x h, Watts x h, kWh, Joules, litres diesel per 100km, litres gasoline per 100km) are only vaguely understood by less educated population parts. Although it should be possible to increase public knowledge in this respect and to simplify and harmonise the presented energy figures, CO_2-figures are comparably straightforward. Especially the fact that CO_2 is gauged in grams increases the likelihood of a wide public perception. Grams and kilograms are measurements of everybody's daily life and therefore help to bridge the abstract nature of the topic.[30]

<u>CO_2-indicators are in line with various new fiscal and legislative procedures</u>

The battle against global warming gained a high level of public and political awareness, which is followed by a series of legal and fiscal rearrangements. In many countries there are serious efforts to strongly integrate greenhouse gas emissions into taxation and limit-value-schemes to curb national emissions and to meet reduction target. CO_2 is a central measurement in these efforts and will therefore gain even more importance in the future. This trend is also supported by the CO_2-based emission trading system under the Kyoto Protocol. Countries like Finland, the Netherlands, Norway and Italy already have carbon taxes in place that price the use of fossil energies in relation to the emitted greenhouse gases. Additionally, France just invented a far-reaching bonus malus system for cars, which is based on CO_2-emissions. Furthermore, a whole variety of CO_2-based laws and tax instruments that aim to promote environmentally sound products and services, is being discussed and developed. The EU initiative on upper limits for car emission is the most prominent example. Although most of these initiatives are not yet mature, it is foreseeable that product based CO_2-figures will at least partly play a role in these developments.

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[30] In this context, it still has to be discussed how CO_2-indicators shall be displayed to make best use of this understanding. For many consumers it might be useful to additionally provide average data for comparable products or the mean daily per capita CO_2-emissiones in the EU. Nevertheless it can also be argued that a widespread display of uncommented CO_2-figures itself can after a certain time be sufficient for individual knowledge-based judgements.

CO_2-indicators are closer representing the environmental impact

From an environmental perspective, indicators should as closely as possible address the environmental impacts associated with a product. For greenhouse gas emissions, CO_2-indicators are clearly closer representing the environmental impact than energy indicators. Although energy is at present widely correlated with greenhouse gas emissions and other environmental impacts like acidification and depletion of non-renewable resources, the use of energy is no environmental impact itself. It is at least theoretically possible to tap energy sources without any major environmental impact. To some extent, this goal has already been achieved by many forms of renewable energies, which marks a development that is presumed to continue in the next decades.

Furthermore energy-indicators are not able to stimulate a shift towards greener forms of energy, since they solely allow judgements on the amount of energy used and not on the type and its environmental quality.

Greenhouse gas aggregation method is well established

The method of aggregating greenhouse gas emissions into CO_2-equivalents ($CO_{2\text{-eq.}}$) is well established and allows having one single and undisputed indicator for the key environmental concern of global warming. With CO_2-indicators also greenhouse-gas emission not connected to energy generation can be integrated. Such non-energy-emissions are relevant for a whole variety of products like meat and milk-products (methane emissions in cattle breeding), agricultural products (CO_2-emissions from the mineralisation of soils), fridges (emissions of cooling and foaming agents) and computers (nitrogen trifluoride emissions in chip and monitor production).

CO_2-indicators avoid confusion with traditional energy-indicators

Product focused CO_2-figures are comparably new and just recently started to play a role in product labelling. In contrast, energy-indicators have been applied for decades to give information on the use-phase of energy-using-products. Extending these energy indicators on other life cycle stages would lead to a fundamental paradigm shift that might be hard to communicate to consumers. So far, consumers use energy indictors to calculate running costs, which is not possible with aggregated life cycle energy figures.

Furthermore, the current versions of energy-indicators for electrical and electronic equipment refer to effective energy and ignore transformation losses in electricity generation and transmission. Nevertheless, there is a broad consensus in the LCA-community to use primary energy figures for life cycle calculations.[31] So even in the case that energy-indicators are broken down to life cycle stages, there would remain a significant discrepancy between the LCA-based figures for the use phase and the traditional energy figures. Although it can be argued that the two established energy units – Joules and Wh – can be used to express the two different forms of energy indicators, the principle dilemma of having more than one energy information on a product cannot be solved with energy-indicators.

5.2 Arguments contra CO_2- and pro energy-indicators

A strong CO_2-focus leaves out on other environmental impacts of energy generation

The CO_2-emissions of electricity use are linked to the type of power plant that generates this amount of energy. While lignite fired power plants typically feature CO_2-emissions in the range of 1.09 kg/kWh to 1.22 kg/kWh,[32] power plants with fossil gas generate around 0.56 kg/kWh, nuclear power plants 0.007 kg/kWh and renewable energies between 0.0012 and 0.0000015 kg/kWh.[33] Nevertheless, there are only very few private or industrial users who draw their electricity from one single plant, so that CO_2-emissions of electricity are normally based on the national electricity mix. Alternatively it is possible to use the electricity mix provided by the chosen supplier company for calculation, which was partly made transparent with the implication of EU Directive 2003/54/EC.

If CO_2-indicators do not only calculate CO_2-emissions based on the national or European average, but allow including supplier specific data, these indicators would have the potential to stimulate a shift towards suppliers with less CO_2-intensive power plants. This would especially favour the renewable energies and also nuclear power.

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31 The use of primary energy figures is vital to guarantee consistency in the calculation. Otherwise electrical energy would in most cases be rated as preferable to the direct use of primary energy. Ovens can be taken as an example: While the use of effective energy would suggest that electrical ovens are preferable to gas ovens, this comparisons does not account for electricity generation and transformation losses. In fact, gas ovens are more efficient than electrical ovens, since the direct use of primary energy avoids the efficiency losses inherent to electricity.

32 Hard coal: 1.08484 kg CO_2/kWh; lignite: 1.21725 kg CO_2/kWh (IPCC 2007).

33 Hydropower: 0.001163 kg CO_2/kWh; wind power plant: 0.000128 kg CO_2/kWh; solar power: 0.000001495 kg CO_2/kWh (IPCC 2007).

If the CO_2-emissions across the life cycle of a product are the only means of differentiating “green products”, there is a certain danger that producers will also solely focus on this issue and search for CO_2-extensive energy sources irrespective of other sustainability impacts. Taking into account that – under the current political and economic conditions – nuclear power provides one of the cheapest forms of electricity supply, producers might opt for this source. Since nuclear power is inevitably connected to other especially severe sustainability risks, it can be concluded that a strong focus on CO_2-indicators bears the risk of severe unintentional side-effects and another form of “greenwashing”. Similar issues might arise for large-scale hydro-dams or some forms of bioenergy,[34] which are also connected to severe sustainability impacts others than global warming.

If CO_2-emissions of electricity use are solely calculated with national average data, there would be no major driver for nuclear power. Nevertheless, such national average data would favour countries with a high share of nuclear power. Although this effect will certainly not make people move into another country to operate electric and electronic products under apparently more favourable conditions, it would cause products to appear “greener” if manufactured in a country with an outstandingly high share of nuclear power.

Good data availability for energy

As laid out in previous chapters, the quantification of indicators for product life cycle assessment depends on a good availability of data. Although data gaps can be filled with the use of generic data, primary data are preferable. Especially in cases where these indicators are aimed to differentiate between product models, the use of generic data has to be minimised. In this situation it is important to note that many companies did not yet attempt to compile their greenhouse-gas emissions in a satisfactory way. Especially SMEs very often do not have the capacity to carry out this task. In contrast, almost all companies have for economic reasons quite detailed compilations of their energy consumptions. In contrast to greenhouse gas emissions, energy consumption is linked to direct costs that need to be taken into account by all businesses. CO_2-emissions are still mostly external cost and are therefore not yet systematically accounted for in business calculations.[35] Therefore, the data availability for energy indicators is currently significantly better than for CO_2-indicators.

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[34] E.g. bioenergy produced on deforested land.

[35] With the extensions of cap-and-trade-systems, greenhouse gas emissions are increasingly transformed from external to direct costs.

CO_2-Indicators might lead to a negligence of efficiency

Assuming that the CO_2-indicators of a product carbon footprint scheme allow emission-deductions for the use of green electricity, such deductions could reduce the total product carbon footprint to a level that makes efforts for higher efficiency unattractive: If all producers of a supply chain start using green electricity, this could reduce the electricity related CO_2-emissions to almost 0. With this value, further emission reductions that can only be achieved be efficiency gains have negligible influence on the total carbon footprint. A similar effect is known from consumers that aim to reduce their personal carbon footprint: Purchasing certified green electricity has only limited additional costs but a large impact on the individual carbon footprint. From this optimised carbon footprint level, efforts to reduce electricity consumption have comparably small effects and are partly connected to considerable upfront investments (e.g. expenditure for a new A++ fridge).

Nevertheless, there is a broad agreement that efficiency reductions rank higher than the use of green electricity. This can be justified with the fact that today's economies are still far from an oversupply of renewable energies, so that the existing green electricity also has to be treated as scarce resource.

Energy-indicators have a long tradition and are key-characteristics of energy-using-products

Energy indicators have a long tradition and have been used for decades for various energy-using-products. An extension of such energy-figures could have the positive effect that consumers would become more aware of the fact that also non-energy-using-products consume energy in other life cycle stages. Nevertheless, this advantage has to be balanced against the potential confusion of extending energy-indicators on other life cycle stages (cf. chapter 5.1).

CO_2-indicators on national average data would cause problems with EuPs

Every European country features its own characteristic electricity-mix. If product carbon footprints are calculated using national average data for the use phase of electric and electronic equipment, CO_2-product-values would be different for each EU-country. In this case, thresholds for the EU Ecolabel and the EU Energy Label would have to be negotiated separately in each member country. The use of European average data would solve this problem.

5.3 Aspects to be considered for both types of indicators

A pure focus on energy or CO_2 leaves out on other environmental impact

Although global warming is undoubtedly one of the most serious environmental challenges, greenhouse gas emissions are not the only topic to be considered in environmental policy-making. Both types of indicators would leave out on important aspects such as toxicity, land consumption and biodiversity. One example for the limitations of pure energy- or CO_2-indicators is paper production: Within the last years, the Scandinavian paper industry made significant efficiency gains so that now, paper from primary pulp can – on an energy and CO_2 bases – compete with recycling paper. Nevertheless, recycling paper has still manifold environmental benefits, ranging from a better use of resources, fewer impacts on biodiversity and reduced land consumption. These benefits are not accounted for in pure energy- and CO_2-calculations.

Uncertainties of aggregation methods have to be considered

Both, CO_2- and energy-indicators are dependent on LCA-based aggregation over the life cycle of products. As laid out in chapter 2.1.2, this aggregation features some uncertainties that can only partly be reduced by harmonised approaches and sensitivity analysis. Uncertainties of input data still lead to error margins of at least 10% for primary energy use and greenhouse gas emissions. Although there are several attempts to reduce these uncertainties by formulating uniform assessment procedures for carbon footprinting (e.g. the British PAS 2050 on “Specification for the assessment of the life cycle greenhouse gas emissions of goods and services” (BSI 2008)), it seems very unlikely that error margins can be systematically reduced below 10% in the near future. Therefore, both types of indicators have weaknesses if used to differentiate between similar products with comparable environmental impacts.

No consumer guidance for the use-phase of EuPs

For many energy-using-products the main environmental impacts are caused in the use phase. Nevertheless, the use-phase of energy-using-products can be quite diverse, depending very much on the individual consumer behaviour. Both, energy- and CO_2-indicators would – if applied to the whole life cycle – have to make assumptions on this consumer behaviour covering frequency, intensity and/or duration of operation. An aggregated indicator-value based on such assumptions could be critical since it would present values that are at best applicable for one major consumer group or the “average” of all consumers. Although such indicator-values are still meaningful to guide purchasing decisions, they provide no support for environmentally sound usage behaviour. To support environmentally sound behaviour, it is important to inform on energy-use (or alternatively on CO_2-emissions) per unit of the delivered function and alternative modes of operation to reduce energy consumption.

Need for regular updates

Changes in electricity generation networks (e.g. through growing shares of renewable energies, more efficient coal and gas power plants) lead to shifts in the conversion-factors for primary energy – CO_2 and primary energy – effective energy. For both types of indicators, this would mean that the calculated footprint of products will change over time even if there is no change in the product model and its production processes. Although this effect will lead to gradual changes only, periodical updates will provide a significant logistic challenge since they would affect all products under the scheme.

5.4 Summary and conclusion

The compilation of pros and cons of CO_2- and energy-indicators shows that both types have specific strengths and weaknesses, which have to be considered in practical applications. Generally, global warming and greenhouse gas emissions receive a high level of public and political awareness so that a general cause-effect understanding can be presupposed for a large part of the population. Furthermore the measurement-unit for CO_2 (grams) is quite straightforward and corresponds with everybody's the day-to-day knowledge. With this measurement, consumers would be enabled to make simple cross-sector comparisons and rough judgements on their consumption behaviour. The various energy measurement-units are comparably complex and require a certain scientific understanding, which cannot be presupposed for all population parts. Furthermore it can be observed that CO_2-indictors are increasingly applied in fiscal and legal procedures so that product carbon footprint will tap many synergies with these efforts.

With regard to traditional energy indicator schemes, it can be argued that it is better to stay within this logic and further use energy-indicators for product footprint. Nevertheless, there is a discrepancy between the traditional focus on the use-phase and effective energy, and the need for a life cycle approach and primary energy figures. This discrepancy might create confusion amongst consumers.

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.

With CO_2-indicators there is also a certain danger to unintentional promotion of CO_2-extensive but unsustainable forms of energy like nuclear power. Nevertheless, this must be seen as a worst case scenario. So far, companies eager to compete on the market of “green products” strictly avoided to directly or indirectly support nuclear power or into any other form of clearly environmentally unsound business practice, since any negative press release or NGO report would seriously endanger the acquired positive image. Also the current industry led trend of product carbon footprint avoids nuclear power and focuses on efficiency and renewable energies. Furthermore, the promotion-effect for nuclear power presupposes energy suppliers that offer an explicit high share of this energy source. Currently, there is no such offer on the market, which is also due to the fact that nuclear power can be used for base load only and has to be supplemented with regulating energy such as electricity from gas power plants.

A more realistic problem with CO_2-indicators is the vague definition of green electricity: In many cases, suppliers offer “green electricity” that was formerly part of the general electricity mix: Since this practice does only lead to a demixing of the electricity supply and has no influence on the share of renewable energies, it should be carefully considered, which supplier specific emission data should be allowed for CO_2-indicator schemes. Generally, it is suggested that only certified green electricity (e.g. ok power label in Germany) that increases the market share of renewable energies should be allowed to replace national or EU-wide average data.

Regarding the applicability of energy- and CO_2-indictors, both indicators are easy to aggregate into one single figure. For energy indicators there is better primary data availability since almost every company needs these figures for its own economic calculations. Nevertheless, CO_2-figures are closer representing the environmental impact of global warming. Furthermore, they enable the aggregation of energy related CO_2-emissions and the emissions of other greenhouse gases such as methane or NF_3.

Regarding energy-using-products and CO_2-indicators, there are difficulties if national average data is used instead of EU-average data for electricity: With national data, the same product would have another carbon footprint figure in each member country, which would have repercussions for threshold values and classifications.

There are some aspects to be considered with both types of indicators: Both indicators only represent a certain part of the environmental impacts of a product or service, while others are ignored. Furthermore they only provide guidance for purchasing decisions and not for environmentally friendly user behaviour. Additionally, the calculation factors for both types of indicators are dependent on the energy mix of the EU, which is changing over time. Therefore, both footprint-schemes need to be updated on a regular basis, even if there are no changes in product composition and production processes.

It general it can be concluded that CO_2-indicators will inevitable play a major role in future labelling initiatives and that this type of indicator has some unique strengths that clearly overcompensate their weaknesses. Compared to energy-indicators it is believed that CO_2 will after all provide the better solution for product footprint. Nevertheless, there are also risks associated with CO_2-indicators that need to be minimised. Therefore, it is proposed to design CO_2-footprint schemes according to the following principles:

- To calculate the carbon footprint of electric and electronic equipment, EU average emission data should be applied for the product use phase. National data would lead to a situation, where the each product is rated with a different carbon value in each member country.
- It should be considered to allow credits for the use of certified green electricity. Although this could partly reduce the incentives for higher efficiency, it would help to promote renewable energies.
- Carbon footprint should not be used as standalone product information but shall be combined with information on environmentally sound use and disposal as well as information on other environmental impacts. For the latter issue, a combination of indicators beyond CO_2 should be considered. Thereby, the CO_2-indicator can be the compulsory base-indicator. Other indicators should be added, according to the characteristic environmental impacts of a product. Furthermore it could be considered to add a primary-energy-indicator as additional compulsory indicator.

6 Quality benchmarks for environmental data sheets

6.1 Introduction: from type I and type III label to Environmental Data Sheets

More and more environmental aspects play a role in the purchase process of products. This holds true particularly for business-to-consumer (B2C) but also for business-to-business (B2B) purchases. There is a need for easy-accessible tools helping to take decisions.

Type I labels rewarding the best-performing products are relatively easy to handle and much appreciated by the consumer. The requirements to be fulfilled by the product before the label may be awarded are developed in a stakeholder dialogue with experts (e.g. manufacturers, consumer organisation, environmental NGOs). These requirements are defined according to the general targets of the respective label. Although they might be influenced by existing LCAs they may cover any issues that appear relevant to the experts. This independence from the methodological restrictions of LCAs is a major advantage of type I label. The strength of the label mostly depends on the targets of the label and on the well-balanced stakeholder dialogue for criteria setting. Widely accepted type I label with the focus on the overall environmental performance of products are the European Ecolabel (EU-flower), the Nordic Swan and the German Blue Angel. The aim of these labels is to distinguish the best performing products in the market.

Type III labels are based on an LCA covering the entire life cycle and describe the environmental impact of a product. The comprehensiveness turns to a disadvantage because type III label usually are complex and not easy to read. Interpretation of the information of a type III label is difficult since the presented performance (environmental impact) of the product is not set in relation to the impact of other products. It is neither compared to products within the same product group nor does it help to judge on the relative impact to other product categories. Consequently type III label may be helpful for experts but are of limited use for the decision-making process of consumer.

In a study commissioned by ANEC (FORCE-study) so-called Environmental Data Sheets (EDS) were developed that suggest combining information of type III label with those of type I label. Although the information given in the EDS is kept as simple as possible it should cover the most relevant issues related to the product. An important feature of EDS's is that they compare the product to the "average" product within the product group and compare between product groups (both comparisons are not made either by type I[36] or type III labels). Furthermore, an EDS gives information on the product gathered with other instruments. These can be the classification according to the energy labelling scheme or other schemes where appropriate (e.g. Indoor Air quality for construction products). Of major importance as additional information is the potential compliance with ecolabel (e.g. European Ecolabel, Blue Angel, Nordic Swan). The EDS's checks whether the product complies with the individual requirements of a relevant ecolabel and comments on the relation of the product to the criterion.

[36] Type I label by definition is awarded to the best performing products. Since neither data of the awarded product nor benchmarks are given direct comparison with other products remain impossible.

6.2 Transfer of environmental information on other products

The concept of the EDS anticipates that an appropriate type I ecolabel with updated requirements exists. As an accepted international type I label the EU Ecolabel (EU-flower) plays a central role. Requirements, however, are only available for a limited number of product groups. In these cases national type I label may serve as reference points. Although attempts are made to harmonise the various national labels, differences in scope and requirements exist. Furthermore the development of the requirements in the different type I labels may be based on different technological situations (year of development or latest revision of the requirements). The conclusions drawn from the EDS's, therefore, may depend on the label taken into account.

In the following case study (fax machine based on thermal paper) these consequences are illustrated and conclusions are drawn.

6.3 Case-Study: Fax-machines

Fax machines use one of the four different marking (= printing) technologies:[37]
thermal transfer (7); thermal paper (7); laser (= Electro photographic) (10); inkjet (2).

The number in brackets gives the number of manufacturers (total 15) that offer appliances using the respective marking technology.[38] In the following it is assumed that an EDS for a fax machine with thermal paper printing technology is to be developed.

For the check of compliance of the product with type I label, relevant ecolabel need to be identified. The European Ecolabel (EU-flower) as one of the type I label covering the overall environmental impact of a product does not cover a closely related product group. Two national labels, however, cover imaging equipment.

The German Blue Angel[39] "Office Equipment with Printing Function" recently was developed and focuses on printers, copiers and Multifunction Devices. Although the primary function of "Sending and receiving of electronic messages and faxes via internal modem" is included, the scope is limited to appliances that "work as electrophotographic devices (LED or laser technology) by using toner or as ink jet devices by using ink". Fax machines based on thermal marking technology, therefore, are NOT covered by this label.

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37 As defined in the Energy Star Program requirements for imaging equipment.

38 Source: EuP Preparatory Studies "Imaging Equipment" (Lot 4). Final Report. Fraunhofer IZM on behalf of the European Commission.

39 RAL-UZ 122: Office Equipment with Printing Function (Printers, Copiers, Multifunction Devices); May 2008.

The scope of products in the Nordic Swan "Imaging Equipment"[40] in contrast is not restricted to a given marking technology and covers all fax machines.

The table 3 summarises the aspects covered by the requirements in the two labels. Comparing the requirements of the two labels comes to the following results:

- Both labels largely address the same issues.
- Details of the requirements (e.g. level of ambition, calculation of thresholds) differ for some requirements.
- For some key-requirements (e.g. energy consumption, emissions) the Nordic Swan refers to the requirements of the Blue Angel (although to the older version of June 2006).

Table 7 Aspects covered by the requirements in the Blue Angel (Office Equipment with Printing Function, RAL-UZ 122) and Nordic Swan for Imaging Equipment

	Blue Angel	Nordic Swan
Scope includes fax machines with thermal paper marking technology?	NO	YES
Batteries	+	+
Chemicals in materials used	+	+
Use of recycled material	-	+
Design for end-of-life	+	+
Life-time extension	+	+
Paper consumption	+	+
Toners and inks (including container)	+	+
Emissions	+	+
Energy consumption	+	+
Limits for return time and activation time	+	-
Noise	+	+
Packaging	+	+
Consumer information	+	+

Products contain components that are used in other product categories. Therefore, requirements for certain product groups might also be useful for the development of requirements in not closely related product groups. Fax-machines, for example, contain circuit boards similar to those that are used in most other electronic devices. Criteria concerning the circuit boards (e.g. restriction of the use of certain flame retardants) would affect all products having a circuit board.

40 Swan labelling of Imaging equipment Version 5.0; 14 June 2007 – 31 December 2010.

Comments

- The Nordic Swan includes all fax machines without adding particular requirements. This may be considered as indicator that the extension of the scope (in relation to Blue Angel) does not change the crucial issues to be addressed.
- A major disadvantage of thermal marking technology is the high energy consumption for heating the system.[41] This issue is covered by the Blue Angel requirements.
- The use of a different marking technology most likely has no fundamental influence on the production, the chain of custody, the way the fax machine is used (exposure) and the treatment at the end-of-life.
- Since the respective requirements of the Blue Angel and the Nordic Swan only slightly differ it most likely does not change the overall picture of the EDS whether one or the other label is used as reference.

6.4 Conclusions

- The target of the label needs to be in accordance with the intention of the EDS. Preferably it covers the overall environmental impact of a product (rather than being limited to a single parameter).
- Only widely accepted and reliable label should be taken as reference. Besides the European Ecolabel (EU-flower) some national labels (e.g. Nordic Swan, Blue Angel) seem appropriate.
- If more than one label on a given product group exist, it should be considered to indicate in the EDS whether the product fulfils the respective requirements (thus comparison to all relevant label).
- For horizontal aspects it might be helpful to cross-check compliance with requirements for other product groups. E.g. restrictions of the use of flame retardants in electronic circuit boards may be relevant for a wide array of electronic appliances.
- Ecolabel for product groups are not developed simultaneously but are established consequently and revised periodically. Therefore, the requirements of a type I label for a given product group reflect among others the sensitivity of the society to certain impacts, technical options and market situation.

[41] No other additional negative environmental impacts specific to thermal marking technology are known to the author.

These parameters may change over time. This has to be taken into account when adopting requirements from one type I label to another.

- When referring to a type I label for another product group it has to be carefully checked, which differences between the product groups exist and to which extent they might have environmental or health impacts.

7 General Conclusions

The EU Commission's Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy has set an overarching aim of improving "the energy and environmental performance of products and foster their uptake by consumers" [EU COM, 2008 (397/3); 2]. One of the key issues is to reinforce "information to consumers through a more coherent and simplified labelling framework" [EU COM, 2008 (397/3); 3]. Although many policies, such as the Ecodesign (EuP) Directive, the Energy Labelling Directive, the Ecolabel Regulation and the Energy Star Regulation, exist in the EU to improve the energy and environment performance of products, a lack of coherence among such policies leads to 'absurd' and 'incomplete' environmental information and results in the manipulation of consumers' interests. The Energy Labelling Directive and the Energy Star Regulation provide information solely on energy efficiency of household appliances and office equipment, while the Ecolabel Regulation covers only a limited number of products. Realising such deficits in the EU product policy, the Action Plan seeks to harmonise the various industry and product related environmental policies, and emphasises that several European labelling instruments of product policy, such as the European Energy Label and the European Ecolabel, which are of particular relevance to the consumers, will be revised.

For the purpose of environmental product labelling, it can be said that Life Cycle Assessment (LCA) methodology is indispensible in the initial phase from the methodological point of view. Although not all environmental impacts (including unquantifiable issues such as biodiversity loss and site-specific aspects such as emission of VOC) of a product are covered with LCA, it still enables a good overview on the occurrence of some key impacts like the emission of greenhouse gases and toxic substances. Furthermore, LCA-results serve as solid basis for product differentiation among wider defined product groups (such as PCs/Notebooks and system-alternatives of fuels). However, for product model differentiation in narrowly defined product groups, LCA cannot replace other product specific assessment methodologies that incorporate local situations. Further problems are rooted in the fact that many product systems and supply chains are more flexible than the LCA-databases and calculations, leading to situations where LCA-results do not necessarily represent the actual environmental impacts at a given time.

For the purpose of comparisons between models of different product groups [Environmental Data Sheets (EDS) as proposed by the FORCE Technology], the limitations of LCA-methodology (chapter 2.1.2) seem to be less significant. The LCA-approach fits quite well with the idea of EDS, as widely secured average data – as compiled in the generic datasets – would be preferred over product model specific primary data. Despite this, there is the need to predefine a uniform approach and product-specific minimum performance requirements and benchmarks for all LCAs carried out for the comparison. Besides aspects already described in ISO 14040 and 14044, this should encompass the issues of system boundaries, data requirements, allocation rules and stakeholder engagement. Such a common LCA-approach would also help to deal with the problem of excluded inputs and outputs that lack significance for the overall results. By applying a uniform standard for the sensitivity analysis it can be assured that data gaps are kept to an extent that still allows comparability. Therefore, a constant stakeholder engagement is recommended in order to guarantee a high level of acceptance and to insure that the final results cannot be easily challenged by individual interest groups.

Stakeholder engagement to formalise a uniform approach for product labelling will help to counter a well-established bias inherent in the LCA-methodology, which systematically restricts the number of environmental parameters under analysis. The parameters analysed with LCA represent only quantifiable data that can be aggregated using the functional unit approach. For example, in EcoGrade methodology, the aggregation is restricted to only four impact categories (global warming potential, acidification potential, eutrophication potential and photochemical ozone depletion potential), while other impact categories (cumulative energy demand, ozone depletion potential, waste accumulation, water use, land-use and hazardous substance potential) are ignored due to difficulties related to quantification and operationalisation. Secondly, the requirement for a complete logical causal chain for feeding the impact categories with quantifiable and aggregated data is not always met and entails high level of uncertainty.

However, if many more important environmental issues are identified during the hotspot analysis than actually covered by the widely used LCA-indicators, more flexibility is required for refraining from the practice of grouping everything under a common functional unit. As illustrated in chapter 3, qualitatively descriptive summaries and disaggregated results can be presented along with the aggregated results for interpretation. Variety of other methodological tools, such as product-specific risk assessments and complementary instruments, multistakeholder workshops and product-specific expert judgement, should be used to cover other aspects that are left out of LCA. This goes in line with ISO 14025 which calls for the requirement for additional environment information, complete life cycle assessment of a product and the obligation to involve consumer and environmental interest representatives, as for instance in the development of type III declarations.

Taking all these aspects into account, it can be concluded that LCA has some considerable weaknesses for application in product model differentiation. However, the approach of LCA can be used to look for potential trade-offs while assessing a product or system. These trade-offs have to be met due to costs, time and human capital constraints. They enable the practitioners to focus on the assessment of most significant environmental burdens of a product or a system, while avoiding the overflow of information. Thus, it can be said that LCA is an appropriate tool to conduct a structured and precise assessment of only those aspects which it can cover. For non-LCA-indicators, it is important to use additional environmental and health assessment methodologies.

Furthermore, different types of environmental declarations (type I and type III) and product-specific regulations can be combined to achieve a comprehensive environmental information system. As envisaged in the environmental data sheets (EDS), possibilities of comparison of the product to the “average” product within and between product groups should be facilitated. Information on the compliance of a product with type I label helps to judge on the environmental performance of a product. For practical reasons, widely accepted and reliable labels (such as Blue Angel, Nordic Swan and EU-Flower) should be taken as reference, and possibilities to transfer their criteria to other product groups should be explored. For horizontal aspects it might be helpful to cross-check compliance with requirements for other product groups. E.g. restrictions of the use of flame retardants in electronic circuit boards may be relevant for a wide array of electronic appliances.

As most existing labelling schemes have an individual set of criteria for each narrowly defined product group, LCA cannot provide any added-value for product differentiation in such cases. Nevertheless, there is an increasing tendency to introduce footprint schemes (such as carbon footprint, water footprint etc.) aiming at a higher comparability between system alternatives and different product types. These schemes are primarily focused on greenhouse gas emissions and have an inherent necessity to apply LCA-methodology. Although these schemes can also be questioned in terms of completeness and informative value as explained quite comprehensively under chapter 5 by elucidating the arguments for and against using pure CO_2-indicators for product labelling, they are a main reaction on the ongoing public and political debate on global warming and will soon form an additional type of product information. Therefore, the methodological challenges cannot be pushed aside but in turn need further attention in order to come to a quick standardisation for applications in product footprint.

8 Literature

BSI 2008 — British Standard Institution: PAS 2050:2008 – Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. London 2008.

Bundesregierung 2007 — Deutsche Bundesregierung: Entwurf einer Verordnung über Anforderungen an eine nachhaltige Erzeugung von zu Biokraftstoffen verwendeter Biomasse (Biomasse-Nachhaltigkeitsverordnung – BioNachV). Berlin 2007.

Christiansen et al. 2006 — Christiansen, K.; Wesnæs, M.; Weidema, Bo P.: Consumer demands on Type III environmental declarations. 2.-0 LCA consultants, commissioned by ANEC, Copenhagen 2006.

Dauensteiner 2001 — Dauensteiner, A.; Der Weg zum Ein-Liter-Auto: Minimierung aller Fahrwiderstände mit neuen Konzepten. Berlin, Springer 2001.

Ecoinvent 2007 — Swiss Centre for Life Cycle Inventories: Ecoinvent 2.0. Zürich 2007.

EPD 2008 — The International EPD Cooperation: EPD – General Programme Instructions for Environmental Product Declarations, EPD. Version 1.0 dated 2008-02-29. Internet: http://www.environdec.com/documents/pdf/EPD_instructions_080229.pdf (retrieved 10.12.2008).

EU COM 2008 — EU COM (397/3): Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan. Website: http://ec.europa.eu/environment/eussd/pdf/com_2008_397.pdf.

Gensch and Grießhammer 2004 — Gensch, C.-O.; Grießhammer, R.: PROSA – PKW-Flotte. Forschungsbericht des Öko-Instituts. Freiburg 2004.

Huijbrengts 1998 — Huijbrengts, M.A.J.: Application of Uncertainties and Variabilities in LCA. Part II: Dealing with Parameter Uncertainty and Uncertainty due to Choices in Life Cycle Assessment. In: International Journal of Life Cycle Assessment (1998) 3: 343-351.

IPCC 2007 — Intergovernmental Panel on Climate Change: Fourth Assessment Report. Geneva 2007

Möller et al. 2006 — Möller, M.; Bunke, D.; Gensch, C.-O.; Quack, D. und Vogt, P.: Eco-Grade 2.1 – Methodological Description. Öko-Institut, Freiburg 2007.

PROSA 2007 — PROSA – Product Sustainability Assessment – Guideline. Öko-Institut, Freiburg 2007.

Quack and Rüdenauer 2007	Quack, D.; Rüdenauer, I.: Stoffstromanalyse relevanter Produktgruppen. Energie- und Stoffströme privater Haushalte in Deutschland im Jahr 2005. Öko-Institut, Freiburg 2007
Reap et al. 2008	Reap, J.; Roman, J.; Duncan, S.; Bras, B.: A survey of unresolved problems in life cycle assessment. Part 2: impact assessment and interpretation. In: International Journal of Life Cycle Assessment (2008) 13: 374-388.
Schmidt and Brunn Poulsen 2007	Schmidt, A.; Brunn Poulsen, P.: Benchmarking and additional environmental information in the context of Type III environmental declarations. Commissioned by ANEC, FORCE-Technology. Brussels 2007.
Umweltbundesamt 2001	Umweltbundesamt (Hg.); Handbuch Umweltcontrolling, 2. Auflage, Berlin 2001 http://www.umweltbundesamt.de/u cumulation ba-infodaten/daten/uin/index.html.
UNFCC 1997	United Nations Framework Convention on Climate Change: Kyoto Protocol, Kyoto 1997.
WBGU 2008	German Advisory Council on Global Change (WBGU): Flagship report on biomass. Berlin, in progress.
Williams et al. 2007	Willliams, E.D.; Ayres, R.U.; Heller, M.: The 1.7 Kilogram Microchip: Energy and Material Use in the Production of Semiconductor Devices. In: Environmental Science and Technology 36, Number 24, pp. 5504-5510.